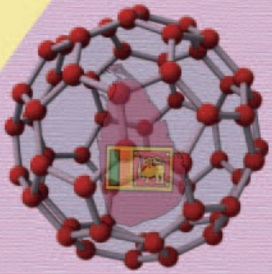

FIRST NATIONAL NANOTECHNOLOGY CONFERENCE

2012

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FIRST NATIONAL NANOTECHNOLOGY CONFERENCE 2012

Nanoscience and Nanotechnology in Sri Lanka : from Science to Commercialization

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Foreword

Prof. Sirimali Fernando, Chairperson, National Science Foundation

The National Nanotechnology Initiative (NNI) was launched in 2006 by HE Mahinda Rajapakse, the President of Sri Lanka on the recommendation of Hon. Prof. Tissa Vitarana, then Minister of Science & Technology. This was a key achievement for the National Science Foundation (NSF), which mooted the idea with a Task Force on Nanotechnology in 2005.

Since then, the NSF has played a key role in the promotion of nanotechnology in Sri Lanka. It had been an active partner in setting up of SLINTEC (Pvt.) Ltd. as a public - private partnership in 2008 and creating awareness in nanotechnology in the industrial sector, schools and amongst the general public. The NSF is also working towards a National Nanotechnology Policy and a regulatory framework for nanotechnology in Sri Lanka. The NNI today has triggered much enthusiasm on the advanced technologies and many hitherto neglected facets of research that are so vital for economic development of any country. It is heartening to see the interest generated by NNI amongst scientists, technologists industries and the policymakers on commercialization of research, industry oriented research and public private partnerships in research. It is in this backdrop that the National Nanotechnology Committee at NSF decided to organize the first National Conference on Nanotechnology titled “Nanoscience and Nanotechnology in Sri Lanka: from Science to Commercialization” to deliberate on economic utilization of nanoscience and nanotechnology.

This book is a compendium of research papers, review papers, case studies and presents a snapshot of Sri Lankan Nanoscience and Nanotechnology. It also illustrates the challenges posed in the context of nanotechnology R&D commercialization, occupational and environmental safety aspects, public-private partnerships and governance.

I am pleased to write a foreword for this book and I congratulate the authors for providing valuable information for the research community and policymakers. I take this opportunity to thank Prof. Ajilth de Alwis, the

Chairman together with the members of the NSF National Committee on Nanotechnology, members of the editorial committee and Mr. Shantha Siri, Scientific Officer and others at the Technology Division of NSF for their untiring efforts and cooperation to make this national event a success.

Preface

It is our pleasure to write the inaugural editorial message for the proceedings of the first National Nanotechnology Conference in Sri Lanka to be held during 24-25 August 2012 in Colombo. The idea of holding a National Nanotechnology Conference has been germinating for a few years and finally it has come to realism. The Editorial Committee comprised three members representing University of Colombo (UoC), Industrial Technology Institute (ITI) and National Science Foundation (NSF) with the support and contributions from the other members of the National Nanotechnology Committee and the staff of the Technology Division of the National Science Foundation, Sri Lanka. An important decision made by the National Nanotechnology Committee was that the Conference should be the focus of many who are engaged in different areas of nanotechnology research in the country. This national Conference will also become a recognized forum for learning and exchanging ideas by scientists who are involved in nanoscience and nanotechnology research.

Nanotechnologies promise to be the foundation of the next industrial revolution. Nanotechnology applications have the potential to develop advanced technologies to generate low cost and clean energy, purify water, develop advanced materials, new drug delivery systems as well as the next generation of computing devices. A culture of inter-disciplinary research with the participation of R&D institutions, Universities and Industries, is required to carry out industry-oriented research in nanoscience and apply the resultant research findings to develop commercially viable products successfully. The government has initiated this effort through the National Nanotechnology Initiative (NNI) with participation of some of the private sector companies that recognized their pivotal role in developing and applying the potential of nanotechnology. This rapid and broad involvement of Sri Lanka in nanotechnology can be interpreted as a feature of the global character of nanotechnology revolution, and as a new trait of global production of science. Differently from the previous technological revolutions, these characteristics would place Sri Lanka in a more favorable position to face this revolution via nanotechnology and get benefits from it.

By looking at Abstracts of the first Conference we are happy to note the progress of research related to industry oriented/collaborative projects. A total of 48 papers under the subjects discussed in the Conference are divided into ten sectors namely Nano Safety, Policy and Awareness (06 papers), Solar Energy (05 papers), Medicine (05 papers), Nano Characterization (05 papers), Medicine and Agriculture (05 papers), Nanocoatings (04 papers), Energy Conversion and Storage (04 papers), Nanomaterials and Nanocoatings (05 papers), Environment Purification (05 papers), Nanocomposites and Nanostructures (04 papers). Based on the knowledge shared and gathered therein, the next step will be to device this unique approach towards a more coordinated manner with a view to take the lab scale research to pilot scale to deliver innovative products/ processes to attract the competitive edge of the industries enabling them to compete and harness opportunities in the global market. The National Nanotechnology Committee is grateful to the National Science Foundation, Colombo for the cooperation extended to make this Conference a reality. In future we will build the fame and the reputation and perhaps open this forum to scientists from outside Sri Lanka. This will further benefit the Sri Lankan scientists who are willing to undertake collaborative research with the other part of the world.

Editorial Committee
August 2012

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Session A

Nano Safety, Policy and Awareness

NANO-EDUCATION IN SECONDARY SCHOOL SCIENCE CURRICULUM?

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ABSTRACT

"Nano" is a prefix that has invaded the scientific literature during the last few decades. It is considered as the anchor of the next industrial revolution that will have broad socio-economic implications. As a result, many countries currently competitively engage in developing nanoscience and technology in order to be at the forefront in the revolutionary change to be expected to take place within the next couple of years.

It is unarguably agreed that the whole nation should be educated and made aware of the field of nanotechnology in order harvest the fruits at the early stages of the technological revolution. Therefore, at global level it is being strongly agreed that "nanoscience should be part of the secondary school science curriculum". This article attempts to justify the need to introduce nanoscience into the secondary school curriculum in Sri Lanka while a proposal for an interactive module is presented.

Keywords: *Knowledge based economy, nanotechnology, school curriculum, nanoscience*

INTRODUCTION

As science and technology are crucial elements contributing to development in the modern world, a scientifically and technologically literate population is more important than ever. "The emergence of a highly competitive and integrated international economy, rapid technological innovation, and a growing knowledge base will have a profound impact on our lives."[1] In this context, science education plays a key role in developing a tomorrows' youth to meet the need for a sustainable environment, economy, and a society. While they are expected to understand the key concepts and principles of science, they should be trained to positively contribute towards the problems of sustainability created by earlier technologies, which swept through the world, in the past two hundred years. Therefore, education specialists speculate that the science curriculum needs to be assessed and updated according to the emerging socio-economical needs.

WHY NANO-EDUCATION?

Over the past few decades the word 'nano' has become rapidly insinuating into the world consciousness. It has already conjured up speculation about a seismic shift in almost every aspect of science and engineering.[2] Nanotechnology is about new ways of making things. It promises more for less viz., smaller, cheaper, lighter and faster devices with greater functionality, using less material and consuming less energy.

At a global level, educating the nanotechnology workforce has been debated since the beginning of the new millennium. The central question to be answered is "Do we need nano-education"? Many of the educationalists have focused their attention to answer this question since the beginning of this millennium. In 2005, ICS UNIDO developed an Action Plan for a comprehensive nanotechnology education from the primary to post-graduate and life-long learning. As an initiative step, the US government, through the National Science and Technology Council, launched the National Nanotechnology Initiative (NNI) involving 25 federal agencies to coordinate federal nanotechnology development. NSF through the National Centre of Learning and Teaching (NCLT) in Nanoscale Science and Engineering strives to introduce nano science and technology into science curricula and have funded research on their development in secondary school and undergraduate courses. Consequently, and partly due to NSF grants, science education research on nanoscale science has been developed for a few years globally.[3,4]

Sri Lanka too is currently at the door step of moving from a commodity exporter economic pattern to a knowledge based economy. In order to make this forward leap the first step would be to educate each category of the society particularly by introducing an innovation driven education system, which fulfill the 'student profile of the 21st century'. One such attempt is to embed new technological advancements such as nanoscience and technology into various levels of school curricula. However, these modifications are still in the introductory level and the specialist believe that such modifications should not dilute the expected learning out comes set for the school science curriculum.

'NANO' CURRICULUM FOR SCHOOL SCIENCE SYLLABUS

The proposed interactive nanoscience and technology module for the high school science curriculum, which particularly leads to a student centered learning activity, is discussed here. The following sections are expected to be spread towards several levels of the high school curriculum.

- Introduction to Nanoscience: Concept of atom, molecule, and nanoparticle using interactive physical models and interactive videos
- History and nature nanotechnology: students are encouraged to build this knowledge with close interactions with the nature and study of the historical events

- Structure property relationships and synthesis of nanoparticles: students will gather the classic knowledge through class room experiments
- Current applications and Nano future

REFERENCES

1.British Columbia Ministry of Education (2001), Science Curriculum Review Report, British Columbia Ministry of Education, USA.
2.Ratner M. & Ratner D. (2009). Nanotechnology : A Gentle Introduction to the Next Big Idea, 1st Edition, Dorling Kindersley (India) Pvt. Ltd., New Delhi, India.
3.Malsch I. (2008). Nano-education from a European perspective. Journal of Physics: Conference Series 100:32001.
4.Hinganta B. & Albe V. (2010) Nanosciences and nanotechnologies learning and teaching in secondary education: a review of literature. Studies in Science Education 46(2):121–152.

NANOTECHNOLOGY AWARENESS AMONG UNDERGRADUATES IN SRI LANKA

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ABSTRACT

Nanotechnology is a relatively new field of science, therefore it is important to investigate the level of awareness and their motivation to learn nanotechnology among undergraduates in Sri Lanka. That is the aim of this study. A total of 217 undergraduates from Uva Wellassa University and University of Peradeniya were interviewed using a self administered structured questionnaire. Data was entered and then analysed using Microsoft Excel 2007 software. This study indicated that the majority of the study population have heard about nanotechnology but among them comparatively low percentage know what nanotechnology is.

Keywords: *Nanotechnology awareness, undergraduates*

INTRODUCTION

Nanotechnology is a relatively new field of science, and thus it is not yet widely understood by the public1. Significant efforts have to be made to increase public awareness of this new field2. In order to popularize this new technology including products based on nanotechnology in Sri Lanka, it is a pre-requisite to investigate the present level of awareness and interest about nanotechnology among the local population. The aim of this study is to assess the level of awareness and their motivation to learn nanotechnology among undergraduates in Sri Lanka.

MATERIALS AND METHODS

A total of 217 undergraduates in the Faculty of Science and Technology of Uva Wellassa University (144) and the Faculty of Allied Health Sciences of University of Peradeniya (73) were interviewed using a self-administered structured questionnaire. All respondents were science stream students in different degree programmes. Data were entered into a computer (Microsoft Excel 2007 worksheet) and analyzed.

RESULTS

All studied participants submitted the completed questionnaires and among them

131 (60.36%) were females and 86 (39.63%) were males. A majority (98%) of the respondents had heard about Nanotechnology. However, only 64.0% of them stated that they knew about nanotechnology.

The sources through which they gathered information about nanotechnology was inquired. A majority stated through the Internet (34.9%); by the course work (28.9%); by print media such as news papers and magazines (28.5%), and by peers (7.6%). Majority of students (96.6%) expressed their willingness to learn about nanotechnology as a subject in their course curriculum.

The questionnaire inquired whether they know about the SLINTEC (Sri Lanka Institute of Nanotechnology) and 33.5% stated “yes”. Among the respondent, 59.5% knew about the products, which are manufactured using nanotechnology and of them (83.8%) stated that they prefer to purchase products,which are manufactured using nanotechnology.

DISCUSSION

This study indicated that a majority of the studied population has heard about nanotechnology but among them comparatively low percentage knows what nanotechnology is. The study also revealed that a majority of the undergraduates wishes to learn nanotechnology as a subject in their undergraduate degree programme. The Internet and print media seem to play a major role in disseminating information about nanotechnology among the undergraduates in Sri Lanka. However many of them were not aware about SLINTEC.

In conclusion, we should improve the nanotechnology awareness among undergraduates in order to make them more knowledgeable about this new technology. They are interested in learning about this new technology. Therefore, as academia we should provide more opportunities to undergraduates to learn nanotechnology, as this is an area of strategic importance for future industry.

REFERENCES

1. Dyehouse, M.A. & Dux, H.A. (2008) ‘Development of an Instrument to Measure Undergraduates’ Nanotechnology Awareness, Exposure, Motivation, and Knowledge’, Springer [Electronic], vol. 17, no. 5, pp. 500-510.
   Available at http://www.springerlink.com/content/5h08r1850300872q/?MUD=MP, Accessed 8 Aug 2008
2. Sheetz T. & Vidal J. and Pearson T.D. (2005). Nanotechnology Awareness and societal concerns. Journal of Technology in Society 27(3): 329-345.

PUBLIC ENGAGMENT IN NANOTECHNOLOGY; LESSONS & EXPERIENCES FROM SRI LANKA

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ABSTRACT

Communication, in the present day, has made significant changes on the society. One of the major changes is that there is less face to face communication. ICT communication technologies have changed the life styles of people from e-banking, e-channeling/ ticketing, instant messaging, to E-Life; the buzzword in the century. Smart phones and tablets are instrumental in bringing e-life to society. According to the statistics from the Telecommunications Regulatory Commission of Sri Lanka, as of December 2012, the country experienced a total of 17.4 million mobile subscribers out of the 21 million population of the country1. Given this, public engagement/raising awareness has to be re-worked to suit the current trends of communications. Use of conventional approaches poses doubtful in developing a fruitful public engagement or a debate on a given subject.

The question is how we could link these approaches in getting the interest of the public for a subject like Nanotechnology, a topic which is said to be the next industrial revolution. Do people know about this? How can we raise awareness? Is this the next industrial revolution? What sort of effects this would have on the society? We might need to look at it in a different angle. How can a general debate raised on this within the society?

Keywords: *Nanotechnology, Public, Engagement, Social-Media, Communication*

INTRODUCTION

The project forming a Regulatory Framework on Nanotechnology in Sri Lanka, funded by IDRC (International Development Research Centre) has a component of engaging the public on Nanotechnology; mainly on raising of the awareness. Practical Action as one of the partner organizations has been involved in implementing this work package.

The first attempt of the project was to put up a website and populate it with information. But the challenge was to create a user-friendly, attractive website that had information on Nano and also giving an impression of creativity Nano character with a series of other different icons related to Nanotechnology advances that have been central to this web-portal.

Can a website itself promote awareness and public interest? What could be other sources of technology as people are more into easy access on the Internet? What is the status of the e- World?

The social media storm has grown into a hurricane turbulence. Some might say that it is not worth using the social media tools, while some may debate that it is one of the major tools used for the promotion of products, activities, services and so on. It is difficult to say that only one particular age group is involved in social media, which is not true at all. Social Networking is the most popular online activity worldwide. In October 2011, nearly 1.2 billion users around the world visited the social networking sites, accounting to 82% of the world's population[1].

RESULTS & DISCUSSION

Practical Action has used the Facebook and Twitter and these approaches have become very successful two social media tools to raise awareness on Nanotechnology and raise enquiries from among the society on Nanotechnology. This paper attempts to use the challenges and the experiences gained from this project in using ICT tools and social media to promote the visibility of Nanotechnology into the world from a Sri Lankan perspective.

REFERENCES

1. Marketer Pulse (July/August 2011). Global Snapshots, Local Implications.
2. It's a Social World: A Global Look at Social Networking, http://blog.comscore.com/2012/01/its a social world.html

NEED FOR NANO MARK IN SRI LANKA

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ABSTRACT

As technology develops at an ever faster speed, the results or the benefits of it come to the country. Nanotechnology is such a latest technology in the 21st century and already some products manufactured out of nano materials are available in the market. But, safety of nano product is a major concern in today's' world.

This paper presents a need for nano mark to Sri Lanka in order to identify nano products, to have an idea on risk associated with nano products, to have the marketing advantage and also to have recognition and credibility in the society on nano products.

Nano mark certification will be an important factor to promote consumers' acceptance of nano products while encouraging manufacturers/importers to develop/import prominent nano products to Sri Lanka.

***Keywords**: Nanotechnology, Labeling scheme, Nano mark*

INTRODUCTION

Today, the Sri Lankan world of consumers is experiencing a proliferation of "nanotechnology enhanced" products. There are numerous products in the market that are the result of nanotechnology, in the form of electronic, cosmetics, automotive and medical products. In the sports sectors, there are tennis balls that last longer, tennis rackets that are stronger, and golf balls that fly straighter. The textile field comprises pants that repel water, shirts that will not stain, shoe inserts that keep cool in the summer and warm in the winter and nano socks that do not have a horrible smell due to the presence of nano sliver particles. The world of electronics also has been using many of the applications, which are the results of nanotechnology for many years.

NEED FOR A NANO MARK

The nanotechnology products are gaining momentum in commercial use, after more than twenty years of research and experimental development (R&D). But it has been difficult to find out the number of "nano" consumer products available in the market and which products could be called as "nano". The safety of nano product is also a major concern in the today's' world. Therefore, the need for a "nano mark" is very vital and it is imperative that an independent organization such as Sri Lanka Standards Institution (SLSI) shall launch a labeling scheme for products manufactured out of nano materials. Nano mark certification will be an important factor to promote consumers' acceptance of nano products while encouraging manufacturers/importers to develop/import prominent nano products to Sri Lanka.

The nano label will act as evidence of the existence of follow-up agreements between manufacturers and nationally accredited testing laboratories and the certification body in Sri Lanka and the label will play an important role in the trade sector.

IMPLEMENTATION OF A NANO MARK

In the implementation of a nano mark in Sri Lanka, the following activities shall be carried out by the relevant organizations.

An independent organization such as SLSI shall identify the products with a nano claim available in the Sri Lankan market.

i) Identify the nano products available in the Sri Lankan market
ii) Analyze the product specifications and declarations given by the manufacturer/ importer
iii) Establishment/coordination with a testing laboratory (SLINTEC) to confirm characteristics of nano materials in the product
iv) Investigate further on the actual presence of nano materials
v) Examine further on various characteristics such as chemical entity, shape of the nano material and concentration, also the product form and whether the particles are free or fixed
vi) Reference to applicable standards
vii) A criteria for the nano labeling scheme shall be developed by the independent organization (SLSI) and obtain approval from relevant authorities for it
viii) Using a LCA approach will ensure applicability of the nano labeling criteria related to various life cycle stages of the nano product including raw material acquisition, manufacturing, distribution, product use and disposal
ix) Obtain approval for the sketch of nano label
x) Constitute a committee, which is responsible for implementation (granting, withdrawing, cancelation) of nano labels
xi) Follow up verifications by a periodical monitoring system by the certification body (SLSI)

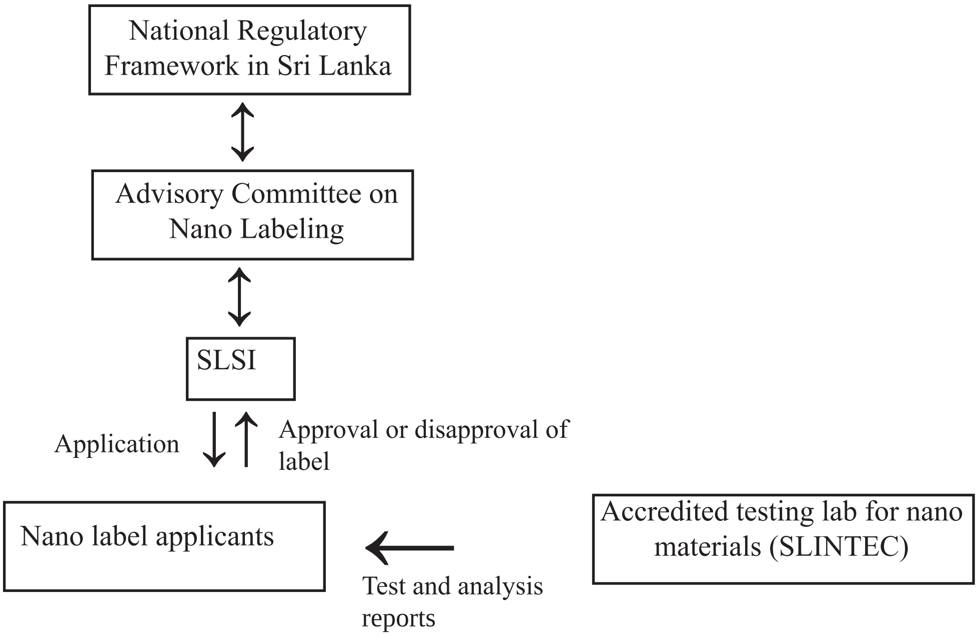

Figure 1: Schematic diagram of the operation of nano labeling scheme

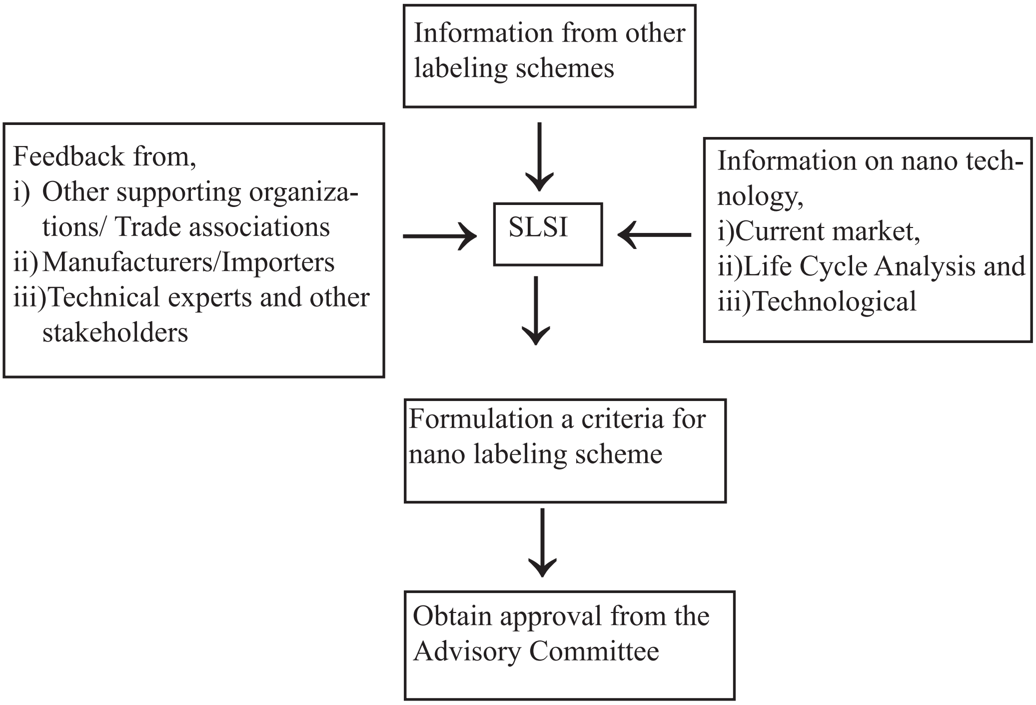

Figure 2: Procedure for Criteria Development and Launching of the nano labeling scheme

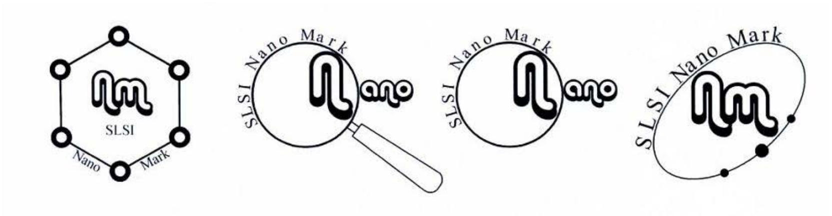

Figure 3: Typical sketches which can propose as a nano Label

CONCLUSION

A proper labeling scheme on nanotechnology for Sri Lanka is needed to:
- identify the nano products,
- lower the risk associated with nano materials,
- have recognition and credibility in the society,
- differentiate with other products
- have the marketing advantage

In the regulatory framework for nanotechnology in Sri Lanka, the necessity of the nano label and its implementation shall be included.

REFERENCES

1. Joop de Boer (2003). Sustainability labeling schemes: The logic of their claims and their functions for stakeholders. Institute for Environmental Studies, Vrije University of Amssterdam, The Netherlands.
2. Michael Gleiche, Holger Hoffschulz, Steve Lenhert (2006). Nanotechnology in consumer products, Environmental Law Institute, Washington, DC.

Session A

PLANNING A REGULATORY FRAMEWORK FOR NANOTECHNOLOGY RELATED ACTIVITIES IN SRI LANKA

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ABSTRACT

In this study National Nanotechnology Initiatives (NNIs) undertaken by more than sixty countries and salient mechanisms by various national agencies were explored through a web based methodology and analised with a view to understand regulatory frameworks implemented for nanotechnology governance. From the sixty NNIs, the top ten Initiatives were selected based on their activities and nanotechnology competitiveness to carry out an in-depth analysis with a view to develop a draft regulatory framework for nanotechnology related activities in Sri Lanka.

It was found that risk assessment is a key to developing nanotechnology governance. NNIs have focused on responsible nanotechnology with a view to environmental, health, and safety concerns in particular. In the context of nanotechnology governance, many NNIs' effort were to facilitate formulation of laws, regulations and standards to meet arising risks and challenges. However, its application to nanomaterials is impaired by significant uncertainty and variability in available data. Maintenance cost, high price, limitations in performance of equipment, diverse range in shape and size of nano particles/fibers were identified as limitations for risk assessment by many countries.

Initiatives have been taken by most of countries from the top ten to harmonise their governance with international standards (ISO/TC 229) through networking domestically and internationally. Proposed application frameworks clearly acknowledge the need to integrate expert judgment and public engagement to support the risk assessment and decision-making process. The strategy stresses the importance of sharing current knowledge and the development of nanotechnologies with the relevant internal and external stakeholders.

***Keywords**: Regulatory framework, risk assessment, governance, policy makers, health effects, environment*

INTRODUCTION

Nanotechnology is relatively new to Sri Lanka. It is noted that at present, the risks, benefits and exposure data of nanomaterials are still fairly unknown in the world. Even countries which are in frontier of this technology need to confront the risks seriously. Therefore, it is a significant necessity to understand the risks that govern this technology. A developing country like Sri Lanka cannot afford to embark on expensive research for classifying the risks of Nanotechnology. Knowledge of the up-to-date findings of the world on nano risk governance could be used to design a draft framework appropriate to the country.

Nanotechnology being a disruptive technology will touch every facet of industry. Intrinsically built into it is the ability to provide broad based benefits in the supply chain for the local growth and technological advancements in the value chain. Be it nano-agro products, developing on Sri Lanka's abundance of water beyond 2025 which is predicted to be the only country in the region containing water for economic exploitation, enhancing fertiliser absorption and thus yield or nano-materials which are in high demand in the global marketplace, nanotechnology is to facilitate the inclusive growth within Sri Lanka. Aghion et al.'s inverted-U hypothesis stipulates that industries closer to the technological frontier evolve and innovate to differentiate, while industries which are further back in the spectrum discourage innovating. Historically the hypothesis is especially true of Sri Lanka, though at this juncture we could be as effective as Brazil and China in trying to catch up to the Korea, one of the predominant trend setters in science and innovation. The commitment and "distance-shorting" (between high and low technology industries) for such endeavour should be ingrained in public policy, which the Sri Lankan government has committed to in the form of NANCO. Dictating policy in developing countries on emerging technologies is extremely important due to negligence seen in the past. Unfortunately policy makers are ill equipped in most cases due to the lack of a unified knowledge pool. These factors translate to loosely self regulated entities in which environmental, public and worker safety are not taken in to consideration resulting in long term implications. Due to the largely unknown health and environmental impact pertaining to nanotechnology, these unregulated activities could result in negative footprint on orders of magnitude higher than previous disruptive technologies. Thus in the context of nanotechnology, policy and regulatory frameworks are of paramount importance.

MATERIALS AND METHODS

In the first phase, literature information on more than sixty National Nanotechnology Initiatives (NNIs) and salient mechanisms in the world was explored through a web based methodology and were compiled the same. From the sixty NNIs, the top ten Initiatives were selected based on their activities and nanotechnology competitiveness to carry out in-depth analysis covering policy actors, industry & market trends, international coordination and cooperation, spending/ investment, nanotechnology companies, nanotechnology Patents, nanotechnology publications, nanotechnology risk governance, framework etc. with a view to develop a draft regulatory framework for nanotechnology related activities in Sri Lanka.

United States of America, Germany, Japan, South Korea, China, United Kingdom, Taiwan, France, Canada and Australia were selected as the top ten initiatives. The following recommendations are based on the analysis of these top ten countries.

RESULTS AND DISCUSSION

Top ten countries have allocated some percentage of their R&D budget to address implications, related to environment, health, and safety. Their emphasis was to establish appropriate infrastructure with well trained and skilled workforce to address the societal implications of nanotechnology. Multidisciplinary projects including the environmental issues were commonly observed in many NNIs. Initiatives have also been taken for occupational health surveillance, exposure registries, and epidemiological research.

Regulatory regimes have been formulated with an emphasis on evaluating additional product chemistry, toxicology, exposure, and environmental data. Toxic Substances Control Act (TSCA) of USA and Comprehensive Environmental Assessment (CEA) framework, which combines a product life-cycle perspective with the risk assessment paradigm are examples for such regimes.

US has identified importance of a national regulatory developments on human health and environmental safety with an emphasis on occupational exposure to carbon nanotubes and nanofibres. Accordingly, regulations have been enacted for manufacture of these nano scale materials under limited conditions. As described in the rule, relevant stakeholders are expected to provide information on use, production volume, certain physical properties and chemical/structural characteristics, methods of manufacture and processing, exposure and release information, and available health and safety data.

According to recent findings, it is essential to conduct a measurement of the working environment as well as investigate the raw materials to be compared with international standards. Working environment analysis could be done instead of personal exposure measurements due to the cost factor involved. Instructions about nano materials, (physical and chemical properties), potential adverse health effects, and control measures for the working environment should be given to workers who are involved with the direct processes. Workers should use personal protective equipment and follow manuals such as operational procedures, cleaning methods, operational records, waste disposal and emergency situations. It should also take measures to ensure sufficient nano particle exposure control techniques are in place as per standards.

CONCLUSION

In conclusion, planning of a regulatory framework should be done with the involvement of relevant stakeholders especially the general public. It is important to establish a web based inventory of activities and information sources with the Practical Action in Sri Lanka which should be updated and maintained. There should be lead agencies established for various areas of specific responsibility, to name lead contacts and to identify the role of the main lead government agency. Sri Lanka Standards Institution, Consumer Affairs Authority, National Institute of Occupational Safety & Health, Central Environmental Authority, Ministry of Economic Development, Ministry of Education, and National Science & Technology Commission will be prospective organizations. Terminology, metrology and related technical issues should be done with the international collaboration. Regulatory approach, including science, risk assessment and stakeholder involvement should be identified immediately, since most of the parameters are unidentified. Labeling of nano materials in consumer products and consumer protection, liability and intellectual property regimes, science and research support should be more improved. Commercialization of R&D, social and economic benefits should be well known. Training is very important for the workers involved in nano production. Since this is a new technology, security concerns or uses and threats should be determined to avoid any social outfits.

Sri Lanka would focus on self-regulation, government registration, enforced self-regulation and command regulation. Initially, it can focus on self regulation where the framework defines a systematic process for identifying, managing, and reducing the potential environmental, health, and safety risks of engineered nanomaterials across all stages of a product's 'lifecycle which can be used freely by companies and other organizations. Failures of self-regulation could damage public acceptance of nanotechnology. Thus, effective self-regulation with the threat of external pressure from enforced self-regulation has been found to be more effective.

Substitution options, technical measures, organizational measures and personal protection measures can be taken at ground level implementation of regulatory framework. It can also implement basic risk management practices such as worker training, use of available engineering controls, product labeling, customer training, and waste management practices. Economic tools such as tax breaks and tax penalties to promote adherence of companies to their industry code of conduct while penalizing those that fall behind and acceleration of the review and approval process for environmentally beneficial new products can be considered for implementation. Mechanisms such as nano mark certification system, setting up institutions and institutional processes and mechanisms to monitor and administer arising policy issues, establish criteria for determining emergency situations and sharing the latest knowledge on identifying, assessing and managing or governing nanotechnology- specific risks to occupational health and the environment can be focused subsequently. Networking domestically and internationally is essential to acquire frontier knowledge in governance.

REFERENCES

1. Brian G. Priestly (2007). Toxicological and health effects relating to six nanomaterials. Australian Centre for Human Health Risk Assessment (ACHHRA), School of Medicine, Nursing and Health Sciences, Monash University, Australia.
2. Prime Minister's Science, Engineering and Innovation Council (PMSEIC) (2007). Enabling technologies for Australian innovative industries. Prime Minister's Office, Australia.
3. Australian Office of Nanotechnology (2009). National Nanotechnology Strategy Annual Report 2008–09, Australia.
4. Ludlow K., Bowman D. & Hodge G. (2007), A Review of Possible Impacts of Nanotechnology on Australia's Regulatory Framework
5. Flinders Consulting Pty Ltd (2006). Potential occupational health & safety implications of nanotechnology. Flinders University Company Bedford Park, South Australia.
6. Holtz S. (2007), Policy Framework for Nanotechnology, Canadian Institute for Environmental Law and Policy, Canada
7. Federal Institute for Occupational Safety and Health (BAuA) (2006). Nanotechnology: Health and Environmental Risks of Nanoparticles – Research strategy. Federal Institute for Risk Assessment (BfR), Federal Environment Agency (UBA), Germany.
8. Expert committee (2009). Environmental impact of manufactured nanomaterials. Ministry of the Environment, Japan
9. Working Party on Manufactured Nanomaterials (2011). Current developments/ activities on the safety of manufactured nanomaterials. Paris, France
10. Mantovani E., Porcari A. (2011). Developments in nanotechnologies regulations and standards. Italian Association for Industrial Research (AIRI/Nanotec IT), Italy.
11. Linkov I., Satterstrom F. K., Monica J. C., Hansen S. F. & Davis T. A. Nano Risk Governance: Current Developments and Future Perspectives.

LIFE CYCLE ASSESSMENT FOR NANO PRODUCTS BY SLSI

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ABSTRACT

Nanotechnology is rapidly growing science and already this has touched many industries. As a result many products manufactured by using nano materials appear in the market and their market potential is high due to their special features such as durability, anti oxidency, high strength etc. At the same time, the challenge of understanding potential risks and impacts of nano products and nano materials to human health and the environment is critical.

Life Cycle Assessment (LCA), in particular provides new perspective on nano products and processes. It examines the systems and evaluates the product performance starting from the extraction of raw materials through all the varied operations until their final disposal as waste. Likewise, LCA determines the impact of nano products through its entire life cycle from the cradle to grave.

This paper presents the methodology adopted relative performance of the nano products in relation to international bench marks regarding raw material and risk factors.

Keywords: *Nanotechnology, LCA, nano products*

INTRODUCTION

The opportunities offered by technology that grows exponentially at a speed faster than most of us keep up with. Nanotechnology, which is a rapidly growing science for producing and utilizing the nano size particles that measure in nanometers and its market potentials are high. This technology already touched many industries from medicine textile to electronics. It is predicted that the value of nanotechnology-enabled products entering into the market will rise from €22.6 billion in 2005 to €2 trillion in 2014. At the same time, the challenge of understanding potential risks and the impacts of nano products and nano materials on human health and the environment are critical.

Life cycle assessment (LCA), the cradle-to-grave assessment of the health and environmental impacts of a product or substance, is vital for the successful and safe commercialization of nanotechnologies. LCAs identify the impacts of a product.

Another advantage of LCA is that it allows for comparisons with the equivalent conventional products.

Nano products, processes and applications are expected to contribute significantly to the environmental and climate protection by saving raw materials, energy and water as well as by reducing greenhouse gases and hazardous wastes. Therefore, LCA is an appropriate tool to analyze and evaluate the sustainable benefits, ecological advantages or environmental impacts of a nano product, a process or an application over its entire lifespan.

The LCA can analyse whether the benefits from the use of nano materials are really much larger than the resource use conventionally and the environment impacts associated with producing nano materials. It already leads to the important conclusion that nano products must be managed after use to ensure that none of the nano matrials can escape in to the environment. Further, the Assessment of nanotechnology and nano products with LCA gives an opportunity for preventive action for different stakeholders, in order to prevent or minimize potential adverse effects to human health as well as the environment over the entire lifespan of nano products.

METHODOLOGY

Life cycle analysis of nano products/ nano materials consists of four stages;

1. Defining the goal and scope of study
2. Making a product life cycle with all environmental inflows and out flows. This data collection is referred to as “Life Cycle Inventory”.
3. Understanding the environmental relevance of all the inflows and out flows
4. The interpretation of the study.

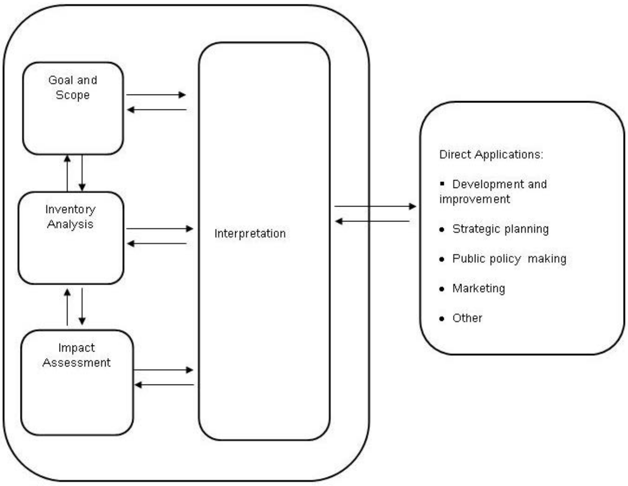

Figure 1- Stages of life cycle assessment

Stage 1: Goal and scope

1. Formation of a LCA Core Group
2. Identify nano products/materials available in the country
3. Modeling of the nano product/ material manufacturing processes
4. Application of the LCI methodology rules

Stage 2: Inventory Analysis

1. Procurement of reliable software
2. Installation and the software
3. Data collection on energy inputs, material inputs, ancillary inputs and other physical inputs
4. Feeding to the software

Stage 3: Impact assessment

1. Results of the LCA in graphical representation/tabular formats

Stage 4: Interpretation

1. Validation of Results
2. Report Preparation
3. Assumptions made

DISCUSSION

WHY SLSI SHOULD ENGAGED IN LCA OF NANO PRODUCTS:

As the technology develops at an ever faster speed, the result of it comes to our country also. Already some nano products are available in the Sri Lankan market. Some of the products are refrigerators, CFL bulbs, washing machines and ankle guards. These have been gained the marketing advantage among people due to the new technical word "nano". But the health hazards and other environmental impacts of these products have not been analyzed yet. Hence, the followings are the benefits of conducting LCAs for nano products to the country:

- It can produce environment related data for formulating regulations with respect to occupational health and safety, consumer protection and environmental protection.
- LCA results can take into account as environmental information when procuring goods (Green purchasing)
- Through the Import Inspection scheme, highly environmentally impact products can be controlled.
- When formulating national product standards, their impacts to the environment can be considered and accordingly, the relevant special requirements can be included.

- By analyzing the results, the product stages can be early identified and through this support, a safe, responsible and sustainable development in nano products/ materials can be achieved
- SLSI can provide the services on LCA to private/ public organizations.
- Working towards coordinating among other government / non government organizations on environmental impacts of products
- Promotion of processing environments to adhere to best practices such as ISO14001, OHSAS 18001 and GLP (Good Laboratory Practice) etc.

BARRIERS IN IMPLEMENTING LCA FOR SLSI

There are barriers for conducting the LCAs in nanotechnology that are as same as in other fields;

- Limited data is available today on material and energy input, and on environmental releases in manufacturing and transportation, or end of life cycle activities of nano components and nano products.
- Lack of awareness on application of the LCA concept
- Proprietary data and information on manufacturing processes
- The absence of toxicological test results of nano products and materials
- Wide variation in manufacturing process(process-to process variation)
- Financial constraints
- Lack of experts and less demand for LCA

CONCLUSION

Even though there are barriers and constraints, Sri Lanka has to go with the rapid growth of science in the world. According to the results of the nano project implementing from last few months, following recommendations can be made;

- Develop a data inventory for LCA of nano products
- Issue a special label for nano products/materials based on LCA results

REFERENCES

1.International organization for standardization(2006). Environmental Management-Life Cycle Assessment- Priciples and framework: ISO 14040

2.Geoferey Hunt and Michael Mehtha, Earthscan, (2007). Nanotechnology risk, ethics and law. London

3.Nanotechnology and Life Cycle Assessment(2006), Synthesis of results obtained at a workshop, Woodrow Wilson International center for scholars Washinton, DC

Session B

Solar Energy

EFFECT OF ALUMINA COATING IN HYBRID NANOCRYSTALLINE TITANIUM DIOXIDE / POLYMER SOLAR CELL

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ABSTRACT

Hybrid polymer solar cell comprising conjugated polymer with porous metal oxides is the theme of several recent researches because of the desirable properties possessed by the metal oxide such as the stability, good electron transport properties, ease of fabrication, low cost and the environmental friendly nature as well as the possibilities for controlling surface morphology. Although the hybrid metal oxide / polymer solar cells provide several merits, its photovoltaic power conversion efficiency is still poor compared to all organic solar cells. This work focuses on improving the performance of hybrid metal oxide / polymer solar cell by modifying the metal oxide-polymer interface by introducing thin alumina (Al_2O_3) layer. The optical absorbance measurement of the alumina coated TiO_2 electrode shows a higher polymer uptake than its control structure. This may be due to the presence of more basic surface on the alumina coated porous TiO_2 film than that of the bare film. In general, alumina coating on nanocrystalline TiO_2 increases the current density and the open circuit voltage of TiO_2 / polymer devices and therefore improves the overall efficiency by a factor of two. This may be due to suppression of interfacial recombination. The champion device with alumina coating shows the power conversion efficiency over 1 % at AM 1.5 illuminations of intensity 70 mW/cm^2.

***Keywords**: solar cell, titanium dioxide, polymer, alumina*

INTRODUCTION

Composites of conjugated polymers with nanostructured metal oxides are promising material combinations for low-cost solar energy conversion. However, the performance of devices based on such structures is still limited by several factors, including inefficient exciton dissociation, interfacial charge recombination and low absorbance of polymers. One strategy to address these issues is to control the interfacial charge transfer rates by modifying the physical properties of the interface.

The metal/organic interface plays an essential role in determining the overall device performance of the photovoltaic cell. It has been reported that the conformal growth of insulating over layers on the surfaces of such nanoporous films may be an important approach to achieve a high efficiency in the dye sensitized solar cells[1-4]. In the present work, we investigated the effect of alumina metal oxide insulating over layer on nanocrystalline TiO_2 films of hybrid metal oxide solar cell. Concerning the interfacial energetic in a hybrid polymer / TiO_2 structure, we expected the treatment with alumina coating suppresses the interfacial recombination.

MATERIALS AND METHODS

The TiO_2 electrodes, consisting of an ITO coated glass substrate with a 50 nm thick dense TiO2 layer and a ~100 nm thick mesoporous TiO_2 layer were prepared as described in Ref.[5,6,7]. Hybrid polymer / TiO2 structures were prepared by first dip-coating the TiO_2 electrodes in 1Mm alumina solution followed by N719 dye (Solaronix) and P3HT polymer (Merck Chemicals Ltd.) solution and then spin coating a polymer layer of effective thickness 50 nm. The optical absorbance of the films was taken using UV-VIS spectrometer (JASCO). Top contact electrode was made by the thermal evaporation of Au using the thermal evaporator (Edwards E306) after deposition of a poly (ethylenedioxythiophene) : polystyrene sulphonate (PEDOT: PSS) layer, as in Ref.[7, 8]. The electrical characterization of the solar cells was carried out using a source measure unit (Keithley 2400) in dark and under 70 mW/cm^2 illumination by using solar simulator (SCIENCETECH) with AM 1.5 filter.

RESULTS AND DISCUSSION

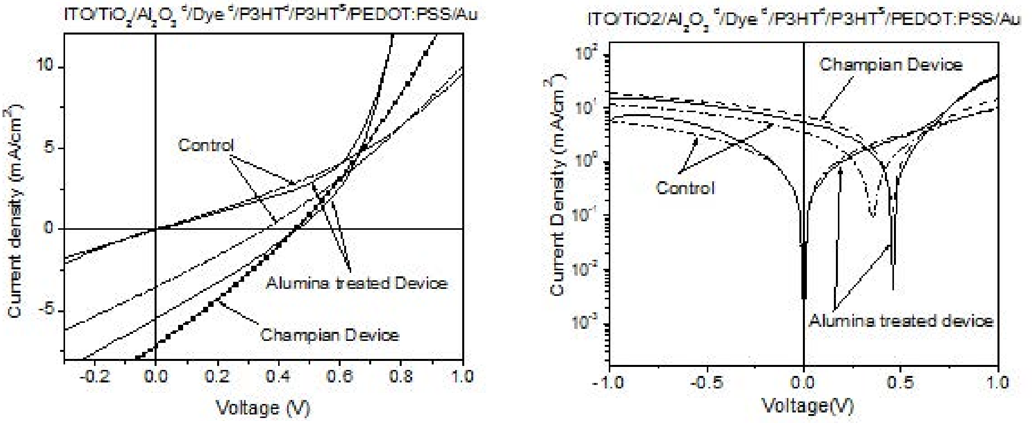

Figure: (a) J–V characteristics, under AM 1.5 solar spectrum irradiation (70 mWcm^{-2}, 1 sun) of multilayer device (ITO/PorousTiO2/Al2O3d /Dye d/P3HT d/P3HT s/PEDOT:PSS/Au) with 1mM or without alumina coating and that in dark(dashed line)
(b) Its corresponding logarithmic curves. Superscripts d and s indicate dip and spin-coated layers, respectively.

We observed that the absorbance of polymer on nanoporous is high compared to the bare film due to the presence of more basic surface on the alumina coated porous TiO_2 film. The figures show the current-voltage characteristic for the Alumina coated device, and its control. In general, the insulating alumina layer increases the open circuit voltage of 0.45 V, and short circuit current density of 7.12 mAcm-2. Due to better attachment of polymer on alumina coated surface and suppression of interfacial recombination, the amount of the charge carriers produced in the active layer reaching the top electrode are increased. Thus the alumina coating improves the overall power conversion efficiency over100%.

ACKNOWLEDGEMENT

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REFERENCES

1.Tennakone K., Bandara J., Bandaranayake P.K.M., Kumara G. R. R. A. & Konno A. (2001). Enhanced efficiency of a dye-sensitized solar cell made from MgO-coated nanocrystalline SnO_2. Japanese Journal of Applied Physics 40: L732-L734.

2.Kumara G. R. R. A., Tennakone K., Perera V. P. S., Konno A., Kaneko S.& Okuya M. (2001). Suppression of recombinations in a dye-sensitized photoelectrochemical cell made from a film of tin IV oxide crystallites coated with a thin layer of aluminum oxide. Journal of Applied Physics D: Applied Physics 34 (6): 868-873.

3.Zaban A., Chen S. G., Chappel S. & Gregg A. (2000). Bilayer nanoporous electrodes for dye sensitized solar cells. Journal of the Chemical Society, Chemical Communications 22: 2231-2232.

4.Palomares E., Clifford J. N., Haque S. A., Lutz T. & Durrant J. R. (2002). Slow charge recombination in Dye-Sensitised Solar Cells (DSSC) using Al_2O_3 coated nanoporous TiO_2 films. Journal of the Chemical Society, Chemical Communications 14: 1464-1465.

5.Ravirajan P., Haque S. A., Durrant J.R., Poplavskyy D., Bradley D.D.C. & Nelson J. (2004). Hybrid nanocrystalline TiO2 solar cells with a fluorene–thiophene copolymer as a sensitizer and hole conductor. Journal of Applied Physics 95 (3): 1473-1481.

6.Palomares E., Clifford J. N., Haque S. A., Lutz T. & Durrant J. R. (2003). Control of charge recombination dynamics in dye sensitized solar cells by the use of conformally deposited metal oxide blocking layer. Journal of American Chemical Society 125 (2): 475-482.

7.Ravirajan P., Haque S. A., Durrant J.R., Poplavskyy D., Bradley D.D.C. & Nelson J. (2005). The effect of polymer optoelectronic properties on the performance of multilayer hybrid polymer / TiO2 solar cells. Advanced Functional Materials 15 (4): 609-618.

8. Ravirajan P., Haque S. A., Durrant J.R., Smith S. J. P., Kroon J. M., Bradley D.D.C. & Nelson J. (2005). Efficient charge collection in hybrid polymer/TiO_2 solar cells using poly (ethylenedioxythiophene) /polystyrene sulphonate as hole collector. Applied Physics Letters 86 (14): 143101.

9. Clifford J. N. (2003). Control of electron transfer dynamics in dye sensitized solar cells. Ph.D. Thesis, University of London, London.

10. Ravirajan P. (2004). Characterisation and optimization of hybrid polymer /metal oxide photovoltaic devices. Ph.D. Thesis, University of London, London.

NANOTECHNOLOGY FOR IMPROVING THE ORGANIC SOLAR CELL ACTIVE LAYER FOR BETTER EFFICIENCIES

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ABSTRACT

Organic solar cells (OSCs) have received a great deal of attention as a cheap and clean renewable energy source, which has the potential to tap the freely and abundantly available solar energy. As a result OSCs have made remarkable progress in manufacturing techniques, durability and more importantly, in device efficiencies. Many of these improvements are concentrated on the active layer of the device. The nanotechnology and nanostructures have played an important role in these advances. Various approaches taken for efficiency improvements in terms of characteristics, morphology and performance, which are concentrated on the active layer are discussed here considering the donor acceptor polymer based OSCs. The directives for further improvements are also given.

Keywords: *Bulk heterojunction organic solar cells, Carbon nanotube, Nano morphology*

INTRODUCTION

Organic solar cells (OSCs) have recently attracted a great deal of attention as an inexpensive alternative to crystalline solar cells based on Silicon, for harvesting freely and abundantly available solar energy. The use of cheap, easily available raw materials and environmental friendly, low energy consuming, and readily up scalable processing techniques have made them even more appealing. In addition, the unique feature of being flexible and the light weight opens up a whole new area of applications for OSCs, which were not reachable with conventional solar cells. However, despite all these advantages, OSCs are still not competitive with Silicon crystalline solar cells and occupy only a very small fraction of the market. This is due to their extremely low efficiency and limited lifetime, and in order to make them economically viable these two shortcomings have to be overcome first. This issue had been the focus of quite a number of research studies and this paper would look at different approaches and progress made so far with improvements in the donor acceptor conjugate polymer based OSC active layer.

Donor Acceptor Polymer Blend

The poor performance of the OSCs lies partly with the polymers themselves, as they are not efficient semiconductors. These have band gaps that are ill matched with the solar spectrum, very poor charge mobilities and very short exciton diffusion lengths (Nakamura et al., 2005). Thus only a small fraction of incident solar spectrum is absorbed by the active layer and the actual amount of charges reaching the two end electrodes is even lesser. Thus, in terms of new active layer material, the current focus is on low band gap polymers to better match solar spectrum and strong charge acceptors with good charge mobility for efficient exciton dissociation. Among many high performance polymer blends reported the P3HT: PCBM blend is especially noteworthy. P3HT (Poly-3-Hexylthiphene) with a low band gap of 1.8 eV, in the regioregular form can assume a crystalline structure for improved charge mobility (Cook et al. 2009). PCBM (Phenyl C61 Butyric Acid Methyl Ester) is a very good electron acceptor having better electron mobility than most polymer semiconductors and therefore, very efficient in terms of exciton dissociation and charge separation (Cook et al., 2009). The best reported OSC efficiencies so far are for this particular active layer blend.

Nano Morphology

Another one of major research focuses is the morphology of the OSC active layer and manipulating it to account for the shortcomings of the organic semiconductors. Formation of bulk heterojunction (BHJ) instead of a planar heterojunction allows for overcoming the thickness limitation exerted due to poor charge mobility and very short exciton diffusion length to a certain extend (Barrau et al., 2009). Considering the research efforts focused on improving the performance of BHJs, three major pathways can be identified. They are (i) controlling the phase separation of polymers and keeping the phase sizes in par with exciton diffusion lengths, (ii) improving the local crystallinity within polymer phases, and (iii) providing continuous percolation pathways across the active layer. The phase separation and active layer thickness have been successfully controlled by varying the polymer solution concentration, the particular solvent used, and the spin time and spin speed employed in the case of spin coating the active layer. Important points to note are a) the use of a solvent with higher evaporation temperature, which allows the active layer to dry at a slower rate (Kim et al., 2010), b) post fabrication thermal annealing improve the phase formation and the local crystallinity within the individual phases, c) efficiency can be improved significantly due to enhanced charge mobility, and d) efficient exciton dissociation (Sakai et al., 2009; Ebadian et al., 2010). Moving along the same lines, the use of liquid crystals in small quantities in the active layer blend (Jeong et al., 2010) and the use of an external electric field during fabrication and annealing of the active layer (Bagui & Iyer, 2011) had been attempted with the aim of better alignment of the individual molecules within individual phases, yet successfulness or the extent of it for each approach is not very clear at this point.

Charge Mobility

By far, the most extensively investigated approach is to provide percolation pathways across by incorporating nanotubes/nanowires in the active layer. Carbon nanotubes (CNTs) have been the choice of conductor in most of the investigations due to their remarkable electrical properties. Both single walled (SWNT) (Nam et al., 2011; Kymakis & Amaratunga 2003) and multi walled (MWNT) (Miller et al., 2006) CNTs have been used either in the functionalized form (Lee et al., 2011; Kymakis & Amaratunga 2003) or as they are (Mallajosyula et al., 2011), to improve the mobility of either holes (Nam et al., 2011) or electrons (Kymakis & Amaratunga, 2003) or both (Lee et al., 2011). Most of these studies have reported the success and efficiency improvements due to CNT incorporation to a varying degree. Despite of many differences in type and functionalization, several factors are common to above investigations. (i) CNTs were randomly dispersed in the active layer, (ii) Best performance at a very small amount (less than 1%) of CNT, and (iii) Unsorted CNT samples containing both metallic and semiconducting tubes were used. It is now known that while semiconducting CNTs are beneficial as mobility enhancers, metallic CNTs act as the charge recombination sites and are actually detrimental to the OSC function. Thus in the above studies, the beneficial effects were quickly overcome by the detrimental ones, limiting the CNT incorporation to very low concentrations. Therefore, it appears that the sorted samples with only semiconducting SWNTs (s-SWNT) are best suited for charge mobility improvements and in the case of MWNTs, they have to be either functionalized or doped to assume semiconducting behavior. Another limiting factor here is the nature of CNT incorporation; with the random dispersion, when present in larger amounts CNTs tend to form bundles together and shunt the two electrodes with debilitating effects on the solar cell operation. In addition though randomly dispersed CNTs improve the charge mobility of the active layer they do not transport charges specifically towards the end electrodes. A CNT network that interpenetrates the active layer and connected to the end electrode would collect the charges from the active layer and bring them to the respective electrode. The efforts made in this direction were not successful due to limitations imposed by the experimental setup itself, such as the use of MWNTs that have metallic characteristics, disturbance to the electrode transparency due to the density and nature of CNT incorporation rather than due to the flaw in the fundamental concept (Borchert et al., 2011; Radbeh et al., 2010).

Solar Concentrators

The current best performed OSCs cannot absorb incident sunlight completely due to limited thickness. To make best out of the available active layer thickness, attempts have been made to integrate solar concentrators with OSCs in the form of transparent optical spacers placed in between the active layer and the reflective electrode, with metallic nanoparticles embedded in the active layer, and metal gratings placed adjacent to the active layer and so on (Spyropoulos et al., 2012; Kang et al., 2011).

While successfully increasing the absorbance of the active layer, these concentrators have introduced some other limitations in to the device such as the increased series resistance, and additional charge recombination sites. The actual improvements of the overall performance of these approaches are not very clear at this point.

FUTURE WORK AND DISCUSSION

A great deal of improvements has taken place in terms of overall OSC performance and in specific areas such as polymer blend, nano morphology, and charge mobility of the active layer. However the OSCs are still far from optimal in their performance and there is a lot of room for further improvements. Considering the literature on OSCs, it can be seen that nanostructures have played an important role in the current improvements, which is not surprising as the OSCs have many of their parameters in par with the nano scale. Considering the actual nature that these nanostructures have been accommodated, these have been used in a random manner with little control to alter the properties of the bulk material, rather than utilizing the capabilities of nanostructures at individual level. However, it is logical to presume that further performance enhancements can be achieved by incorporating the nanostructures arranged in a desired alignment with good control. Figure 1 represents the schematic diagram of such an OSC where nano morphology of the active layer is precisely controlled to form an orderly bulk heterojunction and vertically aligned s-SWNT array is formed on an end electrode for efficient charge extraction from the active layer, which requires precise control over CNT type, length and spacing between the nanotubes when fabrication the array. Such an idealistic device is yet to be fabricated and evaluated for its performance.

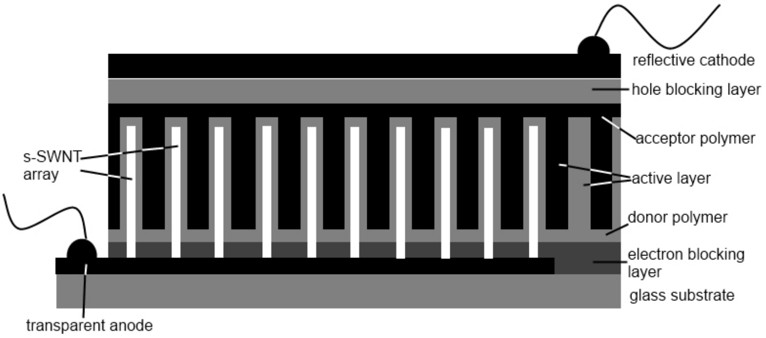

Figure 1: Schematic diagram of an ordered BHJ OSC with vertically aligned s-SWNT array grown on the transparent electrode efficient charge collection from the active layer.

REFERENCES

1.Bagui A. & Iyer S.S.K. (2011). Effect of Solvent Annealing in the Presence of Electric Field on P3HT:PCBM Films Used in Organic Solar Cells. Electron Devices, IEEE Transactions on 58(11): 4061-4066.

2.Barrau S. et al.(2009). Nanomorphology of Bulk Heterojunction Organic Solar Cells in 2D and 3D Correlated to Photovoltaic Performance. Macromolecules 42(13): 4646-4650.

3.Borchert H. et al. (2011). Vertically Oriented Carbon Nanostructures and Their Application Potential for Polymer-Based Solar Cells. The Journal of Physical Chemistry C 116(1): 412-419.

4.Cook S., Katoh R. & Furube A. (2009). Ultrafast Studies of Charge Generation in PCBM:P3HT Blend Films following Excitation of the Fullerene PCBM. The Journal of Physical Chemistry C 113(6): 2547-2552.

5.Ebadian S. et al. (2010). Effects of annealing and degradation on regioregular polythiophene-based bulk heterojunction organic photovoltaic devices. Solar Energy Materials and Solar Cells 94(12): 2258-2264.

6.Jeong S. et al. (2010). Improved efficiency of bulk heterojunction poly (3-hexylthiophene):[6,6]-phenyl-C[sub 61]-butyric acid methyl ester photovoltaic devices using discotic liquid crystal additives. Applied Physics Letters 96(18): 183305-3.

HYBRID TiO_2/ POLYMER SOLAR CELLS MADE WITH FUNCTIONALIZED SINGLE WALL CARBON NANOTUBE (SWNT)

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ABSTRACT

Hybrid polymer/metal oxide nanocomposite is a promising material combination for cost efficient molecular solar cells. However, the efficiency of the polymer/metal oxide solar cell is limited due to poor polymer infiltration and low interfacial area. This study focuses on enhancing the performance of hybrid TiO_2/polymer solar cell by incorporating functionalized Single Wall carbon Nanotube (SWNT) in between active layers. Functionalized SWNT improves the overall power conversion efficiency of hybrid polymer/metal oxide solar cells by a factor of two. This may be attributed to the enhanced interfacial sites, charge transport and/or charge separation efficiencies that influenced in the charge transporting pathways and reduced recombination losses in the presence of functionalized SWNT.

Keywords: *solar cell, single wall carbon nanotube, TiO_2, polymer*

INTRODUCTION

Among the hybrid metal oxide/polymer solar cells, the one having porous TiO_2 templates infiltrated by the polymer has been the most studied system as it could allow efficient exciton dissociation and reasonable charge transportation. Improving the charge transport with reduced recombination is a viable route to enhance the performance of these solar cells. With this perception, some of the nanomaterials possessing favorable electrical and mechanical properties have been attempted to incorporate with these solar cells. Carbon nanotubes is one of those materials, which has also been used in some recent photovoltaic researches with different structured solar cells mainly for its unique electrical properties, high aspect ratio and low density.[2,3] In these studies carbon nanotubes played a wide range of roles, for instance, serving as a transparent flexible electrode,[3,4]modified electrode,[5] buffer layer6 and active component blended with polymer.6 It has also been shown that the TiO_2 nanoparticles dispersed on n- type Single Wall carbon Nanotube (SWNT) films improved the photoinduced charge separation and transport of carriers to the collecting electrode.[5] With this background, the present work focuses on the inclusion of functionalized SWNT in nanoporous hybrid TiO_2/polymer solar cells in which the porous TiO_2 deposited substrates are dipped in functionalized SWNT solution. This functionalized SWNT dipping step precedes the dipping in polymer.

Here the electron transporting function carried out by TiO_2 is expected to be facilitated by functionalized SWNT.

MATERIALS AND METHODS

TiO_2 electrodes, consisting of an ITO coated glass substrate with a 50 nm thick dense TiO_2 layer and a ~100 nm thick porous TiO_2 layer were prepared as described[7]. Samples were dipped in the solution of functionalized SWNT, filtered through 0.22 micron sized filter. These substrates were then baked in order to remove any solvent prior to dip in poly (3-hexlthiophene) (P3HT) polymer (Merck Chemicals Ltd.) solution. After blown with nitrogen gas, 50 nm P3HT layer was spin-coated onto these substrates. The optical absorbance of the samples was measured using the UV-VIS spectrometer (JASCO). Top contact electrode was made by thermal evaporation of Au using the thermal evaporator (Edwards E306). Prior to Au deposition, poly (ethylenedioxythiophene): polystyrene sulphonate (PEDOT: PSS) layer was deposited as described[1]. The electrical characterization of the solar cells was carried out using a source measure unit (Keithley 2400) in dark and illumination under solar simulator (SCIENCETECH) with AM 1.5 filter.

RESULTS AND DISCUSSION

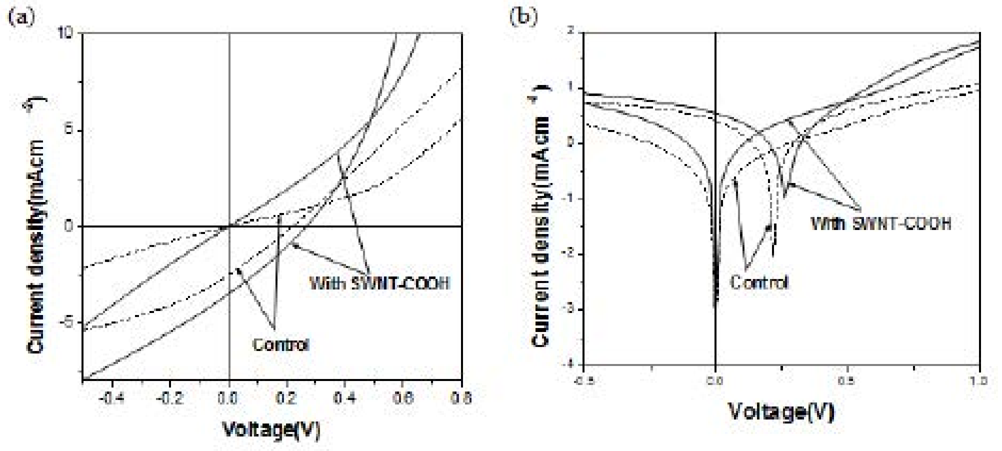

Figure 1 (a) Current density (J)–Voltage (V) characteristics of the SWNT-COOH dip and control hybrid TiO_2 /P3HT solar cells in dark and under AM 1.5 illumination from a solar simulator with 70 $mWcm^{-2}$ intensity (b) and its corresponding logarithmic plot.

The above figure depicts that the short-circuit current density (J_{SC}) and the open-circuit voltage (V_{OC}) of functionalized SWNT supported solar cells is improved by about 40 % and 30 % in comparison with the control cell, respectively. As such, the overall power conversion efficiency of functionalized SWNT supported solar cells increases by a factor of two. The enhancement in the performance may be attributed to the efficient transport of electrons, reduction in the trap charge carriers, reduced resistive and recombination losses.The incorporation of the functionalized SWNT slightly enhanced the open-circuit voltage that might be originated from the shift in energy levels. The introduction of functionalized SWNT not only has the potential of improving the charge transport efficiency but also could boost the photocurrent generation rate by providing additional exciton dissociation sites available at functionalized SWNT/Polymer interface provided the work function supports the dissociation.

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REFERENCES

1. Ravirajan P., Bradley D. C. C., Nelson J., Haque S. A., Durrant J. R., Smit H. J. P. and Kroon J. M. (2005). Efficient charge collection in hybrid polymer/TiO_2 solar cells using poly„ethylenedioxythiophene…/polystyrene sulphonate as hole collector. Appl. Phys. Lett. 86: 143101
2. Ravirajan P., Haque S. A., Durrant J. R., Bradley D. D. C. and Nelson J. (2005). The Effect of Polymer Optoelectronic Properties on the Performance of Multilayer Hybrid Polymer/TiO2 Solar Cells. Adv. Funct. Matter. 15(04):609-618
3. Rowell M. W., Topinka M. A., McGehee M. D., Prall H. J., Dennler G., Sariciftci N.S., Li. Hu and Gruner G. (2006). Organic solar cells with carbon nanotube network electrodes. Appl. Phys. Lett. 88:233506
4. Pasquier A.D., Unalan H.E., Kanwal A., Miller S. and Chhowalla M.(2005). Conducting and transparent single-wall carbon nanotube electrodes for polymer-fullerene solar cells. Appl. Phys, Lett. 87:203511
5. Kongkanand A., Domi´nguez R. M., and Kamat P. V. (2007). Single Wall Carbon Nanotube Scaffolds for Photoelectrochemical Solar Cells. Capture and Transport of Photogenerated Electrons. Nano Lett. 07(03):676-680,
6. Kymakis E. and Amaratunga G. A. J. (2002). Single-wall carbon nanotube/conjugated polymer photovoltaic devices. Appl. Phys, Lett. 80, 112
7. Ravirajan P., Haque S.A., Durrant J.R., Poplavskyy D., Bradley D.D.C., and Nelson J. (2004) Hybrid nanocrystalline TiO_2 solar cells with a fluorene–thiophene copolymer as a sensitizer and hole conductor. J.Appl.Phys. 95(03), 1473-1480

STUDY OF NOVEL DYES TO SUPPORT DSSC RESEARCH

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ABSTRACT

Preliminary investigations on the identification of the natural pigments in the dye-sensitization of nanocrystalline n-type TiO_2 were carried out. Fresh extracts of mangoostein, rambutan, mango, tomato, carrot, king coconut, pumpkin, red banana, beetroot, turmeric, venivel, orange, grape, spinach, pumpkin, and ginger etc., were employed as sensitizers in thin layer sandwich type photo electrochemical dye – sensitized solar cells (DSSC's).

The current-voltage curves obtained with solar cells employing the photo anode with $\mathrm{TiO_2}$ sensitized by different dyes were observed. The values of short circuit current density (Jsc), open circuit voltage (Voc), fill factor (ff), and efficiency (η) obtained for solar cells employing photo anodes with TiO_2 sensitized with different fruit / vegetable extracts were noted. The dye extracts of Turmeric root and Mangoostein fruit were found to be superior to those obtained from other dyes , and were of Jsc = 0.64mAcm^{-2} and 0.778 mAcm^{-2}, Voc = 601.9mV and 638.2mV, ff = 68.31% and 68.46% , η = 0.264 % and 0.34 % respectively.

This work provides the foundation on which research could be conducted to develop low-cost, high efficiency solar energy to electricity conversion units for use in countries like Sri Lanka.

Keywords: *Dye-sensitized solar cells, natural dyes, characterization*

INTRODUCTION

Technological achievements in the clean energy system infrastructure provide a fundamental issue towards the worldwide economy and environmental improvements. Therefore, in this 21st century, the energy based non-renewable sources have to be converted into new energy systems by incorporating the novel technologies derived from the advancements in science. Among several new energy technologies, Die-Sensitized Solar Cells (DSSC's) are considered to be one of the most promising new energy generation systems for photovoltaic technology. It has emerged as one of the renewable energy sources as a result of exploiting several new concepts and materials, such as nanotechnology and molecular devices. Even though the first dye sensitization of semiconductors was reported by Vogel in 1873, where silver halide emulsions were sensitized by dyes to produce black and white photographic films, the use of dye sensitization in photovoltaics had been achieved little noticeable result until a break through by Gratzel's group in the early 1990's. They developed a DSSC consisting of TiO2 electrode sensitized with Ruthenium (II) complex dye, organic liquid electrolyte with iodine/iodide redox couple and platinum deposited counter electrode. The solar energy to electricity conversion efficiencies were reported as high as 7.1% in 1991 and 10% and 11% in 2008. In these devices a monolayer of the dye is directly attached to the semiconductor surface via carboxyl group, which could realize an efficient injection of charge carriers from photo excited dye to semiconductor. However this sensitization of TiO_2 for solar applications requires not only to be efficient but also to be stable and inexpensive sensitizers.

However, in nature, the fruit, flower, root and leaf of plants show various colors from red to purple and contain various natural dyes, which can be extracted by simple procedures. Therefore, it has been emphasized by many researchers to obtain useful dyes as photo sensitizers for DSSC's from natural products, because of the simple preparation techniques, widely available sources, and low cost.

METHODOLOGY

Extraction of Dyes

The extracts of dyes from various fruits and vegetables were obtained from fresh fruits and vegetables. The clean fruits and vegetables were crushed and added to Ethanol (Merck). When necessary, the mixtures were centrifuged and all solutions were protected from the direct light exposure.

Preparation of Nanocrystalline TiO_2 Films

A TiO_2 paste was prepared by blending 200 mg powder of TiO_2 (P-25, Degussa) and 1 drop of Triton X 100 in an agate mortar, and the mixture was ground for 30 min whilst adding 10 drops of acetic acid. Next, a 10ml of ethanol was slowly added whilst grinding continuously for another 30 min. Above pastes were then applied on Fluorine-doped Tin oxide coated transparent conducting glass substrate by the well-known Doctor Blade method to obtain an approximately 10 micrometer thick TiO_2 film. Films were then heat treated at 5500C for 30 min and cooled down to room temperature. Finally, they were immersed separately in alcoholic dye solutions for 12 hours.

Fabrication and Characterization of Solar Cells

Photo electrochemical solar cells were then fabricated by sandwiching a platinum sputtered conducting Tin oxide (CTO) glass plate with the dyed TiO_2 films. A redox electrolyte containing / redox couple was then introduced to the solar cells. I-V characteristics of the solar cells at 100 mWcm-2 (AM 1.5) were measured using a home-made I-V measuring set up coupled with Keithley 2000 Electronic Multimeter with a Potentiostat via a computer controlled software available at the Institute of Fundamental Studies (IFS), Kandy. A Xenon 500 lamp was also used with AM 1.5 filters to obtain simulated sunlight with the intensity of 100 $mWcm^{-2}$. The intensity of the light was calibrated using an EKO Pyronometer and Silicon photodiode. The Absorption Spectra were also obtained with the UV 2450 SHIMADZU UV-VIS Spectrophotometer available at the IFS.

RESULTS AND DISCUSSION

Absorption Spectra Obtained from Various Fruits and Vegetables

Figures 1, 2 and 3 depict the Absorption Spectra of a few natural dyes of the plants grown in Sri Lanka in ethanolic dye solutions. It can be seen that, the dye solutions obtained from Turmeric and Mangoostein absorb more in the blue and red side of the electromagnetic spectrum than the other dyes. Absorbance peaks at 220 nm, 250 nm, 325 nm have been obtained for Mangoostin ; 210nm , 280 nm , 330 nm , 430 nm for Turmeric; 205 nm for Ekkiriya wood , and 205 nm for Fire Fern .

Analysis and evaluation of samples of natural dyes extracted from a cross section of plants grown in Sri Lanka and the summary results of all dyes analyzed were summarized (Not shown). It was observed that extracts of Turmeric rhizome root (dark yellow) and extracts of Mangoostin fruit rind (dark purple) yielded better results amongst these dyes tested. It has been observed from these results that darker the colour of the dyes, the greater would be their conversion efficiencies. Also it has been observed during recent tests conducted that the addition of trace amounts of acetic acid, hydrochloric acid etc., to these natural dyes will possibly change their chemical structures, and hence make them appear darker in colour with an increase in their conversion efficiencies.

The most probable target of conversion efficiencies of these natural dyes suitable for use in DSSC's would be around 2%. The Authors of this paper have recently obtained a practical conversion efficiency of 0.264 % for turmeric root, 0.34 % for mangoostin fruit rind, 0.485 % for eggplant fruit, and 0.547 % for Ekkiriya wood. A conversion efficiency of 0.802 % for Fire Fern leaf (deep purplish brown), which is a garden plant endemic to Ecudor , Venezuela and Colombia in Central America, recently brought down to Peradeniya Botanical Gardens has also been obtained. Even though the efficiency values obtained in this study are not significant with the values obtained in the system with very expensive Ruthenium complexes, the straight forward preparation of photo anodes with semiconductor oxides sensitized by natural dyes still enables a much cheaper and easy environmentally friendly production of solar cells. Further it provides an interesting and cheap alternative, to commonly used expensive and rare synthetic dyes. Therefore, investigations are being carried out in searching for efficient natural dyes, which may have potential to use in these DSSC's [5].

The present work would be the foundation for research and development for the low cost, high efficient solar energy to electricity conversion units for use especially in rural areas of Sri Lanka where access to the national grid electricity supply is limited. This would also enable alleviation of poverty and to improve living standards amongst rural communities.

CONCLUSIONS

This paper describes an investigation on the use of natural dyes of plants grown in Sri Lanka as natural photo sensitizers for DSSC"s. The extracts of turmeric root, mangoostein fruit rind, eggplant fruit, Ekkiriya wood, and Fire Fern leaf have achieved the solar energy conversion efficiencies of 0.264 %, 0.34 %, 0.485 %, 0.547 % and 0.802 % respectively.

The natural dyes based solar cells appear to be limited by low Voc and Isc. The way forward would be to find different additives such as acetic acid, hydrochloric acid etc., which when doped in trace amounts would cause alteration of the chemical structure of these natural dyes making them darkening the colours leading to larger conversion efficiencies. Although natural dyes are still below the present requirements, the results are encouraging and may boost additional studies oriented to the search of new natural dye sensitizers.

REFERENCES

1.Hao S., Wu J., Huang Y., Lin J. 2006. Natural dyes as photosensitizers for dye-sensitized solar cells. Solar Energy 80, 209-214
2.Senadheera G.K.R., Jayaweera P.V.V., Perera V.P.S. and Tennakone K. Solar Energy Materials of Solar Cells, 73, 103 (2002).
3.Tennakone K., Kumarasinghe A.R., Kumara G.R.R.A., Wijayantha K.G.V. and Sirimanne P.M., Journal of Photochemistry and Photobiology A: Chemistry, 108, 193 (1997).
4.O'Ragan B., Gratzel M., 1991. A low-cost, high efficiency solar cell based on dye-sensitized colloidal TiO2 films, Nature 353, 737-740.
5.Gratzel M., 2001. Photo electrochemical cells, Nature 414, 338-344.
6.Smested G.P., 1998. Education and Solar Energy Conversion: Demonstrating electron transfer. Solar Energy Materials of Solar Cells, 157-178
7.Gratzel M., 2003. Dye-Sensitized Solar Cells, Journal of Photochemistry and Photobiology C: Photochemistry Reviews (4), 145-153.

8.Senadheera G.K.R., Nakamuro K., Kitamuwa T., Wade Y. and Yanagida S. Applied Physics Letters, 83, 5470 (2003).
9.Senadheera G.K.R., Fernando J.M.R.C., Natural Anthrocyanins as Photosensitizers for DSSC's, Current Science, Vol.95, No. 5 (2008).
10.Hasan M.S., Roy S., Corkish R., 2010. Sustainable Energy in Asia and the Pacific : Emerging Technologies and Research Priorities in Solar Energy, 28-23.

H_2 EVOLUTION FROM n-Cu_2O NANO-PHOTOELECTRODES FROM VISIBLE LIGHT

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ABSTRACT

H_2 evolution was observed for the first time from the photo-electrochemical cell with n-Cu_2O semiconductor under the visible light irradiation. Three-electrode configuration was used in the photoelectrochemical cell to generate H_2 in the photoelectrochemical cell in the presence of Fe^{2+}/Fe^{3+} redox couple. A pt electrode was used as the counter electrode. H_2 generation was measured by a GC couple into the system during the visible light illumination. A remarkable H_2 evolution was observed compared to the presently available systems.

***Keywords**: H_2 evolution, n-Cu_2O*

INTRODUCTION

One of the simplest solar energy conversion processes involves the dissociation of water into its constituents, H_2 and O_2 that are to be used as energy fuels. Recently, the particulate semiconductor systems have received a considerable attention to produce H_2 from water. However the obtained yields are very small, which were in the range of micromoles. It is well known that, Cu_2O (band gap =2.0eV) is an attractive material for low cost solar energy conversion devices (1-5).

In this study, we present a significant H_2 generation from the n-Cu_2O nano-photoelectrodes in a photoelectrochemical cell in the presence of Fe^{2+}/ Fe^{3+} redox couple under the visible light irradiation.

EXPERIMENTAL

A well cleaned copper plate (99% purity) was immersed into a (0.1M) CuSO4 solution for two days to fabricate the nano-n-Cu_2O on copper sheets. X-ray diffractogram of the n-Cu_2O films deposited on Cu confirmed that the obtained films on the copper substrate were entirely Cu2O. The peaks corresponding to CuO or any other complexes were not significant in the diffractogram. For PEC measurements, a potentiostat was used with three-electrode configuration having Pt counter electrode and AgCl/Ag reference electrode. Shimadzu

GC -2014 was coupled to the photoelectrochemical cell to monitor the H_2 concentration during the illumination at the same time.

RESULTS AND DISCUSSION

Typical V-I characteristics under the dark and illumination for a PEC with n-Cu_2O semiconductor was observed in the presence of Fe^{2+}/ Fe^{3+} redox couple. When the applied potential is more negative than the onset potential, the dark current is increased rapidly. For the positive potentials (vs. NHE), the dark current was almost zero for some regions. Under irradiation, the total current increases at positive applied potentials. The onset potential occurs at +0.11V (vs. NHE). It is assumed that the onset potential is nearly equal to the flat band potential of n-Cu_2O in the presence of Fe^{2+}//Fe^{3+} redox couple with respect to NHE.

The photocurrent action spectra are measured at various biasing conditions. To generate a photocurrent, photogenerated holes must tunnel through the electrode-electrolyte interface to oxidize Fe^{2+} ions and the photo-generated electrons must reach the Pt counter-electrode through the internal circuit to reduce Fe^{3+} ions. When the bias potential is more positive than the onset potential, electric field in the space charge layer at n-Cu_2O-electrolyte interface is increased, facilitating the separation of photo-generated charge carriers since both the CB and VB bend down. The highest evolution on the platinum electrode can be observed when the biasing is nearly +0.5V vs NHE. H_2 bubbling is visible to eyes. This observation can be understood as follows. When the biasing is more negative, the band bending at semiconductor-electrolyte interface is small, which reduces the concentration of the photo-generated charge carriers and thus decreases the H_2 evolution. When the bias is more positive than +0.5V vs NHE, the band position of CB becomes more positive compared to the H_2/H+ redox level, which suppresses the H_2 evolution.

REFERENCES

1. D Duonghong, M Gretzel, J.Chem. Soc.Faraday Trans.1(80)(1984)1631
2. Kajari Das, S.K. De , Journal of Luminescence 129 (2009) 1015–1022
3. Hsin-Chun Lu , Chun-Lung Chu, Chi-You Lai, Yu-Hsiang Wang, Thin Solid Films 517 (2009) 4408–4412
4. C.A.N. Fernando, P.H.C. de Silva, S.K. Wethasinha, I.M. Dharmadasa b, T. Delsol b and M.C. Simmonds, Renewable Energy 26(2002)521
5. X Mathew, J. Material Science Lett. 21, 2002, 1911 – 1914

Session C

Medicine

ENHANCING THE PERFORMANCE OF CONSUMER MEDICAL DEVICES WITH NANOTECHNOLOGY

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ABSTRACT

Consumer medical devices have been the emerging medical technology from the last decade and are becoming an important part of the people's lifestyle with their busy schedules plus the recent development of the technology for consumer products. These devices can be used to improve the health sector of a particular country even with the resource limitations in the medical sector by reducing the number of visits to the doctors and admission periods into the wards. Starting from the portable blood pressure meters and blood sugar meters, the list has extended to various types of portable, wearable, implanted devices and finally it will become a nano-robot injected into the body to automatically detect and cure the deceases.

Even before the Nano robots invade your body, there are various ways that nanotechnology can involve with the consumer medical devices to improve the performance and make them really smart. In this paper we discuss the applications of nanotechnology in wearable and implanted consumer medical devices and target on the improvements of sensing, power consumption, power storage, miniaturization and ease of use.

Keywords*: Nano robots, Medical devices, Nanotechnology*

INTRODUCTION

Consumer medical devices can be described as medical devices as well as consumer devices. They are designed to measure the patient's medical parameters. The main difference of these consumer medical devices compared to the normal medical devices used in hospital premises and by the doctors is the simple operational procedures and simple user interfaces built in them. Most of the consumer medical devices present the results of their intended measurements in a user friendly manner to be able to be understood by their users. Some of the devices have data storage facilities while the others have the communication facilities into a remote server.

All of these devices have taken the advantage of the recent developments of electronics hardware and user interfaces to make the devices smaller and smarter. Some of the recently developed devices are plugged in or wirelessly connected with the user's Smartphone to get the advantage of their sophisticated hardware for data processing and smart user interfaces.

Still some improvements are needed in these devices compared to the standard medical devices and nanotechnology can be used to fill this gap.

RESULTS AND DISCUSSION

Nanotechnology can be used in several areas of consumer medical devices to enhance their capabilities as medical devices as well as consumer devices. Incorporating metal nanowires and carbon nanotubes into the skin contacting sensors and electrodes improves their performance with increased contact area and conductivity. [1,2] Enhancing the performance of energy harvesting devices such as thermoelectric generators and piezoelectric energy harvesters with the use of nanotechnology[3,4,5] makes them possible to use with wearable consumer medical devices. Capacity improvements of Li-ion batteries and making thin film batteries with the use of nanomaterials[6] improves the battery life of these devices and makes the wearable medical devices smaller and comfortable to wear.

REFERENCES

1. L.M. Yu, F.E.H. Tay, D.G. Guo, L. Xu, K.L. Yap, Sensors and Actuators A: Physical, 151 (2009), 17-22.
2. Giulio Ruffini, Stephen Dunne, Esteve Farrés, Josep Marco-Pallarés, Chris Ray, Ernest Mendoza, Ravi Silva, Carles Grau, Sensors and Actuators A: Physical, 132 (2006), 34-41.
3. Diana Dávila, Albert Tarancón, Carlos Calaza, Marc Salleras, Marta Fernández-Regúlez, Alvaro San Paulo, Luis Fonseca, Nano Energy, July 2012.
4. Brijesh Kumar, Sang-WooKim, Nano Energy 1 (2012), 342–355.
5. Jiyoung Chang, MichaelDommer, ChiehChang, LiweiLin, Nano Energy 1 (2012), 356–371.
6. Young-Lae Kim, Heon-Young Lee, Serk-Won Jang, Seung-Joo Lee, Hong-Koo Baik, Young-Soo Yoon, Young-Shin Park, Sung-Man Lee, Solid State Ionics, 160 (2003), 235-240.

MEMS/NEMS BASED SOI MICRO MOTION SENSOR FOR BIOMEDICAL APPLICATIONS

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ABSTRACT

This paper reports the design, fabrication and characterization of a novel 3-DOF Micro/Nano Electro Mechanical System (MEMS/NEMS) based motion sensor with nanoscale sensing elements and surrounding mass structure. It was fabricated using the Silicon-On-Insulator (SOI) technologies and the micro/nano machining techniques. This sensor consists of a sub-millimeter structure with outer seismic mass and cross-beams. The die size of the motion sensor is 700µmX700µmX550µm length width and thickness, respectively. It can detect three components of linear acceleration simultaneously. The sensitivity could be enhanced significantly while miniaturizing the die size of sensor chip with aid of surrounding mass structure and nanoscale piezoresistors on the sensing beams. Therefore, this novel proposed sensor is showing a good performance and smaller than all other comparable miniature 3-axis sensor structures reported thus far. The motion sensor is capable of measuring accelerations up to ±25g in the frequency bandwidth of 320Hz. A comparison of the obtained experimental results and the finite element simulation shows good agreement.

Keywords*: MEMS, NEMS, SOI, Motion Sensor*

INTRODUCTION

MEMS/NEMS relate to micro/nano-electro-mechanical integrated devices fabricated by the extension of microelectronic fabrication technology, e.g. photolithography, thin film deposition and etching, with high accuracy and high throughput. While microelectronic devices are solid and mechanically immovable, MEMS/NEMS devices have movable 3D microstructures, e.g. micro-cantilevers, micro-beams, membranes, etc. However, the significance of MEMS/NEMS is not only in mechanical motion, but also in miniaturization, multifunctional integration and mass production. Compared to Large Scale Integration (LSI) devices, which deal only with electrical signals, MEMS devices relate to conversion and integration of a wide variety of signal types, such as physical (electrical, mechanical, thermal, optical, etc.), chemical and biological signals. Generally, silicon MEMS technology offers the possibility of low-cost, high- performance, and miniaturized multifunctional-integrated devices for use in a wide range of consumer and industrial applications, such as in the automotive, biomedical and telecommunication industries, defense, and so on[1].

Most of the piezoresistive type miniaturized motion sensors developed so far have an overall dimension of more than 1mm x 1mm and these acceleration sensors have found many important and interesting applications, but there are many more especially in the biomedical applications as implantable sensors where the >1mm x1mm overall device area of the MEMS motion sensors are barrier to use. Some reported miniaturized motion sensors are sulfuring from low sensitivity as conventional piezoresistive sensing elements cannot feel maximum stress because of large dimensions of piezore-sistors, low structural sensitivity and small effective mass. It is sometime a challenge to maintain sensitivity of a motion sensor as chip size is decreased. When the feature size of the sensor gets smaller, some technical issues become more serious and need to be carefully considered. In this research, a deliberate introduction of nanoscale piezoresistor is one of the best techniques to enhance sensitivity and the novel beam structure with surrounding seismic mass also maintains higher sensitivity and resonant frequency[2]. Apart from us, there is a one research group including W.T.Park.et.al[3] presented a piezoresistive type micro-motion sensor with total die size area of 0.034mm^3, however, it is a conventional cantilever type 1-axis motion sensor with low sensitivity. Considering all the above facts, this motion sensor has been designed and fabricated as small as with overall dimensions 700µm X 700µm X 550µm length width and thickness, respectively. Figure 1 shows the schematic drawing of proposed structure.

RESULTS AND DISCUSSION

With the aim of optimizing the dimensions of the movable parts of the sensor, the commercially available Finite Element Method (FEM) program ANSYS was used to determine the motion of the seismic mass, the mechanical stress in the beams and the resonant frequency of the sensor (see Fig.3). Twelve p-type nanoscale piezoresistors (see Fig.2) were implanted along the central-longitudinal axes on the upper surface of n-type silicon crossbeam structure. In order to detect 3 components of accelerations, three Wheatstone bridges were formed as shown in Figure 4. The motion sensor has been fabricated by using MEMS/NEMS fabrication techniques utilizing n-type SOI wafer, which has 3µm top-layer. Not only sensing elements but also all interconnections are having nanoscale dimensions (see Fig.5 & Fig.6). Fig.7 shows the fabricated NEMS motion sensor. The average measured sensitivities of the fabricated motion sensor for accelerations Ax, Ay, Az in X, Y, Z axis, are about 0.528mV(Vg)-1, 0.526mV(Vg) -1, 0.498mV(Vg) -1 respectively with 3V power supply. This new 3-axis motion sensor represents a significant step for-ward in MEMS/NEMS sensor product miniaturization and it perfectly meets the space and weight constraints in biomedical applications and other portable electronic devices and so on.

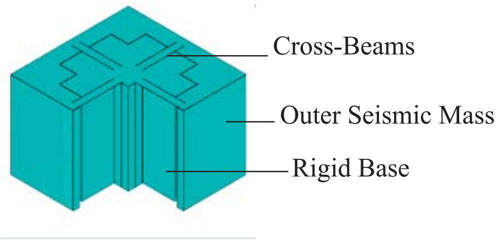

Fig. 1: Sectioned schematic drawing of the 3-axis NEMS motion sensors.

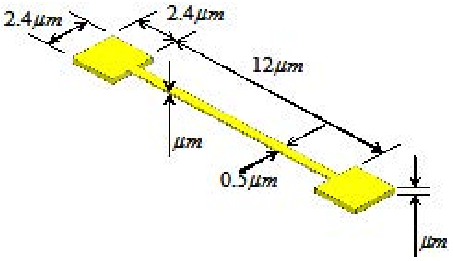

Fig. 2: Dimensions of nanoscale piezoresistor

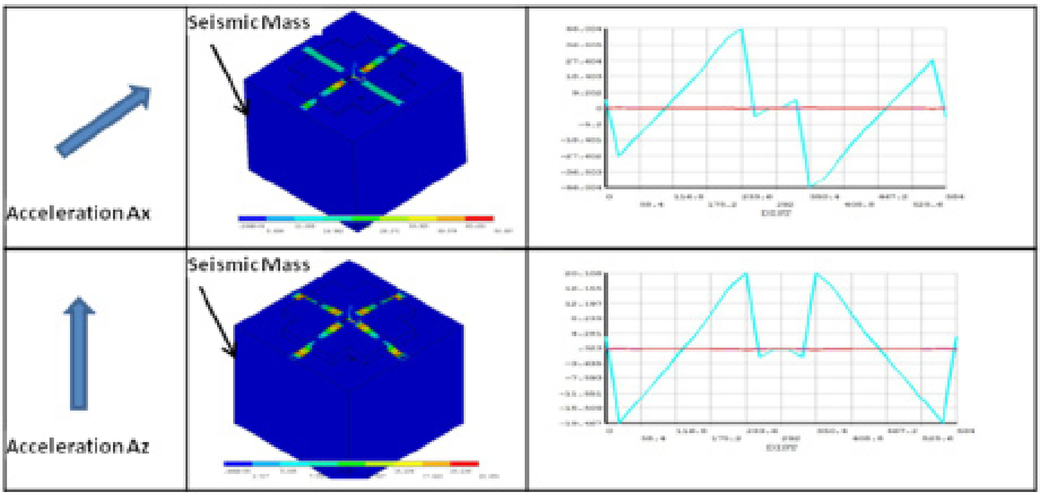

Fig. 3: The stress distributions on surface of X-Y oriented beam structure

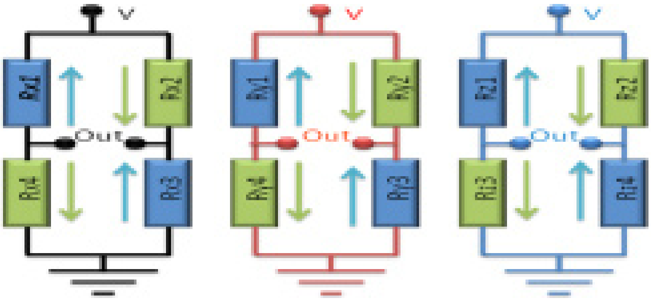

Fig. 4: Circuit diagram of Whetstone bridges on the beam structure

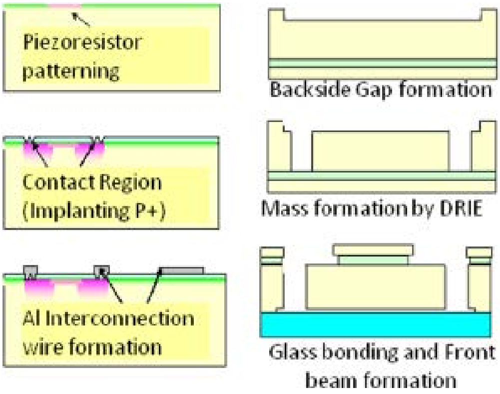

Fig. 5: Fabrication process flow of the motion sensor

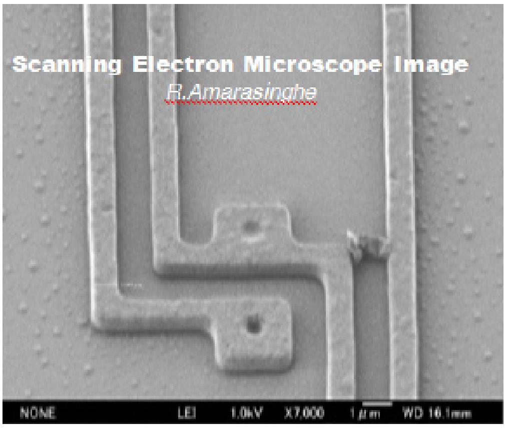

Fig. 6: SEM image of read-out circuits (thickness x width: 200nmx800nm

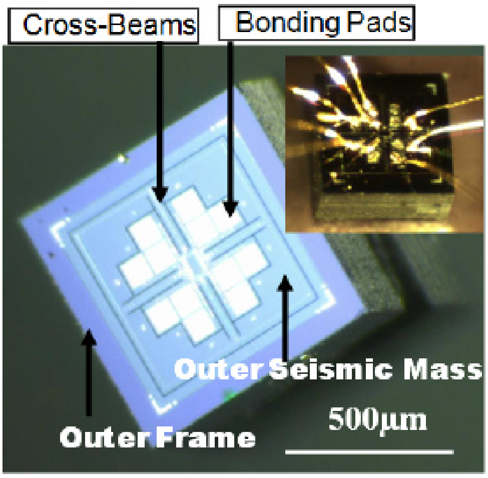

Fig. 7: The fabricated NEMS motion sensor with overall dimensions 700µmX700µmX550µm length, width and thickness, respectively.

REFERENCES

1. Dzung Viet Dao, Koichi Nakamura, Tung Thanh Bui and Susumu Sugiyama ,“Micro/nano Mechanical Sensors and Actuators Based on SOI-MEMS Technology”, Journal of Advances in Natural Sciences: Nanoscience and Nanotechnology, Institute of Physics (IOP) Publishing Ltd, UK, Vol.1, No.1, 10pp, 2010.
2. Ranjith Amarasinghe, Dzung Viet Dao, Susumu Sugiyama, “Novel Three-Axis Solid-state Micro Accelerometer with Surrounding Beam Structure”, IEEJ Transactions on Sensors and Micromachines, Vol. 130, No.6, pp. 242-246, June 2010.
3. W.T.Park.et.al. “Fully encapsulated sub-millimeter accelerometers” MEMS-2005 Conference, pp. 347-350.

USE OF MAGNETIC NANOPARTICLES TO SEPARATE SINGLE AND DOUBLE STRANDED DNA

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ABSTRACT

Engineering of the surface of the magnetic iron oxide nanoparticles are showing an exciting progress for the production of 'smart' miniaturized devices for bioseparation, biolabeling and catalysis. The goal of the project is to synthesize the iron oxide nanoparticles (IONPs) and later modify the surface of these particles with Hydroxyapatite (HAp) in order to separate single (ss) and double stranded (ds) DNA. IONPs were synthesized using a procedure published elsewhere. For the comparing purposes surface functionalization with HAp was carried out using two methods homogeneous precipitation technique and in situ synthesis method. According to the data obtained by FT-IR spectrum and atomic absorption, it could be concluded that homogeneous precipitation technique is a better technique than in-situ synthesis method. Separation of ssDNA and dsDNA was determined by agarose gel electrophoresis.

Keywords: *Hydroxyapatite (HAp), iron oxide nano particles, Asymmetric Polymerase Chain Reaction*

INTRODUCTION

In the last decade, investigations of nanomaterials were highly restricted to the studies of its specific physical and chemical property but now the scientists are entering to the commercial exploration period.[1-2] As a result, many applications of the nanomaterials have been investigated. In our work, a great effort was launched to construct a miniaturized, rapid, high quality, cost effective DNA extraction and a further separation method. Therefore, this HAp coated IONPs can overcome the problems associated with the previous separation methods such as bulkiness and higher consumption of time. Other than the separation and purification of DNA, HAp functionalized IONPs can be used in many fields due to its high binding capacity for DNA.

METHODOLOGY

The synthesis of oleic acid coated IONPs were carried out using a published method. Briefly, solutions of Fe(III) (0.1M, 50 mL) and Fe(II) (0.1M, 25 mL) were mixed with oleic acid solution. To this solution NH_4OH was added until pH is equal to 12 while stirring. Resulting black colour precipitate was washed with degassed water for two times and the precipitate was dried inside a vacuum desiccator. The obtained product was magnetic and it was characterized using SEM and FT-IR techniques.

Synthesis of HAp functionalized IONPs were carried out using two methods. In the homogeneous precipitation method, HAp coating on IONPs were carried out using thermal dissociation of $Ca(edta)^{2-}$ chelate in NaH_2PO_4 solution at 180 °C and pH 7 in a sealed pyrex glass tube.[3] In the in- situ synthesis method, HAp coating on IONPs were carried out by mixing the portions of 0.15M $(NH_4)_2HPO_4$ and 0.4M $Ca(NO_3)_2$ solution with IONPs at 60 ^{o}C and pH 10.

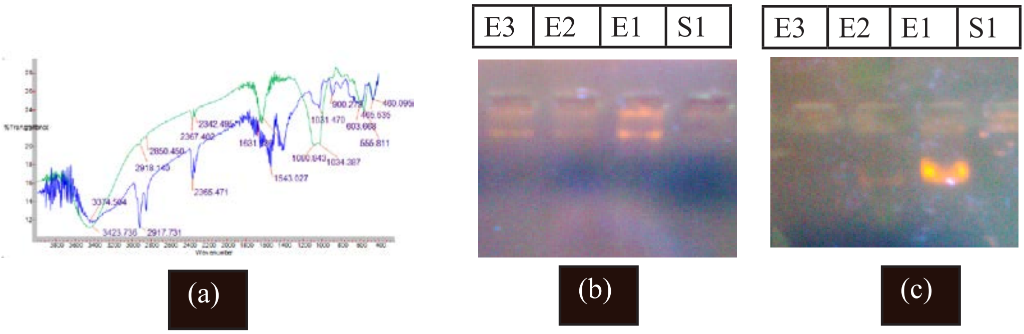
HAp binding on IONPs was quantified by measuring Ca^{2+} level using Atomic Absorption Spectroscopy. In this case, 40 mg of HAp coated IONP from the both methods were dissolved in 2M HCl (2 mL) for the atomic absorption spectrophotometric analysis.

Separation of ssDNA and dsDNA

ssDNA was prepared by Asymmetric Polymerase Chain Reaction and it was done by modifying the primer ratio of the standard Polymerase Chain Reaction. In the case of the dsDNA separation, dsDNA was mixed with binding/washing buffer (0.12 M phosphate buffer, pH 6.8) and HAp coated IONPs were added to it. Mixture was incubated for 15 min. The supernatant (S1) was separated from the nanoparticles using a magnet and the washing step was repeated twice. The nanoparticles were re-suspended in elution buffer (0.5 M phosphate buffer, pH 6.8) for 15 min. The supernatant was collected (E1) and elution step was repeated two times and again supernatants were collected (E2). All the collected samples were electrophorized. The ssDNA separation was carried out by following the same procedure as above but using the 0.2 M phosphate buffer (pH 6.8) as the elution buffer instead of 0.5 M phosphate buffer[4].

RESULTS AND DISCUSSION

Both HAp coating methods gave brown color solid but the color intensity was different. According to the Figure 1(a), both HAp coated IONPs, which were resulted in the homogeneous precipitation technique (green) and the in-situ synthesis method (blue) , clearly exhibit characteristic absorption band of the functional groups of HAp. The bands between 555 cm^{-1} and 606.84 cm^{-1} can be attributed to the bending vibrations of the PO_4^{3-} group. The band around 1030 cm^{-1} can be considered as stretching vibrations of the P-O bond. The characteristic strong peak of IONP (around 580 cm^{-1}) has not shown since it has covered by the peaks of HAp. According to the atomic absorption data, amount of the HAp in the sample 1 (40 mg of HAp coated IONPs from homogeneous precipitation technique) is 6.3155 mg and sample 2 (40 mg of HAp coated IONP from in-situ synthesis method) is 5.8310 mg. Therefore, the homogeneous precipitation technique is a better technique for HAp coating on IONPs than the in-situ synthesis method. As shown in figure 1(b) and 1(c), a very sharp band appears in the 1st elution (E1) of the dsDNA separation. According to that, it can be concluded that these dsDNA have been successfully bound to the both type of the HAp coated nanoparticles.



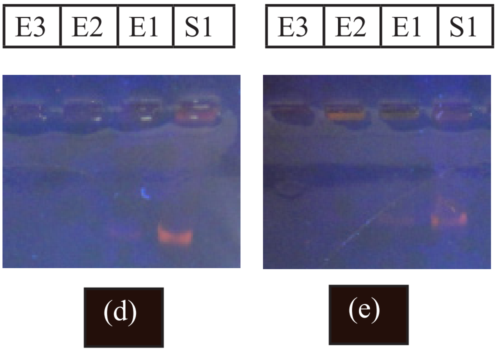


Figure 1. Summarization of the results. (a) Comparison of the FT-IR spectrum of the both methods (brown: homogeneous precipitation technique, blue: in-situ synthesis method. (b), (d) dsDNA and ssDNA separation using HAp coated IONPs produced by in-situ synthesis method respectively. (c), (e) dsDNA and ssDNA separation using HAp coated IONPs produced by homogeneous precipitation technique respectively.

As shown in the Figure 1(d) and 1(e), a low intensity band appears in the 1st elution (E1) of the ssDNA separation and a large amount of ssDNA has remained in the unbound form. Therefore, in order to get a successful binding, further optimization of the binding/ washing buffer has to be performed.

REFERENCES

1. Wu W., He Q., & Jiang C. (1991). Magnetic Iron Oxide Nanoparticles: Synthesis and Surface Functionalization Strategies. Nanoscale Research Letters 3:397-415.
2. Salata O. (2004). Applications of nanoparticles in biology and medicine. Journal of Nanobiotechnology 2:3.
3. Fujishiro Y., Sato T. & Okuwaki A. (1995). Coating of hydroxyapatite on metal plates using thermal dissociation of calcium-EDTA chelate in phosphate solution under hydrothermal conditions. JOURNAL OF MATERIALS SCIENCE: MATERIALS IN MEDICINE 6(03):172-176.
4. Andrews-Pfannkoch C., Fadrosh D. W., Thorpe J. & Williamson S. J. (2010). Hydroxyapatite Mediated Separation of dsDNA, ssDNA and RNA Genotypes from Natural Viral Assemblages. Journal of Applied and Environmental Microbiology 76(15):5039-5045.

SYNTHESIS OF IRONOXIDE NANOPARTICLES FUNCTIONALIZED WITH POLYETHYLENIMINE (PEI) FOR DNA BINDING AND GENE DELIVERY

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ABSTRACT

A simple and a rapid method for DNA binding and gene delivery to eukaryotic cells was investigated using PEI coated iron oxide nanoparticles. Iron oxide magnetic nanoparticles were synthesized using an established method. The surface of the iron oxide nanoparticles was functionalized directly with a cationic branched polymer PEI. The synthesized nanoparticles were characterized using transmission electron microscopy (TEM), and Fourier transformation infrared spectroscopy (FT-IR). Then nanoparticles functionalized with PEI were employed to demonstrate the DNA binding ability using a common plasmid vector pBS. After sometime the loaded nanoparticles with the vector were sedimented by a magnetic field. Separation of bound DNA was carried out using an elution buffer, which leads to the regeneration of PEI coated iron oxide nanoparticles. Gel electrophoresis was used to monitor the separation of DNA from magnetic nanoparticles. Results indicate that PEI functionalized iron oxide nanoparticles have enormous ability to bind with the plasmid DNA. Therefore this could be a suitable candidate for gene delivery, isolation and purification of high quality DNA.

Keywords**:** *Plasmid DNA, Transfection, Ironoxide nanoparticles*

INTRODUCTION

Gene therapy is an emerging area of biomedicine and has the potential to revolutionize the treatment of human diseases. Due to the adverse effects like pathogenicity, immunogenicity etc., the use of viral vectors has been undertaken by non-viral vectors.[1] Magnetofection is a recently introduced method where the therapeutic genes are attached to magnetic nanoparticles, which are functionalized with molecules with a cationic nature. Then they are delivered to the cells using an external magnetic field. Those are taken in to the cells by forming endosomes and the cationic polymer promotes the release of DNA by endosome osmotic swelling and disruption of the endosome membrane. Among the non-viral vectors, PEI is known to exhibit efficient transfection capability owing to their ability to condense DNA or RNA to stable polyplexes.[2] PEI easily associates with magnetic nanoparticles, which allow the rapid gene delivery under the influence of an external magnetic field. The coupling of magnetic nanoparticles in to gene vectors has shown increased transfection efficiencies than the conventional transfection methods.[3] Functionalization of iron oxide nanoparticles with PEI has also been reported.[4] However these functionalizations have been performed using a linker molecule, which involves tedious procedures.[5] Therefore, during our work we carried out direct functionalization of PEI with iron oxide nanoparticles, which involves a single step.

METHODOLOGY

The synthesis of iron oxide nanoparticles was carried out using an already established method.[6] The obtained product was characterized using FT-IR and TEM. SEM images are to be performed.

Pre-synthesized iron oxide nanoparticles were functionalized with 20% (w/w) PEI for 30 minutes at 50°C. The precipitate was washed with water and dried in an oven. This was also characterized by using the mentioned techniques.

PEI- coated iron oxide nanoparticles was suspended in Tris-EDTA (TE) with plasmid DNA and kept for 2 minutes. Magnetic separation was done to remove unbound DNA (S1). Then elution was carried out using an elution buffer for 20 minutes at 60°C (S3). Gel electrophoresis was done using 0.8 % agarose gel with the collected suspension and elution along with a control(C).

RESULTS AND DISCUSSION

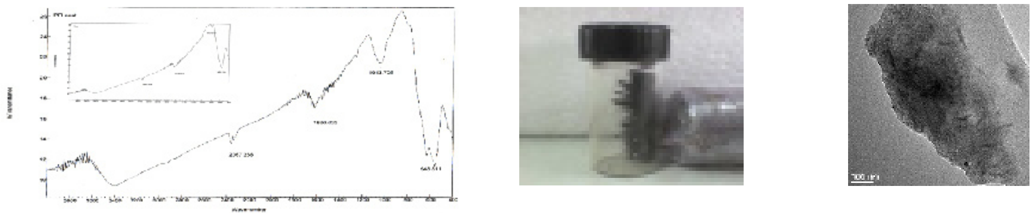

Figure 1. a.) IR spectrum of PEI/ ironoxide, b.) magnetic attraction, c.) TEM image of PEI/ ironoxide

According to the IR spectrum, peaks around 1045 cm^{-1}, 631 cm^{-1}, 550 cm^{-1} correspond to CN stretching of aliphatic amines, CH out of plane bending and (C-C-C) δ bending vibrations respectively.

After the functionalization, the TEM image was not clear enough to get the exact size and particles were around 21 nm size range. This is because of particle agglomeration, where each iron oxide nanoparticle is associated with more than one strand of PEI and each strand is attached to more than one nanoparticle, which causes bridging aggregation. This is in accordance with the results reported in the work done by Petri- Fink et al.[7]

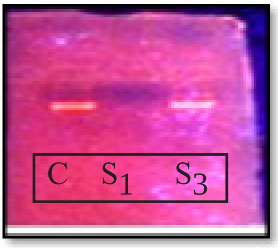

Figure 2. Elution at increased temperature

Elution was successful at increased temperature. This is because of multiple attachment of DNA to PEI, which makes it hard to elute. Thus, in this study it was clearly shown that PEI functionalized nanoparticles have enormous ability to bind with plasmid DNA, which is important for downstream applications like plasmid purification and transfection. Transfection of HEp-2 cells using pCDNA3.1 containing GFP gene is still under process where we are trying to come up with an efficient non-viral transfection agent.

REFERENCES

1.Tros de llarduya C, Sun Y. & Düzgüneş N. (2010). Gene delivery by lipoplexes and polyplexes. European Journal of Pharmaceutical Sciences 40(03):159-70.

2.Basarkar A. & Singh J. (2007). Nanoparticulate systems for polynucleotide delivery. International Journal of Nanomedicine 2(03):353-60.

3.Huth S, Lausier J, Gersting S.W, Rudolph C, Plank C, Welsch U. & Rosenecker J. (2004). Insights into the mechanism of magnetofection using PEI- based magnetofectins for gene transfer. Journal of Gene Medicine 6(08):923-36.

4.McBain S.C, Yiu H. H. P, El Haj A. & Dobson J. (2007). Polyethyleneimine functionalized iron oxide nanoparticles as agents for DNA delivery and transfection. Journal of Material Chemistry 17(24):2561-2565.

5.Kamau S. W, Hassa P. O, Steitz B, Petri-Fink A, Hofmann H, Hofmann-Amtenbrink M, von Rechenberg B. & Hottiger M. O. (2006). Enhancement of the efficiency of non-viral gene delivery by application of pulsed magnetic field. Nucleic Acid Research 34(05):e 40.

6.Ruberu T. P, de Silva K. M. N, Kumar C. S. S. R. & de Silva W. R. M. (2008). Investigation of the effect of structure of surfactants on binding to iron oxide nanoparticles. Proceedings of the 64th SLAAS Annual Sessions of Sri Lanka Association for the Advancement of Science (SLAAS) (eds. H. Goonathileka, M. Wijesinghe), Part I-Abstracts, Colombo 03, Sri Lanka, 1-6 December, Faculty of Science, University of Colombo, Colombo 03, Sri Lanka, pp. 144.

7.Petri-Fink A, Steitz B, Finka A, Salaklang J. & Hofmann H. (2008). Effect of cell media on polymer coated superparamagnetic iron oxide nanoparticles (SPIONs): Colloidal stability, cytotoxicity, and cellular uptake studies. European Journal of Pharmaceutics and Biopharmaceutics 68(01):132.

Session C

SYNTHESIS OF IRON OXIDE NANOPARTICLES FUNCTIONALIZED WITH SILICA FOR DNA PURIFICATION

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ABSTRACT

In our investigation magnetic iron oxide nanoparticles were synthesized using an already established method. Then the functionalization of the iron oxide magnetic nanoparticles (MNPs) was carried out using tetraethyl ortho silicate (TEOS). Silica functionalized iron oxide MNPs were characterized using transmission electron microscopy (TEM) and Fourier transform infrared spectroscopy (FT-IR spectroscopy). These silica coated iron oxide MNPs were then tested on DNA separation. The separation of DNA was monitored through agarose gel electrophoresis. The Agarose gel image shows that this is an efficient DNA purification method compared to the current DNA purification methods.

Keywords**:** *Iron oxide nanoparticles, Silica coated, TEOS (tetra ethyl ortho silicate), DNA purification*

INTRODUCTION

The purification of DNA is fundamental in biological research. It has a great importance in the field of criminal investigations, in identifying the biological parent of a child, in detecting genetic disorders and diseases, as well as many bacteria and viruses within the environment and many more. There are a number of research reports based on the different ways in which DNA can be purified such as cesium chloride-ethidium bromide density ultracentrifugation[1], gravity flow reverse phase C18 chromatography[2], DEAE anion-exchange chromatography[3] and hydroxyapatite chromatography[4]. However, these existing methods have several drawbacks. These methods often involve the use of toxic and mutagenic chemicals, time consuming, difficult to scale up, damage the separated DNA and they also require large equipment and high volumes of reagents and samples. Nanotechnology has gained significant momentum in recent years to interplay in the field of DNA purification. Surface functionalized iron oxide nanoparticles are considered as a prominent class of MNPs in the DNA purification because of its biocompatibility. Even though the surface of iron oxide MNPs could be modified by a number of organic and inorganic materials, silica has been chosen for our purpose. This is because silica possesses a good stability and can be used in organic or inorganic solutions without swelling. It is bio compatible and silica coating also possesses a large amount of terminated silanol that can attach specific ligands to the surface of the MNPs. The benefits of this magnetic separation of DNA using MNPs over conventional methods include quicker processing time, lower amount of chemicals and easier separation plus automation.

METHODS

Synthesis of iron oxide nanoparticles

The synthesis of iron oxide nanoparticles was carried out using an established method[5]. Briefly, solutions of Fe (III) (0.1 M 50.00 ml) and Fe (II) (0.1 M 25.00 ml) were mixed and under N_2 atmosphere NH_3 (5.0 M 10.00 ml) was added. Resulting black color complex was centrifuged at 12,000 rpm for 20 mins at 10^0C. The precipitate was washed twice with double distilled water and was dried inside a vacuum desiccator.

Synthesis of silica coated iron oxide nanoparticles

The functionalization of iron oxide nanoparticles with silica was carried out following a method adopted earlier with some modifications6. The iron oxide nanoparticles, synthesized according to the above mentioned method, was mixed with ethanol, distilled water, ammonia and tetraethyl ortho silicate (TEOS) at room temperature. The mixture was stirred for approximately two hours. Silica functionalized iron oxide MNPs were characterized using TEM and FT-IR spectroscopy. Further investigations are being carried out changing the ratio of alcohol to ammonia and using different mixtures of alcohols.

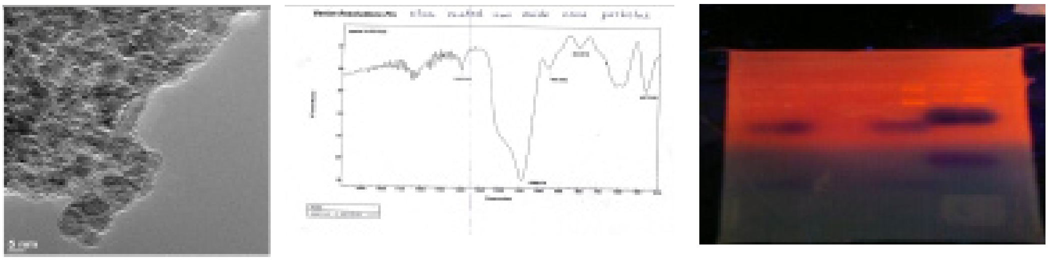
Purification of DNA

Silica coated iron oxide MNPs were washed with ethanol and with distilled water and then was suspended in the binding buffer. This was then added to a mixture of human genomic DNA, a binding buffer and water. Then the sample was gently mixed at room temperature for 5 – 10 min. Next the MNPs were separated in the magnetic stand. Then it was washed by addition of the washing buffer. After washing, the human genomic DNA was eluted from the MNPs. The eluted DNA was analyzed by agarose gel electrophoresis.

RESULTS AND DISCUSSION

Prepared iron oxide nanoparticles showed magnetic properties and were attracted to an external magnet.

According to the TEM image of iron oxide MNPs as shown in figure 1(a), the majority of the iron oxide nanoparticles were spherical with an average particle size around 5 nm.



(a) (b) (c)

Figure 1.

(a) TEM image of slica coated iron oxide MNPs obtained during the study

(b) FT-IR spectrum of silica coated iron oxide MNPs obtained during the study

(c) Agarose gel electrophoresis image

FT-IR spectroscopy was used to characterize the functionality of the resulting silica coated iron oxide nanoparticles. After silica is coated on the surface of iron oxide nanoparticles, the mainly characteristic absorption bands, such as Si–O–Si stretching, Si–OH stretching, Si–O bending, and Si–O–Si bending, are shown at 1086, 955, 803, and 457 cm^{-1}, respectively. From these absorption bands, it is clearly indicated that silica was successfully covered onto the surface of the iron oxide nanoparticles. Agarose gel electrophoresis was achieved from a horizontal gel electrophoresis unit in TAE buffer to determine the efficiency of this separation. Agarose gel electrophoresis was carried out for the eluted human genomic DNA in five different samples.

	a	b	c	d	e
Eluted DNA volume (mL)	1.00	2.00	3.00	5.00	1.00
TE buffer (mL)	9.00	8.00	7.00	5.00	9.00

From the gel picture (Figure 1 (c)) it is clear that DNA has been separated. It also shows an efficient separation of DNA.

REFERENCES

1) Osmanagaoglu O. Beyatli Y. Gunduz U. (2000). Analysis of the genetic determinant for production of the pediocin P of Pediococcus pentosaceus Pep1. J. Basic Microbiol 40(4):233-241.
2) Levison P. R. Badger S. E. Hathi P. Davies M. J. Bruce I. J. Grimm V. (2000). Application of magnetite and silica–magnetite composites to the isolation of genomic DNA. J. Chromatogr.A 820:159-166.
3) Gilar M. (2001). Analysis and Purification of Synthetic Oligonucleotides by Reversed-Phase High-Performance Liquid Chromatography with Photodiode Array and Mass Spectrometry Detection. Anal. Biochem. 298:196-206

4) Jungbauer A. Hahn R. Deinhofer K. Luo P. (2004). Performance and characterization of a nanophased porous hydroxyapatite for protein chromatography. Biotechnol. Bioeng. 87:364-375.
5) Ruberu T. P, de Silva K. M. N, Kumar C. S. S. R. & de Silva W. R. M. (2008). Investigation of the effect of structure of surfactants on binding to iron oxide nanoparticles. Proceedings of the 64th SLAAS Annual Sessions of Sri Lanka Association for the Advancement of Science
6) Stober W. Fink A. Bohn E. (1968). Controlled growth of monodisperse silica spheres in the micron size range. J. Colloid Interface Sci. 26:62-69.

Session D

Nano-charaterization

CHARACTERISATION OF CARBON NANOTUBES USING MOLECULAR DYNAMIC SIMULATIONS

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ABSTRACT

This paper presents a Molecular Dynamic (MD) simulation study on the variation of shear modulus of single wall carbon nanotubes (CNTs) with the temperature. An Adaptive Intermolecular Reactive Empirical Bond Order (AIREBO) potential field was used to represent the force field due to interactions between atoms when performing MD simulations. It was found that the shear modulus decreases with the increase of temperature, and that the arm-chair CNT has a higher value of shear modulus than the zig-zag CNT.

Keywords: *Carbon Nanotubes, Molecular Dynamics, Shear Modulus, Temperature*

INTRODUCTION

A sound understanding of the properties and response of relevant nano-sized elements or structures is essential for the accurate and efficient design of nanodevices. Considering the broad field of potential applications of Carbon nanotubes (CNTs) in nanodevices and their further development, it is very important to characterize their properties in order to understand how they interact with their surrounding environment and to observe their response to external mechanical, electrical and thermal stimuli. The mechanical properties and behavior of CNTs can be studied using a variety of different methods and a number of attempts have been reported in the past[1,2].

Even though experimental measurements are a successful means to measure some of these properties, the use of experiments is a formidable challenge with the existing facilities for measurement. The methods based on the fundamentals of quantum mechanics, which solve the Schrödinger equation are often the most accurate methods of studying the behavior of CNTs. However, such application is limited to small systems due to the high computational cost. The Continuum modeling is perhaps the most computationally efficient method of CNT characterization, but the classical continuum models are unable to account for quantum effects arising from the discrete nature of matter at the nanoscale. Numerical techniques based on semiempirical approaches provide a proper balance between the accuracy and the efficiency. One of the most widely used numerical methods is Molecular Dynamics (MD), which uses Newton's equation of motion to trace the time evolution of a system of interacting atoms or molecules. Compared to approaches based on first principles, MD simulations can be used to study larger systems and can yield accurate results through the use of a suitable and accurate potential field. This paper presents a MD simulation study on the variation of shear modulus of single wall CNTs with the temperature. Adaptive Intermolecular Reactive Empirical Bond Order (AIREBO) potential field was used to represent the force field in MD simulations.

MATERIALS AND METHODS

Molecular dynamics is an atomistic/molecular simulation technique, which was developed in the late 1950's[3] and it can be divided into two basic steps. The first step involved the determination of the interacting forces between a system of atoms using a molecular mechanics (MM) potential field. The second was the tracing of the movements of atoms by integrating Newton's equation of motion. The time evolution of the atoms was obtained by using a numerical integration method such as velocity Verlet method[4]. The interacting forces between atoms were obtained from the gradient of a MM potential field. Reactive Empirical Bond-Order (REBO) potential[5] is one successful example of potential fields, which considers the intermolecular interactions in hydrocarbons. However, it does not capture the non-bonded and torsional interactions between atoms. Adaptive Intermolecular REBO potential (AIREBO) can address this issue in MD simulations[6].

It was necessary to control the temperature and pressure in MD simulations in order to simulate physical systems. Temperature was controlled by changing the velocities of atoms. Anderson[7], Berendson[8], and Nose-Hoover[9] thermostats are the most commonly used thermostats. Berendsen barostat[8] and Nose-Hoover barostat10 are widely used to control pressure in MD simulations.

An MD simulator known as LAMMPS was used in this study. When a CNT was subjected to torsion, in- plane angels as well as out of plane and dihedral angles were changed. In order to capture these effects, AIREBO potential function was used for the simulation. Time step for the simulations was 0.5 fs. Nose-Hoover thermostat and barostat were used to control the temperature and the pressure of the system. Carbon nanotubes of chirality 8-8 (arm-chair) and 14-0 (zig-zag), which have diameter of ~1.08 nm were considered for the study. In order to study the effect of the aspect ratio (length to diameter ratio) of the CNTs on the shear modulus, aspect ratios of 15, 20, and 22 were considered at a temperature of 300 K. It was found that the effect of aspect ratio was negligible. An aspect ratio of 15 was used to find out the effect of temperature on shear modulus. The simulations were done at 300 K, 400 K and 500 K. Torsion was imposed on a CNT by changing the co-ordinates of the atoms according to the applied rotation, and the atoms at the edges of the tube were held fixed in their position during the simulations. Rotation of 50 was applied at a step, and the system was allowed to reach its equilibrium for

80,000 time steps in order to obtain the minimum potential energy of the system at that strain.

Minimum potential energy of the system obtained from the simulation was used to calculate the shear modulus. The slope of the potential energy – twist curve could be related to the torque to obtain a torque-twist curve. The relationship between, potential energy (U), Torque (T), and twisting angle (φ) can be expressed as:

$$T(\text{Ø}) = \frac{dU(\text{Ø})}{d(\text{Ø})}$$

By assuming CNT as a cylindrical shell of length (L), thickness (t) and diameter (a), the surface shear modulus Gt, can be calculated as:

$$Gt = \frac{1}{2\pi a^3} \frac{d^2U(\text{Ø})}{d(\text{Ø})^2}$$

RESULTS AND DISCUSSION

The Variation of Torque (T) with Shear Stain for 8-8 CNT is shown in Figure 1. Gradient of the curve before buckling (up to a strain value of ~ 0.02) was considered for the calculation of the Shear Modulus. Variation of Shear Modulus with temperature for the arm-chair and the zig-zag carbon nanotubes are shown in Figure 2. It was found that the value of the shear modulus decreases with the increase of temperature. Also the value of shear modulus of the arm-chair CNT is slightly higher than that of the zig-zag CNT.

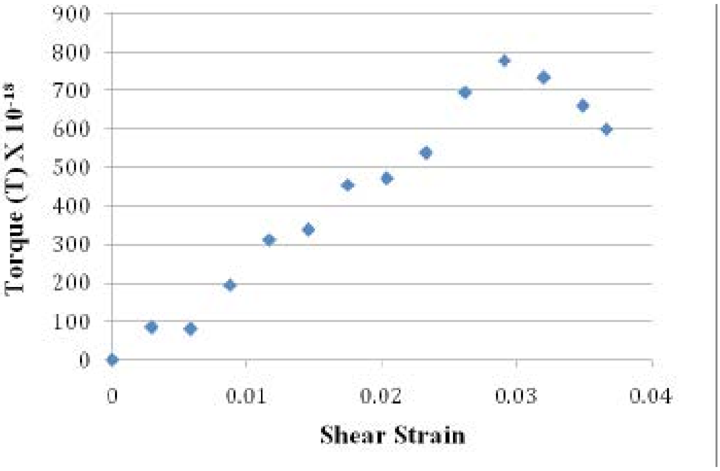

Figure 1: Torque Vs Shear strain Variation of 8-8 CNT

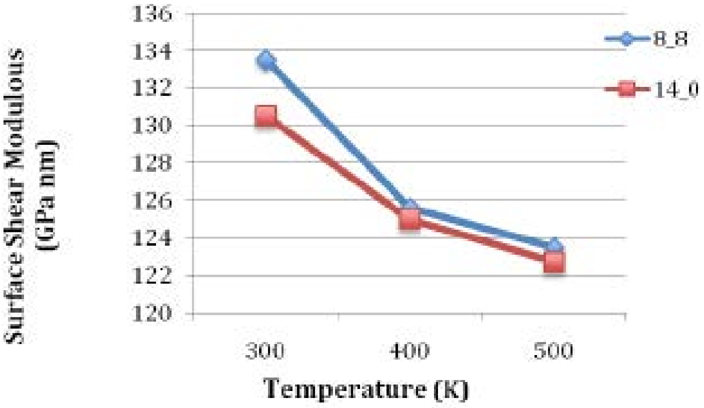

Figure 2 : Variation of shear modulus with temperature

REFERENCES:

1. Quin D. Wagner G.J. Liu W.K. Yu M. & Ruoff R.S. (2002). Mechanics of carbon nanotubes. Journal of American Society of Mechanical Engineers 55(6): 495-525.
2. Ruoff R.S. Qian D. & Liu W.K. (2003). Mechanical properties of carbon nanotubes: theoretical prediction and experimental measures. Journal of C.R.Physique 4: 993-1008.
3. Alder B. J. & Wainwright T. E. (1957). Phase Transition for a Hard Sphere System. Journal of Chemical Physics 27: 1208-1209
4. Rapaport D.C. (1995). The Art of Molecular Dynamics Simulation. Cambridge: Cambridge University Press, UK
5. Brenner D.W. Shenderova O.A. Harrison J.A. Stuart S.J. Ni B. & Sinnott S.B. (2002). A second –generation reactive bond order (REBO) potential energy expression for hydrocarbons. Journal of Physics: Condensed Matter 14: 783-802.
6. Stuart S.J. Tutein A.B. & Harrison J.A. (2000). A reactive potential for hydrocarbons with intermolecular interactions. Journal of Applied Physics 112(14): 6472-6486.
7. Andersen H.C. (1980). Molecular dynamics simulations at constant pressure and/or temperature. Journal of Chemical Physics 72(4): 2384-2393.
8. Berendsen H.J.C. Postma J.P.M. Van Gunsteren W.F. DiNola A. & Haak J.R. (1984). Molecular dynamics with coupling to an external bath. Journal of Chemical Physics 81(8): 3684-3690.
9. Hnenberger P.H. (2005). Thermostat algorithms for molecular dynamics simulations. Journal of Advanced Computer Simulation 173: 105-149.
10. Martyna G.J. Tobias D.J. & Klein M.L. (1994). Constant pressure molecular dynamics logarithms. Journal of Chemical Physics 101(5): 4177-4189.

SYNTHESIS AND CHARACTERIZATION OF GRAPHENE OXIDE FROM SRI LANKA GRAPHITE

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ABSTRACT

As Sri Lanka exports graphite in the raw form at very low price it requires a value addition to export at a high price. Graphite oxide (GO) was synthesized from the Sri Lanka graphite using a laboratory modified version of the Hummer method as a value addition to graphite source in Sri Lanka. The prepared products were characterized using XRD and FTIR. XRD data show a complete conversion of graphite to graphite oxide during the chemical oxidation while FTIR gives an indication of the presence of relevant functional groups.

Keywords: *Graphite, Graphite oxide, value addition*

INTRODUCTION

Sri Lanka has been exporting her own natural resources at low prices with no value addition, one of which is the natural graphite extracted from the mines of Kahatagaha and Bogola, which is known to be one of the purest forms of graphite in the world. Pure graphite is processed into more versatile and value added materials namely graphene oxide and grapheme, which are used to manufacture high-end technical products such as micro-processors, integrated circuits, energy storages and photovoltaic cells that demand high prices. Therefore, a fine value addition should be imparted to our graphite in order to dissuade low priced exports, which can be fulfilled by converting it into graphene oxide (GO) and graphene by further processing of GO. GO consists of an extremely thin layer or several layers of that sort and can be conveniently prepared from the Hummer method1. The present work is limited to synthesis of multi layer graphene oxide from the Kahatagaha and the Bogala graphite mines.

EXPERMENTAL METHOD

A laboratory modified version of the Hummer method was used to synthesize GO, where graphite is treated with sulfuric acid and potassium permanganate followed by the hydrothermal reduction. GO was prepared using the graphite from the mines of Kahatagaha (KG) and Bogala (BG). Characterization of the prepared GO was carried out with BET, XRD and FTIR. The resulting material (GO) was dried at 65^{o}C overnight.

The final products were characterized using FTIR for the analysis of functional groups; XRD for the phase identification; and BET for surface area analysis.

RESULTS AND DISCUSSION

X-ray Diffraction Analysis

Figure 1 shows the XRD spectrum of graphite and synthesized graphene oxide. From the disappearance of the characteristic 2ϴ peak of graphite at about 26º and appearance of graphite oxide (GO) at about 11º clearly show that the graphite is completely converted to graphite oxide during the chemical oxidation. There is no significant difference between GO synthesized from the graphite mines of Bogala and Kahatagala. BET surface area analyses revealed that GO samples were of high surface area indicating 1-6 layer graphene oxide.

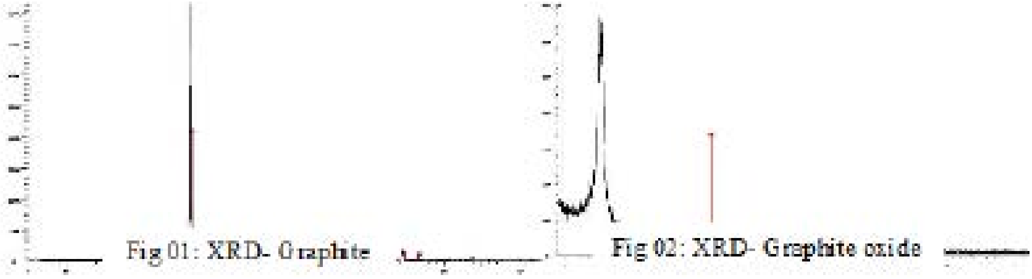

Figure 1. XRD spectrum of graphite and graphite oxide.

FTIR Spectra Analysis

The peak at 3414 cm^{-1} attributable to O–H stretching vibrations of structural OH groups, and the peak at 1371 cm^{-1} attributable to O–H bending vibrations are strong for graphite oxide indicating a high inclusion and attachment of water to the same.

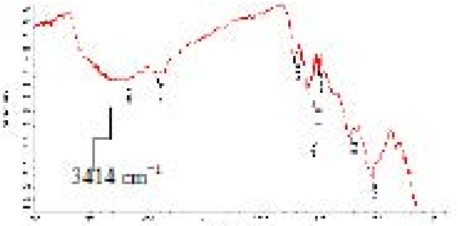

Fig 01: XRD- GO

REFERENCES

1. I.R.M. Kottegoda, N.H. Idris, L.Lu, J.Wanga & H. Liua (2011) Synthesis and characterization of graphene–nickel oxide nanostructures for fast charge–discharge application. Electrochim. Acta 56 : 5815-5822.

KERKER INVISIBILITY WITH FRACTAL SHELLS

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ABSTRACT

The “Kerker Invisibility” has been experimentally realized for silica/gold core-shell microspheres. A scattering suppression was observed for silica microspheres due to a gold shell with fractal structure. It is shown that the scattering peak in the visible range gradually decreases with increasing gold coverage. The relative contribution of the infrared absorption band of silica at 9.5 µm in the total extinction is also decreased for the gold-coated silica microspheres.

***Keywords**: Invisibility, Scattering, Plasmonics, and Nanofabrication*

INTRODUCTION

Metamaterials allow for the advances in both imaging and optical sensors. Metal nanostructures are capable of supporting localized plasmon modes, and act as nano-antennas that resonate in a broad spectral range. The electromagnetic fields can be concentrated by the plasmonic nanostructure in nano-sized areas called hot spots. The resonant frequencies of the plasmon oscillations in such a structure depend on the local morphology of the nanostructure (roughness, shape, etc.). The random nature of a fractal metal film, therefore, assures strong and broadband optical response from plasmons resonating in a range of wavelengths. Such strong, broadband resonances can be used as a basis for the development of efficient optical cloaking and photon harvesting. A general mechanism for scattering cancellation exploits the anomalous property of a local negative polarizability, which is inherent to plasmonic materials[1,2]. It follows from the expression for the core-shell

polarizability at $R_2 = \lambda$:

$$\alpha = 4\pi R_2^3 \frac{(\varepsilon_2-\varepsilon_m)/(2\varepsilon_2+\varepsilon_m)-f(\varepsilon_2-\varepsilon_1)/(2\varepsilon_2+\varepsilon_1)}{(\varepsilon_2+2\varepsilon_m)/(2\varepsilon_2+\varepsilon_m)+f(2\varepsilon_2-2\varepsilon_m)(\varepsilon_1-\varepsilon_2)/(2\varepsilon_2+\varepsilon_m)(\varepsilon_2+\varepsilon_1)} ;f = \left(\frac{R_1}{R_2}\right)^3$$

Cloaking of a silica microsphere with plasmonic shell[3] and cloaking via radial dependence of the shell permittivity[4, 5] was also predicted.

Here we experimentally demonstrate scattering suppression of silica microspheres by Au fractal nanostructures formed as a shell.

RESULTS AND DISCUSSION

The gold shells were chemically synthesized on silica microspheres using formaldehyde reduction method[6], modified in order to form fractal structure. These Au fractal films on silica spheres are shown to have reasonable extinction in the visible and mid-infrared (mid-IR) range[7]. In the experiments, Au-coated silica microspheres were deposited on fused silica/glass and infrared-compatible zinc selenide (ZnSe) substrates for visible and Fourier-Transform Infrared (FTIR) spectroscopy analysis.

The surface coverage of the gold on the sphere surface was varied for different samples. The extinction spectra for these samples are shown in Fig. 1. The spectra for samples with gradually increasing gold coverage are labeled by 1 - 5. It is found that the scattering peak in the visible range gradually decreases with increasing of the gold coverage. The relative contribution of the vibrational stretching band of silica at 9.5µm in the total extinction is also decreased for the gold-coated silica microspheres[8].

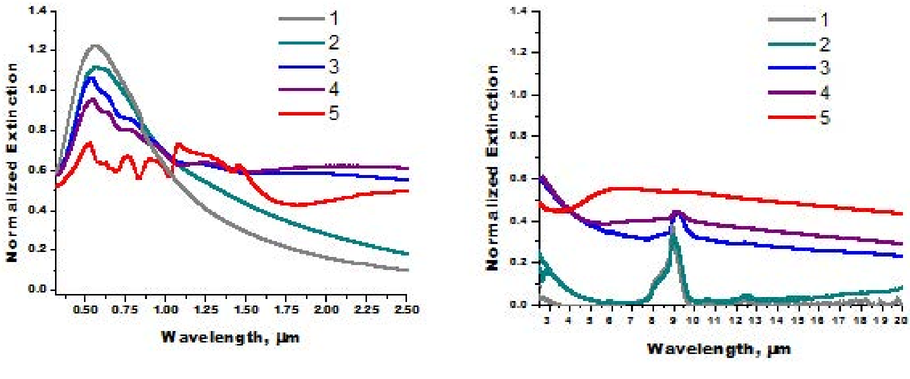

Figure. 1. Shown in (1a) and (1b) are the color coded normalized extinction spectra in both the VIS/NIR and IR, respectively, of increased Au surface density on the silica microspheres.

REFERENCES

1. Arthur L. Aden, and Milton Kerker (1951). Scattering of electromagnetic waves from two concentric spheres. Journal of Applied Physics 22(10): 1242-1246.
2. M.Kereker (1975). Invisible bodies, Journal of Optical Society of America B 65(4): 376-379.
3. A.Alù and N. Engheta (2005). Achieving transparency with plasmonic and metamaterial coatings. Physical Review E 72(1): 016623.
4. U. Leonhardt (2006). Optical conformal mapping. Science 312(5781): 1777-1780.
5. J. B. Pendry (2006). Controlling electromagnetic fields. Science 312(5781): 1780-1782.
6. T. Pham, J. B. Jackson, N. J. Halas, and T. R. Lee (2002). Preparation and characterization of gold nanoshells coated with self-assembled monolayers. Langmuir, 18(12): 4915-4920.
7. V. C. de Silva, J. L. Stewart, V. M. Shalaev, and V. P. Drachev (2012). Broadband extinction of core-shell microspheres. Proceedings of Lasers and Electro-Optics (CLEO) and Quantum Electronics and Laser Science (QELS) conference in San Jose, CA, USA, 6-11 May. Optical Society of America, USA, JTh2A.100.
8. V. P. Drachev, V C. de Silva, P. Nyga and V. M. Shalaev (2009). Scattering cancellation with plasmonic shells. Proceedings of the international society for optics and nanophotonics (SPIE) conference in of in San Jose, CA, USA, 4-9 May. Optical Society of America, USA, QTuJ3.

DETERMINATION OF INTER-LAYER AND STRUCTURAL IRON CONTENT IN MURUNKAN CLAY

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ABSTRACT

The smectite content of bentonite and montmorillonites can be improved by removing the associated gangue compounds such as sand, gravel, quartz, feldspars, calcite, iron and humic acids. In this work, the level of iron impurity in the inter-layer and structure of the Murunken clay was determined using hydrochloric acid in the batch extraction process. In montmorillonite, substitutions mainly take place in the octahedral sheets (2). Various concentrations of HCl were used to remove this inter-layer irons. The structure of the clay was checked by X-ray Diffraction Spectroscopy (XRD) to confirm the structure of the clay. The structural iron content of this clay was determined by digestion of HCl treated clay and the interlayer iron content was determined by batch extraction process with HCl. The iron content of these clay samples were analysed using Atomic Absorption Spectroscopy (AAS).

***Keywords**: Clay, Iron*

INTRODUCTION

Montmorillonite (MMT) and bentonite belong to the general family of 2:1 layered silicates. Their crystal structure consists of the layers made of two silica tetrahedral fused to an edge-shared octahedral sheet of either aluminum or magnesium hydroxide[1]. Isomorphic substitution within the layers generates negative charges that are normally counter balanced by cations residing in the inter-layer space[2]. These irons can be stayed in two places in the clay: (a) In between the layers and (b) In the structure of the clay[3]. Murunkan clay was analysed to determine the iron contents and the results show that iron content was nearly 6.8% by weight. This means both the inter-layer and the structural iron content is about 6.8%. In this work, the iron content in the inter-layer and in the structure was determined by HCl treatment and the digestion process respectively.

EXPERIMENTAL

0.500g montmorillonite clay sample was treated with 50.0 ml of 0.5M HCl solution at 1000C with vigorous stirring for 30 minutes and was kept until all the clay particles settled down. Then the supernatant was separated and remaining clay was treated with

HCl in the same manner. This procedure was repeated until all the free irons (inter-layer iron) come out from the clay. The structure of the clay was checked further with X-ray diffraction spectroscopy. Then the HCl treated sample was completely digested to determine structural iron content. The elemental analysis was carried out using Atomic absorption spectroscopy.

RESULTS AND DISCUSSION

Figure 1 shows the XRD pattern of the HCl treated clay. This XRD pattern proves that the structure of the clay was not damaged during the HCl treatment. The supernatants of the HCl treated clay samples were studied using AAS to determine the inter-layer ion content. The results of this AAS studies are given Table 1.

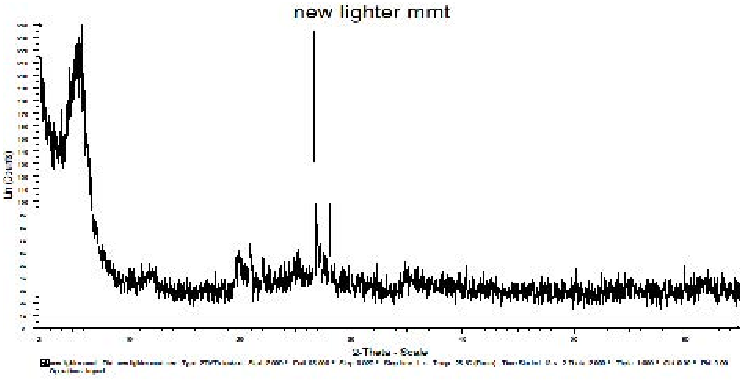

Figure 1: XRD pattern of the clay after the acid treatment

Atomic Absorption Data provides the total free iron amount in montmorillonite in murukan bay around 47.20mg/g.

Table 1: Atomic Absorption Spectroscopy data of supernatants of HCl treated clay

Extraction	**Iron concentration in the supernatant (mg/g)**
1st extraction	7.08
2nd extraction	7.05
3rd extraction	7.00
4th extraction	6.83
5th extraction	6.31
6th extraction	4.24
7th extraction	3.20
8th extraction	2.28
9th extraction	2.13
10th extraction	1.08

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From the batch extraction process, the interlayer iron concentration of montmorillonite clay was determined and it was around 47.20mg/g.

After the batch extraction process, a clay sample was completely digested and the structural iron concentration was determined and it was 21.60 mg/g.

REFERENCES:

1. Chi-Nhan H T., Anne G. C., Laurence R., Fumihiko O., Huy T.H., Laurent D., (2010) Separation and purification of montmorillonite and polyethylene oxide modified montmorillonite from Vietnamese bentonites, Applied Clay Science 49 (3) 229 - 238.
2. Abollino O., Giacomino A., Malandrino M., Mentasti E., Interaction of metal ions with montmorillonite and vermiculite, (2008) Applied Clay Science 38 (3–4) 227 - 236.
3. González J.A., del M. Ruiz C., (2006) Bleaching of kaolin and clays by chlorination of iron and titanium, Applied Clay Science 33 (3–4) 219 - 229.

CORE LEVEL AND NEAR EDGE X-RAY ABSORPTION SPECTROSCOPY (NEXAFS) OF FLEXIBLE MULTILAYER GRAPHITE OXIDE MEMBRANE

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ABSTRACT

Synchrotron radiation based core level photoemission and near-edge X-ray absorption spectroscopy (NEXAFS) are used to investigate self-assembled multilayer graphene oxide (GO) membrane in UHV. GO membrane is fabricated using graphite oxide based on a rare form of naturally occurring graphite namely, Ceylon vein graphite. Survey and core level photoemission spectra show that while natural vein graphite is mainly consisting of sp^2 type carbon, multilayer GO membrane is consisting of sp^2 and sp^3 type carbon atoms. Oxygen functionalities such as C-OH, –C=O and – C-O-C- are responsible for sp^3 carbon atoms in GO. C K edge NEXAFS confirms neither hydrogenated nor oxygenated carbon species present on vein graphite and it is pure and crystalline. C K edge NEXAFS further show that the multilayer GO membrane behaves as a material composed of completely decoupled layers when the electric field vector, E, of the X-ray beam is out-of-plane.

Keywords: *graphene oxide membrane, self-assembled, synchrotron radiation, C K NEXAFS, core levels.*

INTRODUCTION

In recent years, there is a surge in the interest of graphite oxide, in particular, the single layer of graphite oxide, in nanotechnology research because of the rise of a new class of material based on single and few layer of graphite[1-3].Single or few layers of graphite find a number of interesting applications[4-6]. Graphite oxide can be used as a precursor to produce single or few layers of graphite via chemical methods[7]. In this presentation, the fabrication of a multilayer graphite oxide membrane using a rare form of naturally occurring Ceylon vein graphite and investigations using tunable synchrotron radiation based techniques and other spectroscopic and microscopic techniques will be discussed.

RESULTS AND DISCUSSION

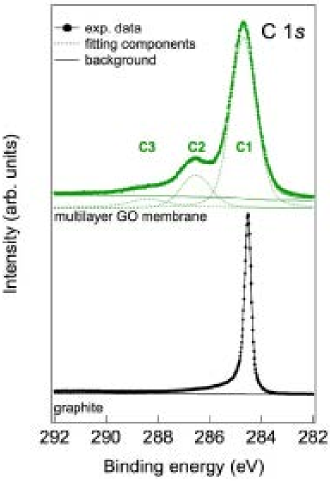

Figure 2

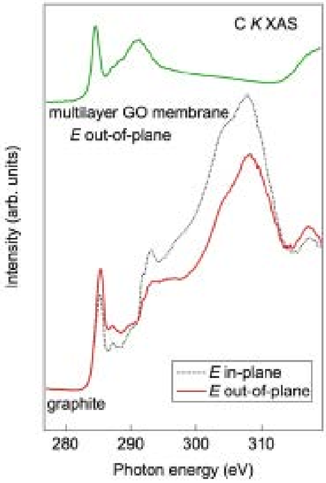

Figure 1

Figure 1 shows the C 1s core level spectrum recorded from vein graphite and multilayer GO membrane at photon energy of 588 eV. The clear peak seen at a binding energy (BE) of 284.5 eV is assigned to sp2 hybridized C atoms in graphite. There are three components in the C 1s spectrum of multilayer GO membrane, which are due to different oxygen functionalities with sp3 hybridized carbon atoms. In Figure 2, C K edge NEXAFS spectra recorded from vein graphite and multilayer GO membrane are shown. The dependence of the intensity of spectral features (1 s to π* and 1 s to σ* transitions) on the polarization of incident light can clearly be seen with vein graphite and multilayer GO membrane. Multilayer GO membrane behaves similar to single layer of graphite, i.e., graphene, when X-ray photons are incident at grazing (E-out-of-plane) with respect to the plane of GO.

REFERENCES

1. Berger, C. et al. Science, 2006, 12, 1191
2. Geim, A. K. & Novoselov, K. S. Nature Mater. 2007, 6,183
3. Allen, M.J., Tung, V.C. & Kaner, R.B. Chem. Rev. 2010, 110, 132
4. Zhang, Y.B., Tan, Y.W., Stormer, H,L, Kim, P. Nature, 2005 , 438 , 201.
5. Novoselov , K. S.. Geim, A. K. Morozov, S. V Jiang , D. Zhang , Y. Dubonos , S. V. Grigorieva, I. V. Firsov , A. A. Science 2004 , 306 , 666.
6. Liu, Y. H. Xue, J. S. Zheng , T. Dahn , J. R Carbon 1996 , 34 , 193
7. Stankovich, S. Dikin, D. A.. Piner, R. D. Kohlhaas K. A,. Kleinhammes, A. Jia, Y Wu Y., Nguyen, S. T. Ruoff , R. S Carbon .2007, 45, 1558.

Session E

Medicine and Agriculture

INVESTIGATION OF POTENTIAL ABILITY OF NANOEMULSION FORMULATION, FOR TRANSDERMAL DELIVERY OF DICLOFENAC SODIUM

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ABSTRACT

Microemulsions have been investigated as the potential drug delivery candidates. The aim of the present study was to investigate a micro-emulsion formulation for transdermal delivery of diclofenac sodium. The micro emulsion area was identified by constructing pseudo-ternary phase diagrams of water, olive oil and Span 80 system. Transdermal permeation of diclofenac through pig ear skin was compared with the commercially available diclofenac gel (DICLORAN* Gel) using a Franz diffusion cell. A significant increase in permeability parameters such as steady-state flux (Jss), permeability coefficient (Kp), and average permeation was observed in optimized microemulsion formulation, which consisted of 79% (w/w) of olive oil, 10% (w/w) of span 80®, 10% (w/w) of distilled water and 1% (w/w) of diclofenac sodium.

Keywords: *microemulsion, Span 80, diclofenac sodium, Skin permeation, Franz diffusion cell.*

INTRODUCTION

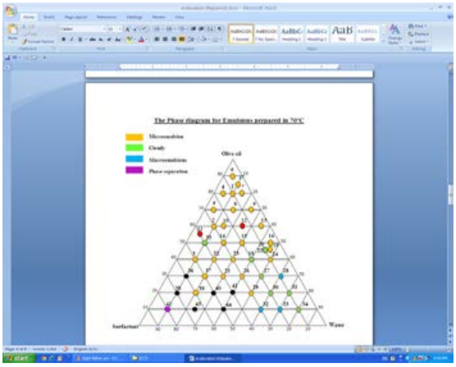
Microemulsions are excellent systems for drug delivery because of their improved drug solubilization, long shelf life, and ease of preparation and administration. Assessment of percutaneous permeation of molecules is one of the main steps in the initial design and later in the evaluation of dermal or transdermal drug delivery systems.[1] Span 80 was used as the emulsifier in the olive oil-water system. Pseudo-ternary phase diagrams were constructed at room temperature and 70 ºC. The objective of this study was to evaluate diclofenac sodium permeation potential in pig ear skin using a Franz diffusion cell system, in order to identify which emulsion combinations (DICLORAN Gel and micro emulsion system) have the highest skin permeation. We determined the steady-state flux (Jss), permeability coefficient (Kp), and the average permeability of microemulsion and commercially available cream, which contains diclofenac sodium.

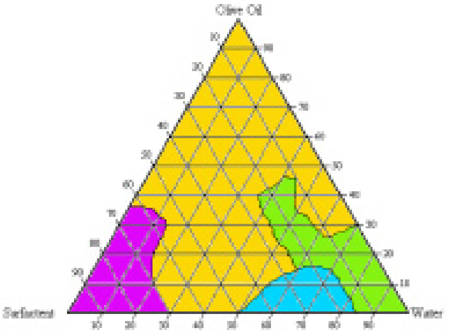
METERIALS AND METHODS

The following reagents were used: Diclofenac was a gift sample from the State Pharmaceutical Corporation. Fresh ears were kindly provided by a slaughterhouse plus the olive oil with a non-ionic surfactant Span 80® (99 %, Fluka). All chemicals used were of analytical grade. Olive oil 79 %, Surfactant 10 %, Water 10 %, and Diclofenac 1 % were thoroughly mixed at 70 ºC using Silverson SL2 Laboratory Emulsifier at 2500 rpm until they appeared to be homogeneous.

RESULTS AND DISCUSSION

By depending on the morphologies of the emulsions which were prepared phase diagrams were constructed at 70 ºC.





The pH values of all emulsions varied between 7 and 8. Flux and permeability coefficient (Kp), average permeation of nanoemulsion, and commercially available cream, which contains diclofenac sodium, average steady state flux, and permeability coefficient were calculated separately for the emulsion system and the commercial gel. These results suggested that nanoemulsions are potential vehicles for improved transdermal delivery of diclofenac sodium.

REFERENCE

1. Gulten Kantarcı, Işık Ozguney,H.,Yeşim Karasulu, Sevgi Arzık, & Tamer Guneri. Comparison of Different Water/Oil Microemulsions Containing Diclofenac Sodium, Preparation, Characterization, Release Rate & Skin Irritation Studies. AAPS PharmSciTech 2007. 8 (4) Article 91.

FORMULATION OF LIPOSOMES ENCAPSULATED WITH ACETYLSALICYLIC ACID

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ABSTRACT

This study is concerned with formulation of liposomes with new promising perspectives for establishing efficient carriers for drug delivery by using different compositions of phospholipids and glycolipids, and encapsulating acetylsalicylic acid (aspirin). A comparison study was conducted to evaluate the performance of the formulations and to characterize the prepared liposomes with respect to encapsulation efficiency, pH effect, and drug release. It was observed that modification of liposome vesicle using phospholipids and glycolipids together enhanced the encapsulation efficiency and provided slow release at stomach pH.

Keywords: *Acetylsalicylic acid, drug delivery, liposomes, encapsulation efficiency*

INTRODUCTION

Liposomes are made of various amphiphiles. The crucial feature of these molecules is that upon hydration they are able to form aggregation structures resembling an array and have properties of natural phospholipid bilayers[1]. Natural lipids, particularly those with aliphatic chains attached to the backbone by means of ester or amide bonds (phospholipids, sphingolipids and glycolipids) are candidates for liposome formation. In the early 70's the use of liposomes as a drug carrier system was proposed by Gregoriadis and Ryman. Since this first report, liposomes were developed as an advanced drug delivery vehicle. They are generally considered non-toxic, biodegradable and non-immunogenic. Associating a drug with liposomes markedly changes its pharmacokinetics and lowers systemic toxicity; furthermore, the drug is prevented from early degradation and/or inactivation after introduction to the target organism[2].

MATERIALS AND METHODS

Materials:

D-glucose, Anhydrous sodium acetate, Acetic anhydride, β–Sitosterol, Dichloromethane, Boron triflouride diethyl etherate (BF3.Et2O), Nitrogen gas, Sodium bicarbonate, Egg Yolk, Ethanol, Pet ether, Acetone, Chloroform, Aspirin, and Deionized water.

Method:

The D-glucose was acetylated and reacted with β–Sitosterol to form glycolipid (β-sitosteryl 2,3,4,6,-tetra-O-acetyl-β-D-glucopyranoside; liquid crystal). Phospholipid was extracted from egg yolk. Liposomes were prepared by using different compositions of glycolipid and phospholipid. Aspirin was added in the hydration step. The liposomes were separated and absorbance of supernatants and the pure drug sample were measured in the range of 200 - 300 nm and encapsulation efficiency was determined.Aspirin release from liposomes was studied using dialysis method in media of deionized water, pH 8.6 and pH 2.0 buffer solutions.

RESULTS AND DISCUSSION

The encapsulation efficiency of drug for all the formulations was around 72- 84 %. This proves that glycolipid shows the properties similar to conventional phospholipids used to prepare liposomal formulations, but best encapsulation efficiency was found in liposomes with 1:1 composition of glycolipid and phospholipid. The content of aspirin in this composition was 83.4%. A good percent loading of the drug makes the delivery of drug clinically feasible. Aspirin is one of the most widely used analgesics, but precipitation in stomach due to its low water solubility is responsible for many gastrointestinal (GI) side effects. Liposomes can entrap poor water soluble as well as water insoluble drugs. Therefore encapsulation of aspirin in liposomes is an efficient way of delivering and it helps to minimize the GI irritation. Also it has slow release in acidic pH (2.0). It increases circulation lifetimes in the stomach and enhance the opportunity for liposomes, administered systemically, to leave the vascular compartment and enter certain extra vascular regions.

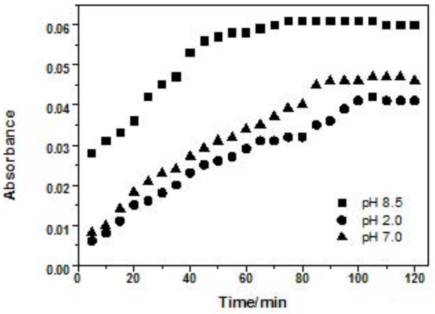

Figure 1: Drug release of liposome formulated with 1:1 composition of phospholipid and glycolipid at different pH values

REFERENCES

1.Williams A. (2003). Transdermal and Topical Drug Delivery from Theory to Clinical Practice, [e-book], Great Britain: Pharmaceutical press, Available at http://books.google.lk/books Accessed September 2011

2.Schuber F. Kichler A. Boeckler C and Frisch B. (1998). Liposomes: from membrane models to gene therapy [pdf], Available at http://media.iupac.org/publications/pac/1998/pdf/7001x0089.pdf Accessed September 2011

EFFECT OF VARIATION OF LIPID COMPOSITION ON PROPERTIES OF A LIPOSOMAL DELIVERY SYSTEM

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ABSTRACT

Liposomes have been used extensively in numerous fields because of the desirable attributes of these vesicles as the carrier systems of various agents including bioactive compounds. In this study, the effect of variation of liposomal composition on encapsulation efficiency and loading capacity was investigated using a highly antioxidant plant extract as the encapsulated species. In addition, *in vitro* release studies were conducted in order to determine the effect of lipid composition on sustained-release properties of liposomes.

***Keywords**: Liposome, phosphatidylcholine, cholesterol, Schumacheria castaneifolia Vahl*

INTRODUCTION

Since the existence of liposomes was reported first by Bangham et. al., numerous researchers have explored and improved the properties of liposomes doing innovative research in order to make these vesicles suitable to execute specific functions. As a result, liposomes, currently, play an important role in numerous industries, functioning as carriers of various structures or compounds.

Lipid composition is a main factor that influences the encapsulation efficiency, loading capacity and release properties of liposomes. Thus, liposomes with different lipid compositions were prepared in order to determine the optimum composition. The effect of lyoprotectants on the loading capacity of liposomes was also investigated. Finally, in vitro release studies were conducted in different media in order to determine the effect of lipid composition on the release of liposomal extract.

MATERIALS AND METHODS

Materials

Phosphatidylcholine (PC) (~ 60 % TLC) and cholesterol (CH) were purchased from Sigma-Aldrich. Sucrose (Extra Pure) and diethyl ether were purchased from LOBA

Chemie PVT. LTD., India. All other solvents were distilled before using and the rest of the chemicals were of analytical grade. Sephadex G50 was from GE healthcare.

METHODS

Preparation of Liposomes

Liposomes were prepared following the reverse-phase evaporation method. Briefly, an emulsion was made using diethyl ether in which the lipids were dissolved in an aqueous solution of water soluble components. After that, the organic solvent was evaporated to form liposomes in the aqueous phase. Either centrifugation or gel-filtration was used to separate extract encapsulated liposomes from free un-encapsulated extract. The ratios of PC to CH used to prepare liposomes were: 10:0, 9:1, 8:2, 7:3 and 6:4. Another set of liposomes were prepared in the presence of sucrose.

Characterization of Liposomes

Particle sizes of liposomes were determined using a particle size analyzer. In order to determine the encapsulation efficiency and loading capacity of liposomes, those vesicles were, first, disrupted using a mixture of methanol and ethanol, and then the amount of encapsulated extract was quantified spectrophotometrically.

In Vitro Release Study

In vitro release studies were conducted using deionized water or buffer systems as the release media. The effect of liposomal lipid composition on the release behavior of extract (i.e. the methanol extract of stem-bark of S. castaneifolia V. encapsulated liposomes was studied).

RESULTS AND DISCUSSION

Particle size measurements revealed that the diameters of plain liposomes and the extract encapsulated liposomes were in the nanometer scale. This result is particularly important because the liposomes with sizes in the nanometer range may facilitate topical or transdermal drug delivery.

High encapsulation efficiencies and loading capacities were observed for the extract encapsulated liposomes. In fact, encapsulation efficiencies of liposomes ranged from 44 - 86 per cent whereas the loading capacities ranged from 4.2 - 8.0 per cent. Also, it was revealed that the presence of lyoprotectants does not affect the loading capacities of the extract encapsulated liposomes.

Lipid packing and fluidity of membranes depend on the cholesterol content. Besides, numerous authors have demonstrated the effect of cholesterol on the leakage of encapsulated material from liposomes. Thus, results of in vitro release studies will be discussed in order to illustrate the effect of cholesterol on sustained-release properties of liposomes encapsulating the methanol extract of stem-bark of S. castaneifolia V.

REFERENCES

1. Bangham A.D., Standish M.M. & Watkins J.C. (1965). Diffusion of univalent ions across the lamellae of swollen phopholipids. Journal of Molecular Biology 13(01):238-252.
2. Abra R.M., Mihalko P.J. & Schreier H. (1990). The effect of lipid composition upon the encapsulation and in vitro leakage of metaproterenol sulfate from 0.2 μm diameter, extruded, multilamellar liposomes. Journal of Controlled Release 14(01):71-78.

PLANT NUTRIENT NANOPARTICLES ENCAPSULATED CELLULOSE MATRIX FOR SLOW AND SUSTAINED RELEASE OF NITROGEN

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ABSTRACT

In this study a green nano-fertilizer system for slow and sustained release of nitrogen has been developed with two nano-systems viz., a) inorganic inner nano-core consisting of macronutrient nanoparticles, and b) a natural cellulose based outer core containing micro/nano porous cavities. Hydroxy Apatite (HA) nanoparticles were synthesized by wet chemical method and the surface modified with urea, the most widely used water soluble plant nitrogen nutrient source and a fertilizer composition was manufactured by encapsulation of urea modified HA nanoparticles into micro/nano porous cavities of the young stem of Glyricidia sepium (Jacg.) Kunth Walp., under pressure. The resulting fertilizer composition was tested for slow release properties in three types of soils from three elevations in Sri Lanka, and compared the release behavior with that of a commercial fertilizer composition. It was found that the nanosystem released the macronutrients in a slow and sustained manner by depending on the morphologies of the emulsions, which were prepared phase diagrams that were constructed at 70 ºC more than over a 60 day period and field trials using paddy indicated an improved crop yield compared to the trials carried out with conventional fertilizer.

Keywords: *Slow and sustained release, nano fertiliser, haydroxyapatite nanoparticles, urea modified hydroxyapatite, encapsulate*

BACKGROUND

Evaluated as a key nutrient source for food, fiber and biomass production in agriculture, nitrogen, phosphorous and potassium are the most important elements in fertilizer. However, considering the energy required in its synthesis and the large tonnage required, the cost of fertilizer has a high monetary value. Because in the conventional fertilizer 50 – 70 % of nutrients particularly N and K are lost to soil nutrient utilization efficiency (NUE) by plants is low, adding to the cost of getting nutrients into the plant; leaching of nitrogen can happen by way of water soluble nitrates, emission as ammonia and nitrogen oxides and soil microorganism mediated incorporation into soil organic matter over time. Attempts to increase the NUE in conventional fertilizer formulations have so far resulted in little success.1 On the other hand, the emerging nano-strategies indicate that, due to the high surface area to volume ratio, nano-fertilizers are expected to be far more effective than even polymer-coated conventional fertilizers.

EXPERIMENTAL

Urea modified HA nanoparticles were synthesized using a method explained by Kottegoda et. al. 2 A fertilizer composition was manufactured by encapsulation of a nano-dispersion of urea modified HA nanoparticles into micro/nano porous cavities of the young stem of Glyricidia sepium (Jacg.) (G. sepium) Kunth Walp., under pressure. Release behavior of nitrogen in the nano-fertilizer composition was studied using soil from three elevations in Sri Lanka viz., sandy soil (pH 7), and acidic soil (pH 4.2 and pH 5.2) and compared the release characteristics with that of a commercial fertilizer composition, which contains urea as the nitrogen source. Field trials were conducted using paddy plants and compared the efficacy of the fertilizer system with that resulted in using conventional fertilizer systems.

RESULTS AND DISCUSSION

HA nanoparticles and urea modified HA nanoparticles displayed a rod like morphology with an average diameter of 15 – 30 nm. Successful surface modification of HA nanoparticles with urea was confirmed by FTIR studies. The nano-dispersion prepared using urea modified HA nanoparticles were characterized using particle size analysis and the stability of the dispersion was studied by zeta potential measurements (59 mv). The composite prepared using urea modified HA nanoparticle dispersion encapsulated G. sepium was also characterized using SEM, FTIR and elemental analysis. The release properties of the nano-fertilizer encompassed an initial burst release and subsequent slow and sustained release. In general, at all pH values, even on day 60, the nano-fertilizer was releasing nitrogen > 200 ppm, showing the efficacy of the slow release process. In comparison, the commercial fertilizer showed release of a large quantity at about day 4 followed by the release of low and non-uniform quantities until around day 23. Field trials carried out at Rice Research and Development Institute indicated an increase in the yield with 25 – 40 % saving in nitrogen fertilizer leading to a successful green nano-fertilizer formulation.

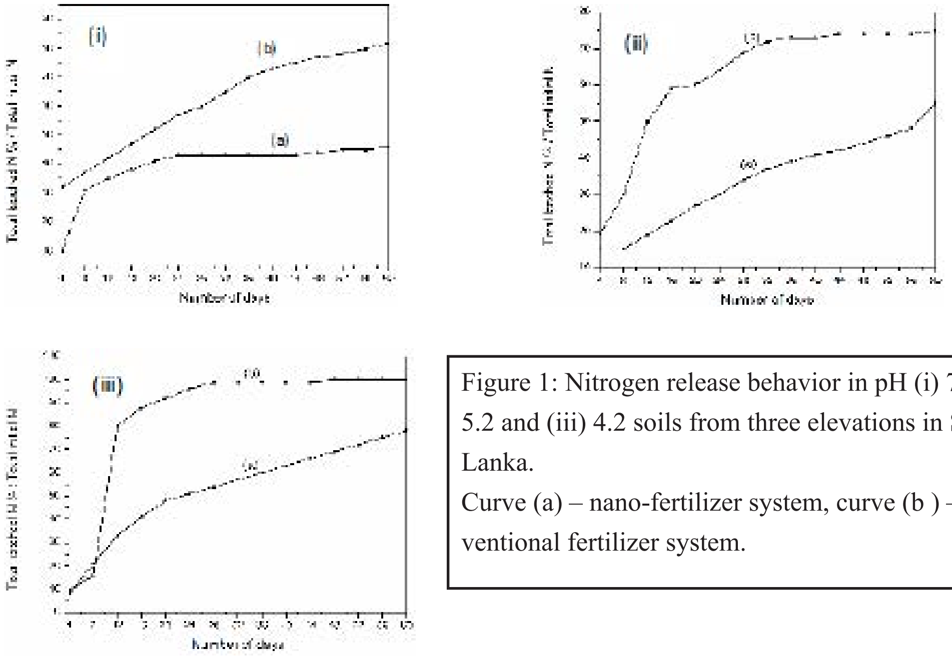

Figure 1: Nitrogen release behavior in pH (i) 7, (ii) 5.2 and (iii) 4.2 soils from three elevations in Sri Lanka.
Curve (a) – nano-fertilizer system, curve (b) – conventional fertilizer system.

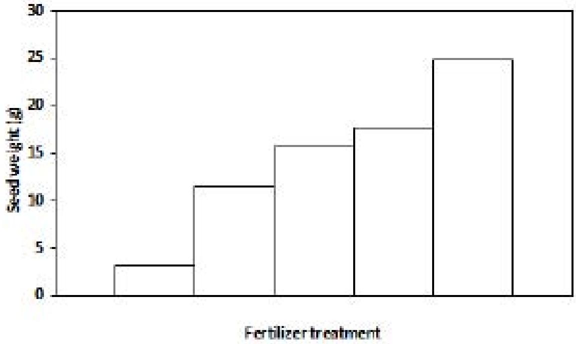

Figure 2: Comparison of the paddy yields for urea modified HA nanoparticle encapsulated wood system
(a) – No fertilizer
(b) - Department of agriculture recommended fertilizer application
(c) – 50 % of the DOA recommended amounts from nano-fertilizer
(d) – 75% of the DOA recommended amounts from nano-fertilizer
(e) – 100% of the DOA recommended amounts from nano-fertilizer

REFERENCES

1.De Rosa M. C., Monreal C., Schnitzer M., Walsh R., Sultan Y. (2010). Nanotechnology in fertilizers. Nature Nanotechnology 5, 91.

2.Kottegoda N., Munaweera I., Madusanka N., Karunaratne V. (2011). A green slow release fertilizer composition based on urea modified hydroxyapatite nanoparticles encapsulated wood. Current Science 101(01): 73 -78.

USE OF NANO-K FERTILIZER AS A SOURCE OF POTASSIUM IN RICE CULTIVATION

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ABSTARCT

Field experiments were conducted after preliminary investigations at green house conditions to find out the suitability of nano-K fertilizer as a potassium source in rice production. Performances of nano-K fertilizer were compared against muriate of potash (MOP). Application rates of MOP and nano-K fertilizer were 20, 30 and 40 kg K_2O ha^{-1}. Application of MOP did not show any significant improvement in yield over 0 kg K_2O ha, but application of nano-K fertilizer at the rate of 20 kg K_2O ha^{-1} showed a significant improvement of number of seeds per panicle and grain yield over 0 kg K_2O ha^{-1}. The estimated yield increase by nano– K fertilizer over MOP at 20 kg K_2O ha^{-1} is around 10% and there was no significant difference between 20 kg K_2O ha^{-1} and 30 kg K_2O ha^{-1}. Results of preliminary investigation at the green house as well as in the field experiments suggested that nano-K fertilizer is a better source of potassium in rice cultivation not only to increase the grain yield but also to save the K fertilizer use.

***Keywords**: Nano-fertilizer, Potassium, Rice*

INTRODUCTION

According to the FAO Report (1992), a majority of the experiments conducted in many locations island wide have not shown a significant response to application of potassium and as such, the potassium use efficiency of rice is below 60 % (Dobermann & Fairhurt, 2000). The slow release K fertilizer application and the demand driven K application are some of the solutions to improve the K use efficiency in rice. Therefore, it is necessary to conduct experiments to find out the suitability of slow release K fertilizers to replace MOP from the rice production.

MATERIALS AND METHODS

Experiments were conducted in 2011 at the Rice Research and Development Institute, Batalagoda. Nano-K fertilizer used in the experiment had 13% K_2O and Montmorilinite contained as a carrier. Treatments in the field experiments were: no applied K fertilizer, K applied at 20, 30 and 40 kg K_2O ha^{-1} in the forms of MOP and nano-K fertilizer each. Nano-K fertilizer was added only as the basal while 50% MOP was added at the basal and 50 % at the panicle initiation.

RESULTS AND DISCUSSION

No significant increase in grain yield was observed when MOP is added as a source of K fertilizer (Table 1). The response was significantly high when K was added as nano-K formulation. With the slow nature of nutrient release, such fertilizer provides nutrients suit to the plant demand (Sirisena et al., 2003). As such, application of nano-K fertilizer produced a higher number of tillers, seeds per panicles, as well as grain yields. The estimated yield increase by nano– K fertilizer over MOP at 20 kg K_2O ha^{-1} is around 10 % and there was no significant difference between the application 20 kg K_2O ha^{-1} and 30 kg K_2O ha^{-1}.

Table 1. Effect of MOP and nano-K fertilizer on number of tillers, grain yield and yield component.

Treatments	Number of tillers	Number of panicle	Seeds per panicle*	1000 grain weight	Grain yield (t/ha)*
0 kg K_2O/ha - MOP	9.2	8.3	103.3b	21	6.21b
20 kg K_2O/ha - MOP	8.4	8.6	105.0b	22	6.29b
30 kg K_2O/ha - MOP	8.7	7.8	112.2b	21	6.37b
40 kg K_2O/ha - MOP	8.9	8.4	111.4b	21	6.29b
20 kg K_2O/ha –Nano-K	9.3	7.0	134.1a	21	6.86a
30 kg K_2O/ha –Nano-K	8.7	6.9	131.6a	22	7.00a
40 kg K_2O/ha –Nano-K	9.9	7.0	127.1a	22	6.66a

**Within each column values followed by same letter are not significantly different at P = 0.05

REFERENCES

1.Dobermann A. and Fairhurt T.H.. (2000). Rice Nutrient Disorders and Nutrient management. 147- 149p Potash & Phosphate Institute (PPI), Potash & Phosphate Institute of Canada (PPIC) and International Rice Research Institute, Manila, Philippine.

2.FAO , 1992. Nutrient management of rice in major lowland rice soils of Sri Lanka. Field Document No. 10, 106 p

3.Srisena D. N., Wickramasinghe W. M. A. D. B., Weerakoon W. M. W., Kumaragamage D. and Bandara S. T.(2003). Evaluation of leaf N based nitrogen fertilizer management in irrigated transplanted rice. Annuls of the Sri Lanka Department of Agriculture 5: 233-241

Session F

Nanocoatings

DEVELOPMENT OF LOW COST AND HIGHLY EFFECTIVE SELF-CLEANING CERAMIC TILES USING NANO TECHNOLOGY

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ABSTRACT

Environmental hygiene in all aspects is becoming a debate today. The present trends in modern developments with less careness to the environment have accelerated the deterioration of the environment. Thus the research and development in the applications of hygiene building materials are taking place rapidly.In the present work, a self-cleaning coating with scratch resistance and semi-transparency was developed with commercially available nano-sized TiO_2. A simple, economically feasible and low firing method of coating with least phase transition of anatase to rutile was adopted.

***Keywords**: self-cleaning, phase transition, tile, Nano-coating,* TiO_2

INTRODUCTION

The recent studies showed that the development of self-cleaning surfaces has been the topic of the advanced research in nanotechnology. A number of techniques are found in the literature that has been used to deposit TiO_2 thin films on different type of substrates. The unique properties such as optical, electrical and photoelectrochemical of titanium dioxide (TiO_2) have been the major reasons for using it as the principal raw material in many applications. More importantly the discovery of photoinduced super-hydrophilicity and self-cleaning effect of nano sized TiO_2 films has paved the way for wider applications for TiO_2 photocatalysis[1]. Recent research and development of photocatalytically active building materials or easy –to clean surfaces including TiO_2 [2-3], such as ceramic tile, glass windows can give self-cleaning and self-sterilization surfaces that could degrade several contaminants in the surrounding environment (e.g. sick building syndrome or reduction of car NO_x pollution) [4] is a good example of its use.

EXPERIMENTAL

A self-cleaning coating consisting of nano-sized TiO_2 was applied on commercially available ceramic tiles using the screen printing method. The temperature is optimized to retain the photocatalytic properties of TiO_2 coating while well adhering to the surface of the tile.

RESULTS AND DISCUSSION

Phase transition of nano-sized TiO_2 (anatase to rutile) is one of the major problems in applying the coating on the ceramic tile due to high temperature used in the ceramic industry. In this research a method was developed to mitigate the phase transition and thus preserving the photocatalytic properties of TiO_2. As shown in figure 1 the anatase phase is retained even at 750^{o}C.

The self-cleaning tile fabricated in the present study showed good hydrophilic, photocatalytic and antibacterial properties suitable to application as wall tiles or floor tiles used in swimming pools, ponds, sunsets that are exposed to sunlight. Light absorbed by the photocatalyst, TiO_2 generates the electron-hole pairs. Holes are accepted by adsorbed OH- ions to generate highly oxidative OH° which degrade the organic molecules. Electrons are consumed by adsorbed oxygen to yield superoxide ion O_2- and the charge transfer cycle is completed by reaction of O_2- with H÷ ions. It is clear that sunlight and the moisture are necessary for reaction of TiO_2 with organic pollutants including bacteria and fungi and decomposing them to non toxic components including CO_2 and H_2O. If the self-cleaning tile is applied in exterior walls, the sunlight destroys the pollutant and the rain washes away the dirt.

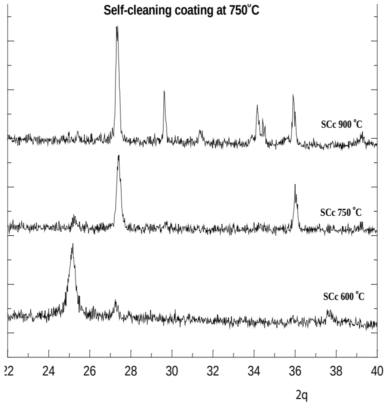

Figure 1: XRD patterns of self-cleaning coating

REFERENCES

1. 1.D'Oliveira J. C., Al-Sayyed G. & Pichat P. (1990). Photodegradation of 2-chlorophenol and 3-chlorophenol in TiO_2 aqueous suspensions. Environ. Sci. Techno 24: 990.

2.Arsac F. Bianchi D. Chovelon J. M. Conchon P. Ferronato C. Lair A. Sleiman M. (2008). Photocatalytic degradation of organic pollutants in water and in air. An analytical approach. Mater. Sci. Eng. C 28(5-6): 722-725.

3.Liu A. R. Wang S. M. Zhao Y. R. Zeng Z. (2006). Low-temperature preparation of nanocrystalline TiO_2 photocatalyst with a very large specific area. Mater. Chem. Phy 99: 131-134.

4.Tobaldi D. M. Tucci A. Camera-Roda G. Baldi G. Esposito L. (2008). Photocatalytic activity for exposed building materials. J. Eur. Ceram. Soc 28:2645-2652.

SURFACE MODIFICATION OF ZINC OXIDE NANORODS USING 3-GLYCIDOXYPROPYLTRIMETHOXYSILANE

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ABSTRACT

ZnO nanorods were successfully synthesised by a wet chemical route. The synthesised ZnO nanorods were coated by 3-Glycidoxypropyltrimethoxysilane (GPMS) under basic environment. The optical and structural properties of the silane coated ZnO nanorods were studied using different analytical techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), UV-Visible spectroscopy, Fluorescence spectroscopy and FT-IR spectroscopy. It has been found that the ZnO nanoflowers contain many radial nanorods with the diameter of 100 nm and the length of 1–1.5 µm and these ZnO single-crystalline nanorods with wurtzite structure grow along the [0 0 1] direction. The formation mechanism of ZnO nanoflowers and nanorods was initially interpreted in terms of the general theory of the crystal nucleation and crystal growth direction. The modified ZnO nanorods improve the photostability of sun blocking activity.

***Keywords**: ZnO nanorods, Photostability*

INRODUCTION

Research on nanocrystalline materials has increased enormously during the past few years. Scientists are focussing on many types of nanomaterials. In recent years, researchers are interested in synthesising various types of ZnO nanomaterials due their unique features such as wide band gap (3.37eV), large excitation-binding energy, luminescent, piezoelectric and photoconducting properties. Due to the distinctive features of ZnO nanorods, this nanomaterial has high potential applications in many fields such as UV detector, LEDs, chemical sensors, thin film photovoltaic solar cells, catalysis, and cosmetic materials[1].

ZnO is one of the remarkable photonic materials for blue, violet, and UV region. Therefore, it has been using in optical instruments, varistors and transparent UV-protection. Inorganic sunscreens, based on TiO2 and ZnO, are a rapidly growing sector in the overall UV protection market. The unique features such as wide band gap energy and the high refractive index of ZnO provide some superior properties like high sun protection factor (SPF), and broad-spectrum coverage in sunscreen. It also reduced the potential irritancy to the sunscreen users3. Therefore, many cosmetic produces are interested in using ZnO in their products. In addition, ZnO nanorods have the anti-bacterial properties which will give them use in many fields.

This work describes the synthesis of GPMS coated ZnO nanorods and characterised them by various analytical techniques such as UV-Visible absorption, Fluorescence spectroscopy, XRD, FT-IR and SEM. The length and width of the nanorods can be tuned by altering the synthesis conditions of nanomaterials. These synthesised silane coated ZnO nanorods can be used for various applications purposes.

MATERIALS AND METHODS

Materials

Zinc nitrate hexahydrate, Sodium hydroxide (anhydrous), Ammonia solution, Polyethylene glycol (PEG), and 3-Glycidyloxypropyltrimethoxysilane (GPMS). All chemicals were purchased from Sigma-Aldrich.

Methods

2g of Zn $(NO_3)_2.6H_2O$ was dissolved in 250ml of distilled and the mixture of PEG (Mw=4000) and 3ml of ammonium hydroxide was added drop-wise into the $Zn(NO_3)_2$ solution. The reaction mixture was heated rapidly to 70°C with vigorous stirring and it was allowed to grow nanorods over 20 h at 70°C. Then, the solid was isolated through centrifugation and dried in a vacuum oven for 2 hours. Then, 1.5 g of ZnO nanorods was dispersed into distilled water (50 ml, pH 6.5– 7.2) and the pH was adjusted to 10.8 with aqueous ammonia solution. The suspension was stirred for a further 1 h and 1 ml of GPMS was added into the suspension. Then the reaction mixture was stirred for a further 24 h and the excess GPMS was removed by washing with alcohol. The powder was dried at 60˚C under vacuum for further analysis.

RESULTS AND DISCUSSION

Morphology of samples was studied using Scanning Electron Microscope (SEM). Figure 1 shows that the SEM images of bare and GPMS grafted ZnO nanorods. These images confirmed that the surfaces of ZnO nanorods were successfully coated with GPMS.

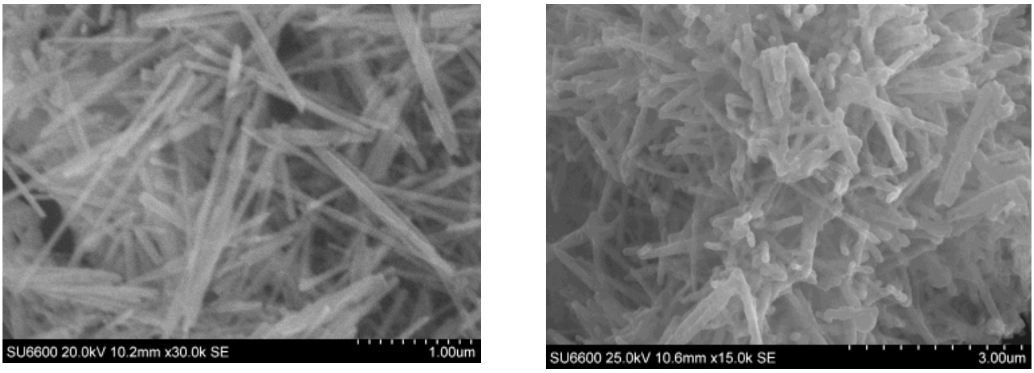

Figure 1: SEM image; (A) Untreated ZnO nanorods (B) GPMS grafted ZnO nanorods

The prepared coated ZnO samples were characterised using different spectroscopic techniques such as UV- Visible absorption spectroscopy, Fluorescence spectroscopy, XRD and FT-IR.

REFERENCES

1. Applerot G., Perkas N., Amirian G., Girshevitz O., Gedanken A.. (2009) Coating of glass with ZnO via ultrasonic irradiation and study of its antibacterial properties, Applied Surface science. 2565 (256) S3-S8.
2. Grasseta F., Saitoa N., Lia D., Parka D., Sakaguchia I., Ohashia N., Hanedaa H., Roisnelc T., Mornet S., Duguet E., (2003) Surface modification of zinc oxide nanoparticles by aminopropyltriethoxysilane, Journal of Alloys and Compounds. 360 (1–2) 298-311.
3. Zhang H., Feng J., Wang J., Zhang M. (2007) Preparation of ZnO nanorods through wet chemical method, Material Letters. 61 (5) 5202 - 5205.

PREPARATION AND CHARACTERIZATION OF SUPERHYDROPHILIC SILICA COATINGS AND THEIR APPLICATION AS ANTIFOGGING GLASS

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ABSTRACT

This paper reports the fabrication of antifogging glass coatings using simple sol-gel based procedure. The coating was applied to the glass by using dip coating method followed by firing in a furnace to improve the mechanical properties. For the morphological characterization of thin films, both atomic force microscopy (AFM) and scanning electron microscopy (SEM) were used. It could be observed in AFM that thin film mainly consists of nanoparticles while the SEM observation suggests that porous coating was developed on the glass surface. Transmission spectra were recorded for the coated glass using UV-Vis spectrophotometer, which suggested the near 100% transmission at visible light range. A weak antireflective property was also observed in the glass samples treated with silica coating. Both these observations provide the evidence that coating has not significantly modified the optical properties of the glass but imparted an antifogging property with weak anti-reflective property.

Keywords: *superhydrophillic, antifogging, thin film coatings, sol-gel*

INTRODUCTION

Superhydrophillic and superhydrophobic coatings have been subjected to a great interest due to their potential applications in many different industries. Unlike normal surfaces, these surfaces exhibit extreme wetting characteristics, when in contact with water[1]. Application of superhyrophilic coatings on glass surfaces can produce very low contact angles that will effectively increase the spreading of water droplets, resulting antifogging effect[2]. But in the case of normal glass, the contact angle is higher than that of the coated glass and droplet equilibrate in a much larger angle resulting in the lower spreading.

The negative effects of fogging on glasses and mirrors are well known. Fogging is due to condensation of water vapor on these surfaces, forming a large number of small water droplets. These localized water droplets can scatter, reflect and refract light in all directions rendering the transmission of light waves through the glass distorted. As a result, visual clarity of these devices is significantly impaired. Especially for applications like window glasses, automobile glasses, sun-glasses and for optical lenses etc., the minimization of fogging is of high importance.

Among many materials reported in literature on antifogging coatings, both TiO_2 and SiO_2 coatings were given high importance. But it's very well known that the superhydrophilicity of TiO_2 is highly UV dependent. It's believed that upon UV irradiation, surface hydroxyl groups increase dramatically, possibly due to photocatalytic reaction with water vapor in the atmosphere[3]. Once the UV irradiation is removed its superhydrophobic property tends to decease with time. This is the fundamental limitation of antifogging coatings based on TiO_2, limiting its application mainly for outdoor coatings. On the other hand SiO_2 has a large number of hydroxyl groups on its surface and can be used with our without surface modification as antifogging coatings. The main advantage of SiO_2 based antifogging coatings is its versatility and possibility to use even in the indoor applications.

MATERIALS AND METHODS

Tetraethyl orthosilicate (TEOS) was used as the SiO_2 precursor and was purchased from Sigma Aldrich (Singapoor). Ammonia solution (NH_3OH, 28%), and ethanol were also purchased from Sigma Aldrich and were used without further purification. Coating was prepared on top of microscopic glass slides (Sail Brand, China) and was used for coating preparation after cleaning. In a typical cleaning process, glass slides were ultrasonicated for 15 min in ethanol and then gently dried with a dry nitrogen purge.

The fabrication of thin films was done by dip coating method where pre-cleaned glass slides were dipped in silica sol and a withdrawal rate of 3 mm/s was maintained. Then the slides were dried at $80^{o}C$ for 15 min followed by firing at $300^{o}C$ in a furnace. Finally the glass was treated inside a UV C light box to induce superhydrophillicity for 30 min.

Morphological characterization of silica coatings was done using Atomic Force Microscope (AFM) using Park Systems, XE-100 microscope. Imaging was carried out using a non contact mode cantilever, having a tip radius less than 10nm operating at a frequency of 0.5Hz. The microstructures of the silica coatings were characterized using a field emission scanning electron microscope (SEM) Hitachi SU6600 Analytical Variable Pressure FE-SEM. For antifogging characterization, a half coated glass slide was placed on top of a beaker containing hot water. Transmission spectra of the coated glass were recorded using Shimadzu UV-VIS-NIR UV-3600 spectrophotometer using quartz cuvettes for the spectrum range of 250 nm to 800 nm. Wetting behavior of thin films was characterized using homemade setup, where glass slide was wetted using a 20 µl water droplet.

CONCLUSION

In conclusion, a simple procedure to produce superhydrophilic glass surfaces was introduced. The glasses prepared using this procedure showed a good antifogging property with slight antireflective property. We could conclude with the data obtained, this superhydrophilicity is due to combined effect of porous thin film development on the glass surface and hydrophilic hydroxyl groups on the surface.

REFERENCES

1. Wu,S. (1982). Experimental methods for contact angles and interfacial tension, Polymer Interface and Adhesion. pp. 266–273. M. Dekker (Ed.), New York.
2. F.C. Cebeci, Z.Z. Wu, L. Zhai, R.E. Cohen, M.F. Rubner.(2006).Nanoporosity-driven superhydrophilicity: a means to create multifunctional antifogging coatings. Langmuir 22, 2856–2862.
3. X.T. Zhang, O. Sato, M. Taguchi, Y. Einaga, T. Murakami, A. Fujishima. (2005). Self cleaning particle coating with antireflection properties. Chemistry of Materials. 17, 696–700.

PREPARATION AND CHARACTERIZATION OF INDIUM DOPED TIN OXIDE COATED GLASSES AND ITS IR TRANSMISSION CONTROL PROPERTY

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ABSTRACT

Transparent conductive oxide thin films based on Indium doped Tin oxide dispersions have been prepared on glass slides by using the spin coating followed by firing at high temperatures. The optical properties of coated glasses were characterized using UV-Vis, FTIR and the curing process was analyzed using TGA. Thin film surface was analyzed using SEM and AFM, while XRD was used to characterize crystalline behavior of thin films. A homemade light box was used to characterize IR control behavior, which indicates that the heat transmission by radiation was significantly reduced in the coated glass.

***Keywords** : infrared control, thin films, ITO coating, glass coatings*

INTRODUCTION

Glass is becoming more and more sophisticated and specific for the indented use with the advancement of thin film technology. However the most basic application of glass is as the windows in both buildings and automobiles, with the intention of making a transparent barrier between the external environment and the users, protecting them from severe environments such as rain, wind, noise etc. Though the transmission of visible light through glass is the most important property that is sought for, the same is not true for the transmission of infrared rays (IR). Glass is transparent to both the visible and the considerable region of IR wavelengths, making it the largest source of heat penetration in buildings and automobiles[1]. Transmitted heat is absorbed by interior elements and they can be heated to unacceptable temperatures. This is known as the greenhouse effect and can exert huge demand on energy required to regulate the temperature inside at a level which is not uncomfortable to the people inside.

With the increasing cost of energy and rising concerns in the global warming, the energy conservation is given a very significant importance in building design and construction. However, creation of more energy efficient structures in solar control aspect solely depending on the design only, has obvious limitations. Developing the thin film technologies that can cut off IR radiation, typically by reflecting or absorbing, is one of the areas the researchers have looked at, in an attempt to provide better materials for energy efficient buildings. The main strategies to address this problem is three fold, as far as the technology exists today is concerned. First is the development of optical band filters that can selectively transmit visible light through the glass while reflecting IR radiation as has been reported[2]. The method exploits the optical band filtering occurred due to the phenomenon called Bragg's reflection, and obtained by stacking of high refractive index (e.g. TiO_2) and low refractive index materials (e.g. SiO_2, MgF_2)[3]. Though, the performance in these coating systems is good, the utilization of this technology in architectural and automotive uses is rather limited, due to high cost in production. Secondly, low transmission type solar control where high refractive index metal oxide coating is applied on the glass surface is reported as well. However, coatings of this kind effectively reduce the visible light transmission through the glass as well, which present the main limitation of this type of coating. Smart coatings, which can only switch to low transmission mode only under certain sunlight is also reported, using thermochoromic materials[4]. The third, and the method discussed in this paper falls in to special category called low emissivity (Low E) coating system using the transparent conductive oxide (TCO) to impart IR reflectivity feature.

Emissivity is the ratio between the emissivity of an object to that of the black body. Typical glass having higher emissivity values can absorb more heat from the surroundings and pass it on to the other side. Preparation of low E coating on glass will significantly reduce the thermal transmission that happen through this route. Typically low E coatings were prepared by rather expensive processes like sputtering[5]. Ability to use TCO dispersions to impart these properties to the glasses will help manufacturers to treat the glasses at much lower cost, thus widening the use of the same, which is the quest of this paper.

Here we have reported that Indium Tin Oxide (ITO) dispersions can be used to impart solar control properties to the glasses by reflecting UV and IR wavelengths. The effects of film thickness on optical properties of the glasses were evaluated. The solar control property of the glasses were demonstrated using homemade setup.

MATERIALS AND METHODS

ITO dispersion was obtained from Sigma Aldrich. Coating was prepared on top of microscopic glass slides (Sail Brand, China) and was used for the coating preparation after cleaning. In a typical cleaning process, the glass slides were ultrasonicated for 15 min in ethanol and then gently dried with a dry nitrogen purge. ITO coatings were prepared on 2.5 x 2.5 cm^2 glass substrates by casting 500μl of dispersion followed by rotating at different speeds to obtain thin films for 15 s.

Morphological characterization of ITO coatings on glass was done using Atomic Force Microscope (AFM) using Park Systems, XE-100 microscope. Imaging was carried out using non-contact mode cantilever, having a tip radius less than 10nm operating at a frequency of 0.5Hz. The microstructures of the ITO coatings were characterized using field emission scanning electron microscope (SEM) Hitachi SU6600 Analytical Variable Pressure FE-SEM. Transmission spectra of coated glass were recorded using Shimadzu UV-VIS-NIR UV-3600 spectrophotometer using glass slides for the spectrum range of 250 nm to 1250 nm. Furrier transform infrared spectroscopy (FTIR) measurements were taken from the glass slides, using (Bruker FT-IR Vertex 80). A composite film was placed inside transmission mode sample compartment. FTIR spectra were recorded between 4000 cm-1 to 600 cm-1 with the resolution of 4 cm-1 in the absorbance mode for 64 scans at room temperature. Solar control performance was characterized by using a homemade light box (20 cm x 20 cm x 25 cm) where IR light (30 W) was allowed to pass through the glass slides (Figure 1). A thermocouple was placed 5 mm away from the glass slide and the temperature increment was recorded after switching the light source on.

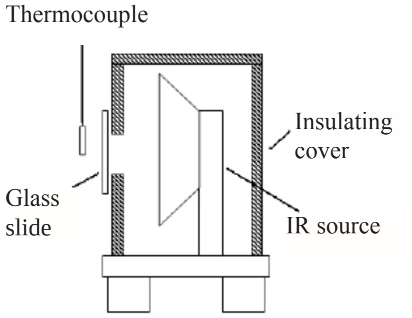

Figure 1. Schematic representation of light box prepared to study IR control behavior of coated glass

CONCLUSION

In summary, the glass slides were coated with ITO dispersions using spin coating and their IR transmission control behavior was evaluated. Significant drop in heat radiation transmission through glass was observed in the glasses coated with ITO dispersions relative to the untreated glass. Using SEM studies, it could be concluded that the thin film was composed of a large number of nanometer sized particles. The data gathered from experiments suggest that TCO dispersions can be a good alternative for expensive sputtering procedures for making low E glasses.

REFERENCES

1. Junichi Ebisawa, Eiichi Ando. (1998) Solar control coating on glass. Current Opinion in Solid State and Materials Science 3(04),386-390
2 Lampert C. (1981) Heat mirror coatings for energy conserving windows. Solar Energy. 6:1-41.
3 E. Yablonovitch. (1987). Inhibited spontaneous emission in solid-state physics and electronics. Phys. Rev. Lett. 58, 2059-2062
4 P. Nitz, H. Hartwig. (2005). Solar control with thermotropic layers, Solar Energy. 79, 573–582.
5 Hamberg IMT. (1984). Indium-tin-oxide thin films: basic optical properties and applications. PhD Thesis. Gothenberg: Chalmers University of Technology.

Session G

Energy Conversion and Storage

NEW KINETIC THEORY MODEL FOR THE PHOTOCURRENT GENERATION OF THE DYE SENSITIZED SOLAR CELL

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ABSTRACT

Kinetics of the photocurrent generation of the dye sensitization was studied for solving the rate equations by the iteration method to obtain a relationship for the photocurrent quantum efficiency ($\Phi\%$) depending on the surface concentration (Do) of the dye and the rate constants of the reactions with connection to the dye sensitization process.

Keywords: *Dye sensitized solar cells*

INTRODUCTION

It is well known that the spectral response of wide band gap semiconductor materials can be extended to the visible region by deposition of suitable dyes on the surface[1-8]. When the dyes with intense absorption bands are deposited, the light absorption at the sensitized surface becomes much higher than a bare semiconductor surface. Although the absorption properties of the dye increases with the concentration of the absorbed dye on the semiconductor surface, a dye sensitized photocurrent enhancement cannot be observed with the increase of the number of dye molecules on the semiconductor because of the energy dissipative processes of the excited states of the dye and the recombination of photogenerated charge carriers [1, 4-6].

In this study we present the kinetics of the photocurrent generation of the dye sensitized solar cell for solving the rate equations to obtain a relationship for the photocurrent quantum efficiency ($\Phi\%$) depending on the surface concentration (Do) of the dye and the rate constants of the reactions with connection to the dye sensitization process. The solution obtained in the steady state by analytically and numerically was found to be of the form $\Phi = AD_o - BD_o^2$ (CAN's model equation). A and B are constants related to the reaction rates of the photocurrent generation.

RESULTS AND DISCUSSION

Photocurrent Generation Processes:

(1) Excitation of the dye molecules D from S_o to S_1 state.

$$D \xrightarrow[h\nu]{k_1,\, I} D^* \tag{1}$$

(2) Hole transfer from the excited dye to the valence band of the semiconductor

$$D^* \xrightarrow{k_2} D^- + h \text{ (VB semiconductor)} \tag{2}$$

(3) Electron transfer from the dye anion D-, to electron acceptor presence in the electrolyte or electron acceptor in the solid state photovoltaic cell.

$$D^- + X \xrightarrow{k_3} D + X^- \tag{3}$$

ENERGY DISSIPATIVE PROCESSES:

(4) Recombination of the photogenerated charge carriers, created due to dye sensitization.

$$D^- + h \xrightarrow{k_4} D + \text{heat} \tag{4}$$

(5) Quenching of the excited dye molecules by a species Y in the junction.

$$D^* + Y \xrightarrow{k_5} Y + D + \text{heat} \tag{5}$$

(6) Energy dissipation through concentration quenching, here excited dye molecules quench each other.

$$D^* + D^* \xrightarrow{k_6} D + D + \text{heat} \tag{6}$$

(7) De-excitation of excited dye molecules by emission of radiation.

$$D^* \xrightarrow{k_7} D + h\nu' \tag{7}$$

[D*], [D^-] and [D] are the surface concentrations of the excited dye, dye anion and unexcited dye respectively. I is the absorbed photon flux (number of photons absorbed per unit area per unit time), k_1 is the rate constant of the reaction-(l) per unit photon flux, k_2, k_3,…k_7 are the rate constants of the reactions-(2)-(7).

Above reactions lead to the following rate equations,

$$dh/dt + J = k_2\,[\,D^*] - k_4\,[\,D-\,]\,[\,h\,] \tag{8}$$

$$dD^*/dt = I\;k_1\,[\,D\,] - (k_2+k_5Y+k_7)\,[\,D^*\,] - k_6[\,D^*\,]^2 \tag{9}$$

$$dD^-/dt = k_2[D^*] - k_3[D^-][X] - k_4\,[\,D^-\,]\,[\,h\,] \tag{10}$$

The right-hand side of the equation-(8) gives the total rate at which holes are produced at the junction, due to dye sensitization process. J is the positive current driven across the interface and dh/dt is the rate of accumulation of the holes at the junction due to dye sensitization. As the cathodic sensitization involves for dye sensitization,

$$[D^-] = [h] \qquad (11)$$

Then the equation-(8) becomes,

$$dh/dt + J \quad = k_2 [D^*] - \quad k_4 [D^-]^2 \qquad (12)$$

Again if D_0 is the total number of dye molecules per unit area,

$$D_0 = D^* + D^- + D \qquad (13)$$

the steady state (ie, $dh/dt=dD^-/dt=0$, $dD^*/dt=0$) solution of the above equations gives the photocurrent quantum efficiency $\Phi == J/I$.

Solution obtained in the steady state by iteration is found to be of the form,

$$\Phi = AD_o - BD_o^2 \qquad (14)$$

$$\text{Where } A = k_1 k_2 / F, \qquad (15)$$

$$B = I\, k_1^2 k_2 \quad [\, 2k_6/F^3 + k_2 k_4 / k_3^2\, X^2 F^2 \,] \qquad (16)$$

$$F = k_2 + k_5 Y + k_7 + k_1 I\, [\, 1 + k_2/k_3 X \,] \qquad (17)$$

REFERENCES

1. C A N Fernando, N T R N Kumara and T N Gamage, Semiconductor Science and Technology 25 (2010)115007
2. B O' Regan, D T Schwartz, S M Zakeeruddin, M Gretzel, Adv.Mater
3. G K R Senadeera, S Kobayashi, T Kitamura, Y Wada and S Yanagida, Bull. Mater.Sci. Vol.28, No 6, October 2005 , pp.635-641.
4. C A N Fernando, Sol. Energy Mater. Sol. Cells 28(1993)375.
5. C A N Fernando, A Kitagawa, M Suzuki, K Takahashi and T Komura Sol. Energy Mater and Sol. Cells. 33(1994)301.
6. C A N Fernando Sol. Energy Mater Sol.Cell 28(1992)255.
7. W Kubo, T Kitamura, K Hanabusha, Y Wada, S Yanagida, Chem.Commun.(2002) 374.
8. J Kruger, R Plass, Le Cevey, M Piccirelli, M Gretzel, Appl. Phys. Lett.79(2001) 2085.

A POLYMER GEL ELECTROLYTE BLEND SYSTEM FOR DYE SENSITIZED SOLAR CELLS BASED ON POLY (METHYL METHACRYLATE) AND POLYETHYLENE GLYCOL WITH NANO-POROUS TiO_2

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ABSTRACT

In this paper, we report the effect of using a polymer gel electrolyte blend system made with Poly (methyl methacrylate) PMMA, Polyethylene glycol (PEG) polymers and nano-porous TiO_2 in enhancing the power conversion efficiency of dye sensitized solar cells. The cell with PMMA electrolyte alone had an efficiency of 3.8 % and the cell with PEG electrolyte had a very low efficiency of around 1.0 % as the electrolyte did not have a gel like nature but had a solid like behavior. After trying out DSSCs with several different composition ratios for PMMA:PEG mixed polymer system, it was observed that the cell with the mixed polymer system PMMA:PEG(weight ratio of 20:13) gave an efficiency of 4.4 % with short circuit current density (JSC) of 8.98 mA cm^{-2}; open circuit voltage (VOC) of 760 mV; and a fill factor of 64.3 %.

Keywords: *Polymers, Dye-sensitized solar cells, Electrolyte,* TiO_2

INTRODUCTION

In the past decade, the dye-sensitized solar cells (DSSC) based on nano-porous TiO_2 and gel polymer electrolytes have been attracting many researchers' interests as a potential competitive alternative to traditional silicon and thin film photovoltaic devices[1, 2]. The polymer gel electrolytes have several advantages, such as low vapor pressure, good long term stability, excellent contacting and filling properties between the nanostructured electrode and counter electrode, and high ionic conductivity. The major drawback of the solar cells with gel electrolytes is their relatively low power conversion efficiencies compared to their liquid electrolyte counterparts. Several attempts have been made to enhance the efficiencies of these cells such as using gel electrolytes with polymer hybrids, incorporating better plasticizers and optimizing the electrolyte compositions. In the present system, we have studied the effect of using a polymer gel electrolyte blend made with Poly (methyl methacrylate) PMMA, Polyethylene glycol (PEG) polymers and nano-porous TiO_2 in enhancing the power conversion efficiency of dye sensitized solar cells.

MATERIALS AND METHODS

TiO_2 electrodes were prepared on pre-cleaned fluorine doped conduction tin oxide (FTO) (16 Ω/cm^2, 2 cm x 0.5 cm size from Solaronix) glass by the doctor blade technique. TiO_2 electrodes were then immersed in Ruthenium dye (N719, Solaronix) solution for 24 hours at room temperature. After sensitization, they were removed and washed with ethanol and allowed to dry in the air. Different compositions of the polymer gel electrolyte system comprising of Poly (methyl methacrylate) PMMA (98%, Aldrich, 120000 m.w), Polyethylene glycol PEG (Fluka 6000 m.w), ethylene carbonate (EC) (99%, Fluka), Propylene carbonate (PC) (99%, BDH) and acetone as organic mixture solvents, tetra propyl ammonium iodide (Pr4N+I-) (98%, Fluka) and iodine (I2) (99.8%, Fluka) as a source of I^-/I^{3-} were initially optimized in order to get a gel electrolyte with high efficiency in the dye solar cells. First, the appropriate amounts of EC, PC, PMMA and PEG were continuously stirred at 70 ^oC for about 2 hours for jellification. Acetone was used to dissolve the PMMA, which does not dissolve in PC. After that, acetone was removed from the solution by heating at 60 ^oC. The amounts of $Pr_4N^+I^-$ and iodine were calculated to have a molar ratio of [I2] / [$Pr_4N^+I^-$] = 0.1. Iodine and $Pr_4N^+I^-$ were added after the solution was cooled to room temperature, to avoid loss of iodine due to evaporation. The composition of the optimized polymeric system was as follows: PMMA (18.5%), PEG (12%), PC (27.8%), EC (27.8%), $Pr_4N^+I^-$ and I_2 (13.9%). Dye sensitized solar cells were then fabricated by sandwiching the above dye absorbed TiO2 electrodes with a Pt coated FTO glass incorporating the polymer blend electrolyte prepared as described above. The I-V characteristics of the cells under illumination of 1000 Wm^{-2}, (AM 1.5) simulated sunlight were recorded using a setup coupled with KEITHLEY 2000 multimeter into potentiostat/ galvanostat HA 301 via a computer controlled software. A Xenon 500 lamp was used with AM 1.5 filters to obtain the simulated sunlight with the above intensity.

RESULTS AND DISCUSSION

The figure shows four different I-V graphs corresponding to the four different electrolyte compositions given below:

Graph	PMMA (g)	PEG (g)	EC (g)	PC (g)	$Pr_4N^+I^-$	I_2 (g)
(1)	0.20	0.13	0.3	0.3	0.1388	0.0112
(2)	0.25	0.08	0.3	0.3	0.1388	0.0112
(3)	0.15	0.18	0.3	0.3	0.1388	0.0112
(4)	0.33	0	0.3	0.3	0.1388	0.0112

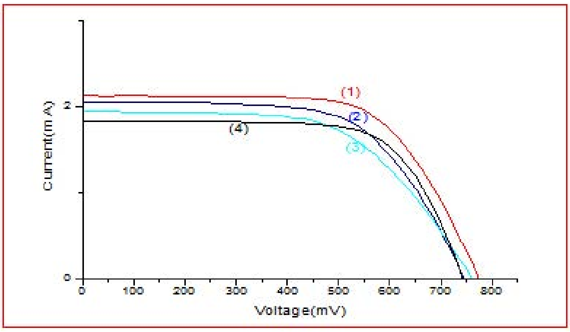

Figure 1: *I-V characterization graph of DSSCs*

All these electrolytes were prepared by having the EC: PC: $Pr_4N^+I^-$: I_2 weight ratio the same but varying the PMMA: PEG weight ratio. The calculated cell parameter such as, short-circuit current (I_{SC}) through the cell area of 0.25 cm^2, open-circuit voltage (Voc), efficiency (η) fill-factor (FF), maximum current density(J_m) and maximum Voltage(V_m) are shown below.

Graph	J_{SC}(mA)	V_{oc}(mV)	η (%)	FF (%)	V_m(mV)	J_m(mA)
(1)	8.524	774.9	4.316	65.33	565	7.64
(2)	8.24	746.8	3.826	62.16	525.3	7.284
(3)	7.788	763	3.483	58.63	509.5	6.836
(4)	7.368	743.9	3.767	68.72	570.3	6.604

All the calculated cell parameters such as Jsc, Voc, η, FF, Jm and Vm are increased by adding the polymers into the electrolyte. The solar cell exhibiting the maximum efficiency with maxium values for the Jsc and Voc , had the composition: 18.5% PMMA: 12% PEG: 27.8% EC: 27.8% PC:12.8% $Pr_4N^+I^-$:1% I2. These parameters decreased while increasing or decreasing the PMMA/PEG weight ratio.

REFERENCES

1. Gratzel M. (2001). Photoelectrochemical cells. Journal of Nature 414 (6861): 338-344.
2. O’Regan B & Grätzel M. (October 1991). A low cost high-efficiency solar cell based on dye-sensitized colloidal TiO_2 films, Journal of Nature 353(24): 737-740.
3. Wolfbauer G. (2001). A channel flow cell system specifically designed to test the efficiency of redox shuttles in dye sensitized solar cells. Solar Energy Materials & Solar Cells 70:85-101.

p-CuI SENSITIZED METHYLVIOLET-C_{18} LB FILMS IN THE Cu/p-CuI/M-C_{18} PHOTO-ELECTROCHERMICAL CELL AND Cu/n-Cu_2O/p-CuI JUNCTION PHOTOELECTRODE IN THE SOLID STATE PHOTO VOLTAIC CELL

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ABSTRACT

Photocurrent enhancements in a dye sensitized photoelectrochemical (PEC) cell with Cu/p-CuI/M-C_{18} photoelectrode and a dye sensitized solid state photovoltaic cell with (DSSC) Cu/n-Cu_2O/M-C_{18}/p-CuI were studied by controlling the formation of dye aggregates of M-C18 LB (Langmuir-Blodgett) films on p-CuI layer. LB films of M-C_{18} are deposited under biasing conditions during the LB deposition process on Cu/p-CuI, Cu/n-Cu_2O/p-CuI and conductive glass plates with three electrode configuration set up coupling to the LB Trough. LB films prepared under positive biasing conditions enhance the photocurrent quantum efficiencies for both PECs and DSSCs controlling and minimizing the formation of dye aggregates.

Keywords: *LB films, Dye sensitization*

INTRODUCTION

Suppresion of the energy dissipative processes by minimizing the dye aggregates may be an interesting area to enhance the efficiencies of the dye sensitized solar cell[1-5]. It is well known that the Langmuir-Blodgett (LB) film deposition technique has an ability to deposit dye films onto the substrate by minimizing the dye aggregates on various substrates.

In this study, the photocurrent enhancements were found due to the suppression of the formation of the dye aggregation in p-CuI sensitized LB films of Methylviolet –C_{18} . During this experiment, dye was deposited by Langmuir-Blodgett technique maintaining a constant voltage on the surface of the semiconductor.

EXPERIMENTAL

The commercially available well cleaned copper sheets (3cmx3cm) were used to deposit p-CuI nano thin films from the following method. A solution of CuI was prepared by dissolving 5mg of CuI in 10ml of moisture free acetonitrile. CuI colloidal solution was lightly spread on the well cleaned copper surface to fabricate Cu/p-CuI photoelectrodes and on the Cu/ n-Cu_2O photoelectrodes to fabricate Cu/n-Cu_2O/p-CuI photoelectrodes until forming a thickness of ~ 0.5µm. Cu/p-CuI and Cu/n-Cu_2O/p-CuI photoelectrodes were used to deposit LB films. A Pt wire and a Ag/AgCl electrode were used as the counter electrode and the reference electrode, respectively. (10-2M) Fe^{2+}/Fe^{3+} (10-2M) and 1x10-2M NaH_2PO_4- Na_2HPO_4 pH=6 buffer solution was used as the electrolyte for LB deposition and for the photocurrent measurements in the photoelectrochemical cell.

RESULTS AND DISCUSSION

The variation of the photocurrent quantum efficiency with number of M-C_{18} LB monolayers deposited on p-CuI at different applied potentials were investigated. It was clearly seen that an enhancement of the photocurrent occured with the LB films deposited potentials were more possitive. Further an optimum surface concentration could be observed in each case. It was interesting to observe that the optimum surface concentration of M-C_{18} LB films increased when the deposition applied potential increased towards a possitive side enhancing the maximum photocurrent quantum efficiencies. Similarly, optimum surface concentration decreased when the deposition potentials were more negative decreasing the photocurrent quantum efficiencies. Maximum photocurrent quantum efficiency reached was ≈ 22% at +0.3V vs AgCl/Ag. Similar characteristics could be observed for Cu/n-Cu_2O/M-C_{18}/p-CuI DSSC devices. When the LB deposition potentials were more possitive Φmax % and Dop increased. When the deposition potentials were negative Φmax % and Dop were found to be decreased. The reason for the photocurrent enhancement may be due to the suppresion of the dye aggregation. When the applied potentials for LB deposition is possitive, the chromorephores of LB film repel each other and facilitate to form monomeric dye in the LB film. For negative deposition potentials, the accumulation of dye molecules in the LB film is much easier to form the dye aggregates to act as the recombination centers for the photogenerated charge carriers.

REFERENCES

1. C A N Fernando, N T R N Kumara and T N Gamage, Semiconductor Science and Technology 25(2010)115007
2. B O’ Regan, D T Schwartz, S M Zakeeruddin, M Gretzel, Adv.Mater
3. G K R Senadeera, S Kobayashi, T Kitamura, Y Wada and S Yanagida, Bull. Mater.Sci. Vol.28,No 6, October 2005 , pp.635-641.
4. C A N Fernando, Sol. Energy Mater. Sol. Cells 28(1993)375.
5. W Kubo, T Kitamura, K Hanabusha, Y Wada, S Yanagida, Chem.Commun. (2002)374.

LI-ION BATTERY ANODE USES NANO SIZED SRI LANKA VEIN GRAPHITE TO ENHANCE BATTERY CAPACITY

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ABSTRACT

Lithium has been electrochemically intercalated into a particular type of the Sri Lanka natural vein graphite (shiny-slippery-fibrous graphite) as well as into those of mechanically treated graphite. The results revealed that the Sri Lanka natural vein graphite shows a high capacity for lithium intercalation and a good rechargeability. The nano-sized Sri Lankan natural vein graphite boosts in the lithium battery applications and other technological applications due its unique morphology, low cost and high purity; hence a value addition to the Sri Lanka graphite.

Keywords: *vein graphite, lithium intercalation*

INTRODUCTION

Graphite is a host material for chemical and electrochemical intercalation and the formed Graphite Intercalation Compounds (GIC) and hence, can be used for various technological applications. The advantage of natural graphite is the possibility to enhance the electrochemical intercalation by mechanical or chemical treatments. For battery applications, the electrochemical intercalation and deintercalation capacities are important characteristics of carbon material, which strongly influence the energy density. Sri Lanka is famous for highly crystalline vein graphite, which is mined in the large areas of the Central Highlands. The Sri Lanka natural vein graphite is found in various morphologies, with different structural and physical characteristics[20]. In the present study, the electrochemical performance of the shiny-slippery-fibrous natural graphite from the Bogala (BSSI) and the Kahatagaha/Kolongaha (KSSI) mines were investigated.

MATERIALS AND METHODS

Material preparation: Natural Sri Lanka vein graphites from BSSI and KSSI were used as starting material. The selected graphite samples were first crushed in a ceramic mortar and then powdered by a high-energy vibratory ball-mill (Fritsch Pulverizette, P0) for 50 hours in air.

Material characterization:

X-ray diffraction (XRD) studies were carried out with a Philips x-ray generator, using Cu Ka radiation with a wavelength of l = 1.5406 Å. Further characterized by SEM , Raman and TEM spectroscopy. The chemical characterization was obtained using an ELTRA CS800 Carbon and Sulfur Determinator and an Atomic Absorption Spectrometer (Perkin Elmer, Model 5000). The coin type cells were assembled with a lithium counter electrode and composite graphite thin film as a working electrode with 1M $LiPF_6$ and 1M $LiClO_4$ in EC/ DMC (1:1). Electrochemical experiments were performed with a MacPile multichannel potentiostat-galvanostat.

RESULTS AND DISCUSSION

Lithium has been electrochemically intercalated into a particular type of the Sri Lanka natural vein graphite (shiny-slippery-fibrous graphite) as well as into those of mechanically treated (sieve-shaken and ball-milled) graphite. The results revealed that the Sri Lanka natural vein graphite shows a high capacity for lithium intercalation and a good rechargeability. In this study, the electrochemical intercalation into graphite, the morphology, microstructure, particle size and other electrochemical properties of mechanically treated natural graphite were seen to be different in the absence of oxygen or in the presence of oxygen.

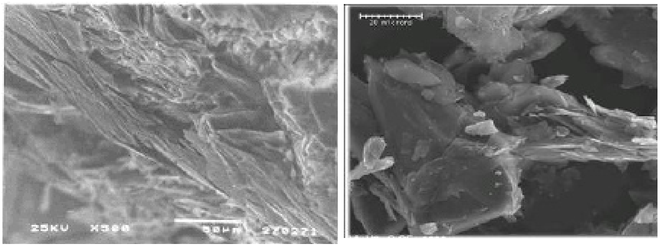

Figure 1. SEM photographs of (a) crystallized needles natural BSSI graphite, (b) before treatment, (c) ball milled

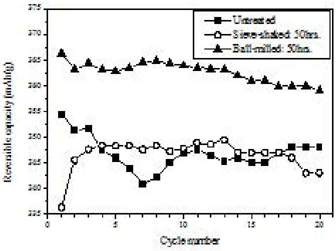

Figure 2. Variation of the reversible capacity as a function of the different cycles for untreated and treated KSSI graphite at a C/40 current rate within 1M LiPF6 (EC/DMC).

The present study confirms that the Sri Lankan natural graphite is a potential intercalation anode material in rechargeable lithium battery applications due its unique morphology, the low cost and the high purity. Moreover, the electrochemical properties of nano-sized BSSI and KSSI graphite can further be enhanced by simple ball-milling or chemical treatments, which can be used for value addition to the Sri Lanka graphite.

REFERENCES

1. Yazami, R., In "Lithium Batteries-New Materials, Development and Perspectives", Pistoia, G., (ed.), 4, p.49, Elsevier, Amsterdam, (1994).
2. Aurbach, D., Zinigrad, E., Cohen, Y., Teller, H., Solid State Ionics, 148, p.405-416, (2002).
3. Touzain, P., Balasooriya, N.W.B., Bandaranayake, P.W.S.K.,. and C. Descolas-Gros, The Canadian Mineralogist, Vol. 48, pp. 1373-1384 (2010).
4. Balasooriya, N.W.B., Touzain, P., Bandaranayake, P.W.S.K, Jour. Che. Phy. of Solids, 67, pp 1213-1217 (2006).

Session H

Nanomaterials and Nanocoating

UV BLOCKING FABRICS WITH NANO TITANIUM DIOXIDE

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ABSTRACT

Nano Titanium dioxide is well known as an UV absorbing and UV scattering material. This property was tried to apply for fabrics in order to block UV radiation. UV blocking property can be obtained in the fabric by attaching nano TiO_2 particles on the surface of cotton. Nano TiO_2 particles were attached to cotton fabric using succinic acid as a cross linking agent. UV blocking ability of the cotton fabric was tested using UV absorbing and transmitting spectra, taken by UV-Vis spectrophotometer. It showed that the fabric modified with nano TiO_2 blocked the whole UV A and UV B range.

***Keyword**: UV blocking, Nano* TiO_2*, cotton fabric, UV-Vis analysis*

INTRODUCTION

The sunlight is a form of electromagnetic radiation (EMR) that covers ultraviolet (UV), visible, and infrared ranges of EMR. Most of the emission is in the visible portion of the spectrum (400–700 nm), and roughly 7% of total solar emission is UV between 290 and 400 nm. The UV region is usually divided into three parts: UVC, UVB and UVA. UVC (<290 nm) is normally not transmitted to the earth because it is absorbed by the stratospheric ozone layer. In contrast, UVB rays (290–320 nm) are only partially absorbed by ozone; a major fraction reaches us especially during the hours close to solar noon, during the summer months, at lower latitudes, and at higher altitudes. Although UVB is a relatively small fraction of total UV radiation (~10% of total UV) it is the major cause of erythema (sunburn), suntanning, photocarcinogenesis and photoaging. UVA wavelengths (320–400 nm) can also cause sunburn and tanning. However, it takes roughly 1,000 times the doses of UVA to produce the sunburn and tanning effects equivalent to those of UVB[1].

With the depletion of ozone layer, the amount of UV radiation that reaches the surface of earth gets increased. As precautions, most people use the sun creams and the textiles, which blocks the excessive UV radiation without reaching the skin. UV blockers are used to improve the UV protective function of textiles. There are both organic and inorganic UV blockers. Organic UV blockers block UV mainly by absorbing UV radiation[2].

Inorganic UV blockers are mostly semiconductor oxides such as TiO_2, ZnO, Al_2O_3 for example. When comparing with the organic UV blockers, the inorganic UV blockers are more preferred due to their low toxicity and chemical stability under the high temperature and high exposure to UV. The UV blocking mechanism of semiconductor oxides are yet not very clear and the scientists hold different views on this. Some researchers suggest that semiconductors reflect and scatter most of the UV rays due to their high refractive index[2]. Other's view is that they absorb UV radiation because of their semiconductor properties[2].

When it comes to nano semiconductor particles, due to their high surface energy and high surface area they show better affinity to the fabrics. Also due to their nano size, the hand feel of fabric will not get much affected. Titanium dioxide (TiO_2) has good UV blocking power and is very attractive in practical applications because of such as advantages as nontoxicity, chemical stability at high temperature, and the long term stability under UV exposure. It is mentioned in the literature that nano sized TiO_2 is more efficient than conventional size for the UV blocking due to their high surface area.[2] According to the Rayleigh's scattering theory, the optimum particle size to scatter UV radiation between 200 nm to 400 nm is between 20 nm to 40 nm.[3]

When it comes to fabrics, nano TiO_2 particles can be attached to the fabric *via* physical bonding and chemical bonding. To obtain a long term performance, the chemical bonding would be preferred. This can be achieved by using polycarboxylic acids as the linking agents between nano TiO_2 and fabrics. While achieving the UV blocking property, it should not affect the moisture spreading ability and the moisture permeability of the fabric.

MATERIALS AND METHODS

Cotton 100%, 1x1 rib, knitted (provided by Textured Jersey Pvt Ltd), Nano Titaniumdioxide (TiO_2, p25,anatase) purchased from Sigma Aldrich was used. Succinic acid and Sodiumhypophosphite purchased from Sigma Aldrich were of the analytical grade.

Fabric Modification

A mixture of succinic acid (6% w/v) and Sodiumhypophosphite (SHP, 4% o.w.f.) was prepared in distilled water. Cotton fabric was dipped in that mixture for one hour at room temperature. Here used material to liquor ratio was 1:20. Then the fabric was taken out and oven dried at 85 oC and cured at 180^{o}C [4]. Nano TiO_2 was dispersed in distilled water and loaded to the cured fabric.

Characterization

Treated fabric was characterized with Fourier Transform Infra Red (FTIR, Bruker FT-

IR Vertex 80) spectroscopy to observe succinic- cotton esterification peak. Scanning Electron Microscope (SEM, HITACHI, SU6600,30 kV) analysis was carried out to see TiO_2 attaching to the fabric and to analyze the particle size of the attached TiO_2. Also Energy Dispersive Xray spectroscopy (EDX) was used to obtain elemental analysis of the treated fabric. X-Ray Diffraction (XRD, Brucker D8 Focus X-ray Diffractometer) analysis was done to analyze the crystal form of attached TiO_2. The loading percentage of TiO_2 was calculated by Thermogravimetric (TGA) analysis. UV-Visible spectrophotometer (SHIMADZU, UV-3600, UV-VIS-NIR) was used to analyze the UV blocking property of treated fabric.

RESULTS AND DISCUSSION

Esterification peak for cotton-succinic was observed at 1730 cm-1-1735 cm-1 range. SEM/EDX analysis confirmed the nano size loading of TiO_2 into the cotton fabric. UV-Vis results exhibited the almost total blocking of UV A and UV B range by the treated fabric.

Figure 1 shows UV absorption spectra of treated cotton and normal cotton.

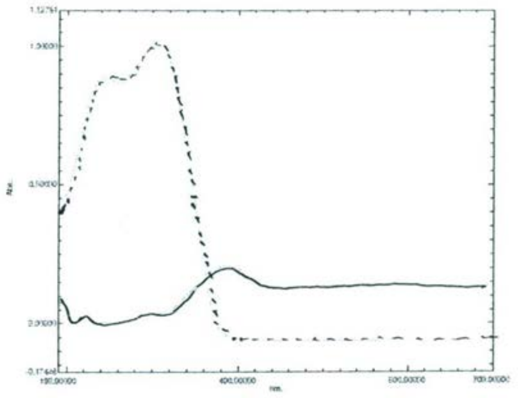

Figure 1: UV-Vis spectra of treated and untreated cotton.

REFERENCES

1. Julian M. Menter, Kathryn L. Hatch, Clothing as Solar Radiation Protection, (2003) 31, 50–63.
2. Hongying Yang, Sukang Zhu, Ning Pan, Studying the Mechanisms of Titanium Dioxide as Ultraviolet-Blocking Additive for Films and Fabrics by an improved Scheme, Applied Polymer Science, (2004), 92, 3201–3210.
3. Jinlian Hu,Adaptive and Functional Polymers, Textiles and Their Applications.
4. L.Karimi, M. Mirjalili, M. E. Yazdanshenas, A.Nazasri, Effect of nano TiO2 on self cleaning property of cross linking cotton fabric with succinic acid under UV irradiation, photochemistry and photobiology, (2010).

SYNTHESIS OF NANO TiO_2 USING SOL-GEL METHOD AND EVALUATION OF TENSILE STRENGTH OF NANO TiO_2 TREATED TEXTILE YARN UNDER UV EXPOSURE

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ABSTRACT

Nano sized TiO_2 colloidal solutions were prepared with sol-gel method under different concentrations of stabilizing agents. The prepared nano colloids were confirmed as anatase-TiO_2 with an average particle size ranging from 4-15 nm using XRD analysis. Nylon, Polyester and cotton textile yarns were physically treated with the prepared solutions, and then exposed to UV-A radiation up to 5 days. The Breaking Tenacity was measured with 1 day intervals of UV exposure for TiO_2-treated and non-treated textile yarns. Significant reduction on the breaking tenacity of Nylon was observed followed by cotton and Polyester, with a reduction in tenacity with smaller TiO_2 Particle sizes.

Keywords: *photo-catalytic degradation, UV exposure, Textile yarn, Breaking Tenacity*

INTRODUCTION

NanoTiO_2 has been widely used as a UV absorbent as well as self-cleaning, anti-microbial and odor removal material on textile and apparel applications. In addition to the textile industry it is being widely used for water purification, Dye-sensitized Solar Cells (DSCs), photo induces water splitting and organic compound degradation in many other industries for a long period of time 1, 2. TiO_2 is one of the most common photo-catalytic materials, which are preferred to other types due to several reasons: natural availability in large convertible reserves; relatively good in harvesting solar energy; high stability; nontoxicity and non-harmfulness to human body[2].

Having an energy band gap of 3.2 eV, nano anatase-TiO_2 has the ability to absorb the UV-A energy[1, 3] and form several different highly oxidizing species such as Oxygen and hydroxyl free radicals1. These species will strongly interact with organic matter in proximity converting them to other simple molecules eventually to water and carbon dioxide[4].

Considering the highly reactive nature on the species produced in the photocatalytic reaction, it is reasonable to assume that there could be an effect on the physical properties on the textile substrate. In one particular study on the physical & chemical properties of TiO_2 treated cotton fabrics, it was reported that around 25% reduction of breaking strength was observed after 120 hours of exposure to sunlight, with the change in degree of polymerization, which provides evidence of fiber degradation[3].

With the trends in the global apparel market, the use of synthetic materials such as polyamides and polyesters in addition to cotton and other cellulosic textile materials, with above discussed advanced functionality in demand, especially for active wear and casual wear applications, it would be important to study the effects on the physical properties of these synthetic materials after nano-TiO_2 treatment. Yet no such studies were reported, to date on this regard and hence the key objective of this research is to investigate the effect of photo catalytic action of nano-TiO_2 on one important physical property; the tensile strength, of not only cotton but also polyamides and polyesters in the yarn form.

MATERIALS AND METHODS

Preparation of Nano Tio_2 Colloidal Solutions

Four different solutions were prepared with 0.01 M HCl and concentrated acetic acid (CH_3COOH) with acetic acid volumes of 0, 1, 2,4 cm3 and named S1, S2, S3, S4 respectively. The final pH values of the solutions were adjusted to 2.5 using 0.1M NH4OH solution with the total solution volume of 100 ml. 3ml of Titanium Isopropoxide (Ti[OCH(CH3)2]4) were added drop-wise to each of the solutions under vigorous stirring that continued for 24 hours at 28 oC. From each of the colloidal solutions thin coatings of TiO2 were prepared on glass slides by dropwise spreading and curing 3-4 times at 130 oC for 10 min, which was sent for XRD analysis.

Treatment of Textile Yarns

Polyamide (Nylon 6,6) , Polyester (Poly Ethylene Terepthale) and Cotton (natural Cellulose) yarns with similar linear densities were used for the treatment of the TiO2 colloidal solutions. The yarns were treated with each solution for 10 min and the excess amount of solution was removed to have 100% w/w solution uptake. The samples were then cured in the oven at 130 oC for 10 min.
A 36 W UV-A type tube lamp was selected for the UV exposure of the treated and non-treated yarns. The UV exposure was set up to give uniform exposure to all samples. yarn specimen were taken out at every 24 hour interval till 120 hour exposure.

Yarn Testing

Using the Universal tensile tester the breaking tenacity of the yarns was measured according to the test method EN ISO 2062-Yarn Breaking Force and Elongation.

RESULTS

XRD Spectroscopy

In all four samples, the characteristic peaks of the XRD spectrograms matched the standard peaks for TiO_2-anatase with the maximum intensity peak at 25.3^o, which confirms that the product is TiO_2 anatase. With the calculations using the Debye Scherrer equation, the average particle sizes were confirmed as 15 nm, 9 nm, 7 nm and 4 nm respectively for S1, S2, S3 and S4.

Breaking Tenacity Analysis

After the TiO_2 treatment in both cotton and Nylon the breaking tenacity has increased by around 10-15%, whereas around 5-10% reduction of tenacity was observed in PET.

Table 1 : Summary of the Yarn Breaking Tenacity Results

Yarn Type	Colloidal solution	Breaking Tenacity (cN/tex)			
		Without exposure	After 1 day UV exposure	After 3 day UV exposure	After 5 day UV exposure
Cotton	Non Treated	24.3	20.9	20.5	18.8
Cotton	S2	28.0	27.6	23.8	20.2
Cotton	S4	26.6	26.5	19.7	10.6
PET	Non Treated	26.5	21.8	21.0	19.7
PET	S2	23.3	22.7	22.6	22.7
PET	S4	25.5	24.8	24.7	21.6
Nylon 6,6	Non Treated	29.6	30.2	22.7	17.9
Nylon 6,6	S2	35.9	27.2	11.5	8.2
Nylon 6,6	S4	33.2	10.2	6.1	3.2

After 5 days of exposure cotton, PET and Nylon showed a 56%,18% and 89% reduction in tenacity when treated with S4 and 17%,15% and 72% reduction in tenacity when treated with S2 respectively. Nevertheless the non-treated cotton, PET and Nylon showed 17%, 25% and 39% reductions in tenacity after 5 days of UV exposure.

DISCUSSION

Treatment of TiO_2 has resulted an increase in tenacity in cotton and nylon which has relatively higher polarity than PET. This could be accountable for the formations of weak inter-polymer chain attraction, where TiO_2 act as a crosslinking agent. After TiO_2

with the UV exposure, nylon has shown alarming level of loss in tenacity. The least effect after UV exposure was observed on PET, and major level of reduction was observed on cotton as well although not as significant as nylon. Also it was confirmed that with the reduction in TiO_2 particle size, the breaking tenacity has dramatically gone down solely due to the increase in photo catalytic activity, as a result of the increase in surface area and quantum effects.

REFERENCES

1. Hua D., Cheuk K., Wei-ning Z., Chen W. and Xiao Chang-fa X. 2007. Low temperature preparation of nano TiO2 and its application as agents, Trans. Nonferrous Met. Soc. China 17:700-703
2. Macwan D.P., Dave P.N. and Chaturvedi S. 2011. A review on nano-TiO_2 sol–gel type syntheses and its applications, J Mater Sci 46:3669-3686
3. Shen Y.,Wang L.M., Zhang H.F., Wang J.C. and Ding Y. 2010. Influence of Nano-TiO_2 Photocatalyst on Physical and Chemical Properties of Cotton Fiber, Journal of Fiber Bioengineering and Informatics 3(2):68-74
4. Zhao J. and Yang X. 2003. Photocatalytic oxidation for indoor air purification: a literature review, Building and Environment 38:645 – 654

ANTI-FUNGAL ACTIVITY OF SURFACE MODIFIED NANO PARTICLES

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ABSTRACT

The main goal in this research was to synthesize nanoparticles of different origin, possessing the anti-fungal activity. Mainly, three types of particles were synthesized ZnO; ZnO doped with Co; and ZnO doped with Ni. The synthesized nanoparticles were coated with polyethylene glycol (PEG) as a surfactant controlling the size of the particles and as to facilitate the internalization of the particles into the fungal cells. By doping various metals to ZnO nanoparticles, an enhancement in biochemical properties of the particle was expected. The presence of Co^{2+} and Ni^{2+} was determined using the atomic absorption spectroscopy. Nanoparticle characterization was done using FT-IR spectroscopy and scanning electron microscopic images. Mainly plant pathogens related to rubber cultivation were selected for the bio assay namely; Colletotrichum gloeosporioides, Colletotrichum acutatum, Curvularia sp. and Fusarium sp. Qualitative determination of anti-fungal activity was done using both the Kirby-Bauer disk-diffusion method and the plate method. An inhibition in fungal growth was observed in the plate method.

***Keywords**: Anti-fungal activity, Zinc Oxide nano particles*

INTRODUCTION

Natural rubber is an important commodity in the Sri Lankan economy. Colletotrichum leaf disease (CLD) is a common and a malignant fungal disease to rubber cultivation as it causes secondary leaf fall reducing the yield significantly.1 Both the fungi Colletotrichum gloeosporioides and Colletotrichum acutatum play a significant role in the development of CLD in Sri Lankan rubber plantations. Many plant pathogens have a tendency to develop high tolerance levels against existing fungicides. Extremely high tolerance of C. acutatum to carbendazim and thio-phanate methyl has been reported.1 Therefore, exploring new means of combating these diseases is important.

Nanotechnology has provided a promising avenue into dealing with these problems. Although metals like silver has already been established as to having anti-fungal properties, being an expensive metal, the mass usage in a field like agriculture is less likely. If cheaper metals such as Zinc, Cobalt, and Nickel turns out be having such properties, it would be of a huge advantage economically. In this study primarily pathogenic fungal species related to rubber cultivation were selected in an attempt to buttress the rubber industry by battling some of the rubber related fungal diseases with the aid of nanotechnology.

METHODOLOGY

The synthesis of nanoparticles was carried out using an already established method.2 The resulted particles were characterized using FT-IR and SEM images. The presence of Co2+ and Ni2+ and their amounts present were determined using atomic absorption spectroscopy. To determine the anti-fungal properties of the particles synthesized, a bioassay was conducted using the Kirby-Bauer disk-diffusion method and the plate method where the particles were incorporated into the medium. At all times seven day old cultures of the plant pathogens were used. Observations were made after 6 days.

RESULTS AND DISCUSSION

Nanoparticles were characterized by FT-IR spectroscopy as shown in Figure 1.

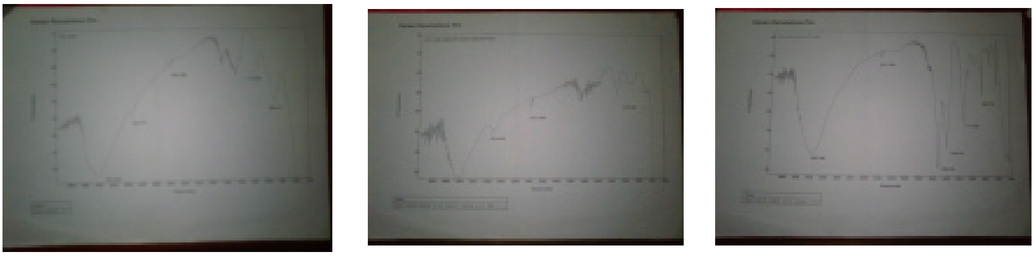


Figure 1: a) ZnO; b) ZnO doped with Cobalt coated with PEG; and c) ZnO doped with Ni

The qualitative analysis of the anti-fungal properties of the synthesized particles was first performed by the Kirby-Bauer disk-diffusion method as shown in Figure 2. Secondly the plate method was carried out incorporating the nanoparticles into the potato dextrose medium. An inhibition of the fungal growth was observed for ZnO doped with Co nanoparticles for three fungi species used, as depicted in Figure 3. a) Curvularia sp. b) Fusarium sp. and c) Colletotrichum gloeosporioides. With increasing concentrations of the nanoparticles the effective inhibition was also increased. The quantitative analysis of these experiments is in progress.

0.5 ppm of ZnO nanoparticles doped with Cobalt coated with PEG			
Observations after six days			

Figure 2: Disk method

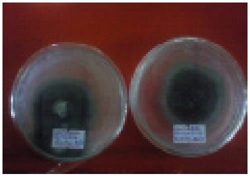
0.5 ppm of ZnO nanoparticles doped with Cobalt coated with PEG			
2 ppm of ZnO nanoparticles doped with Cobalt coated with PEG			

Figure 3: Plate Method: Observations after 6 days

REFERENCES

1. Jayasinghe, C. K., Fernando. H.P.S., Mycopathologia, 143 (1998), 93–95.
2. Glaspell, G., Dutta, P., Manivannan, A., Journal of Cluster Science, 16 (2005), 523-536.
3. Wu, S. H., Chen, D. H., Journal of colloid and interface science, 259 (2003), 282-286.
4. Kanade, K. G., Kale, B. B., Jin-Ook, B., Lee, S. M., Lee, C. W., Moon, S. J., Chang, H., Materials Chemistry and Physics, 102 (2007), 98-104.

LABORATORY INVESTIGATIONS OF STABILIZED NANO SCALE ZERO VALENT IRON FOR THE TREATMENT OF LANDFILL LEACHATE IN THE TROPICS

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ABSTRACT

The aim of the present study was to understand the applicability of Nanoscale Zero Valent Iron (NZVI) for organic and inorganic contaminant rich landfill leachate treatment. Synthesis of NZVI was performed by borohydride reduction method with starch as the stabilizing agent. The nano particles formation and characterization were investigated using XRD, TEM and FT-IR. The XRD results confirmed that the synthesized material was exclusively NZVI and TEM results confirmed approximately spherical shape particles with 10 nm as the average particle size. Time scanning FT-IR results revealed the air stability. Kinetic experiments were conducted for 1.0 g/L NZVI on prior characterized leachate focusing organics (COD) and nutrients (nitrate and phosphate) removal studies. According to the kinetic observations, 50, 97 and 98 % removal percentages were observed within 3 days indicating the efficiency of all in one treatment. However, further studies are necessary to understand the in situ applicability of NZVI for the landfill leachate treatment.

Keywords: *Nanoscale zero valent iron, landfill leachate, COD*

INTRODUCTION

The ability of iron to act as an electron donor is utilized in decontamination of several soil and groundwater pollutants. To date, the use of NZVI have been reported as efficient with low operating and maintaining cost compared to the conventional treatment methods for a large number of pollutants1 . However, not many studies have reported on landfill leachate treatment using ZVI2. Therefore, the main objectives of this study were to synthesize stable NZVI, characterize them and investigate the efficacy for the treatment of landfill leachate in the tropics.

MATERIALS AND METHODS

The NZVI was synthesized by dropping an aqueous borohydride solution (0.5 M) drop wisely into a flask containing 0.14 M $FeSO_4.7H_2O$ solution with 5% (w/w) starch[3]. The landfill leachate collected from the Gohagoda open landfill, was analyzed for nutrients and COD. The kinetic study was performed using 1 g/L NZVI for 3 days in the batch mode.

RESULTS AND DISCUSSION

The advanced characterization methods (XRD, TEM and FT-IR) confirmed the synthesized material was NZVI, and the average particle size was 10 nm (Figure 1) and the time scanning FT-IR results revealed the air stability. The leachate analysis demonstrated an average concentration of 6355, 316 and 243 mg/L for COD, nitrate and phosphate respectively. Kinetic batch experiments showed a medium reduction in COD (50 %) while nitrate and phosphate treatments were extremely high (97 and 98 %) (Figure 2). The long carbon chains of complex organic compounds responsible for high COD might have broken down into small chains of biodegradable hydrocarbon by NZVI2. The reduction of nitrate could occur in different pathways producing nitrite and nitrogen gas4. The phosphate removal can be mainly resulted due to its strong tendency to be adsorbed on metal surfaces, and precipitated with iron species. Nano ZVI is efficient material for multi contaminant remediation1. However, further studies are necessary to understand the in situ applicability of NZVI for the landfill leachate treatment.

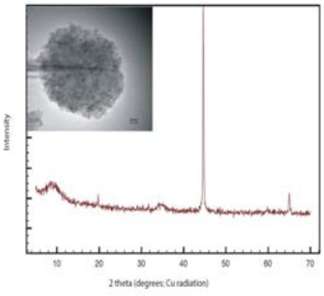

Figure 1: XRD patterns and TEM of NZVI

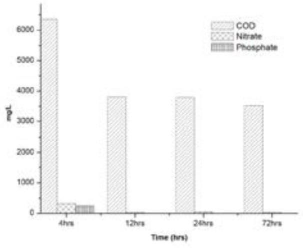

Figure 2: COD, NO3- and PO43- removal behaviors by NZVI

REFERENCES

1. Li X. Elliott D. W. Zhang W. (2006). Zero-Valent Iron Nanoparticles for Abatement of Environmental Pollutants:Materials and Engineering Aspects. Critical Reviews in Solid State and Materials Sciences 31:111-122
2. Jun D. Yongsheng Z. Weihong Z. Mei H. (2009). Laboratory study on sequenced permeable reactive barrierremediation for landfill leachate-contaminated groundwater. Journal of Hazardous Materials 161:224-230.

3. Alidokht L. Khataee A. R. Reyhanitabar A. Oustan S. (2011). Reductive removal of Cr(VI) by starch-stabilized Fe0 nanoparticles in aqueous solution. Desalination 270(1-3):105-110.
4. Hsu J. C. Lio C. H. Wei Y. L. (2011). Nitrate removal by synthetic nanoscale zerovalent iron in aqueous recirculated reactor. Sustainable Environment Research 21(6):353-359.

Session I

Environmental Protection

DEVELOPMENT OF A HEAVY METAL ADSORBING MATRIX BY INCORPORATING IRON OXIDE NANO PARTICLES WITH KAOLIN

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ABSTRACT

Development of a low cost heavy metal adsorbing material for water purification is reported. Two types of granules were prepared by optimizing the ratios of kaolin, rice husk, and iron oxide nanoparticles. Both granules were tested for adsorption of Pb^{2+}, Cd^{2+}, and Zn^{2+} ions. Freundlich adsorption isotherm was used for building the linear relationship between initial ion concentrations and adsorbed amounts. At both types of granules order of uptake capacities of tested ions were $Pb^{2+} > Cd^{2+} > Zn^{2+}$. Addition of iron oxide nanoparticles into the matrix enhanced the adsorption capacity towards Pb^{2+}. Kaolin granules are capable of removing Cd^{2+} and Zn^{2+}.

Keywords: *Adsorption, Kaolin, Iron-Oxide, Nanoparticles*

INTRODUCTION

Heavy metals are elements such as Copper, Cadmium, Nickel, Lead, Zinc, Silver, Chromium, Mercury, Iron and Arsenic, which are generally related with toxic effects.[1] As human activities impact upon the environment, the heavy metal contamination issues are becoming serious. It has been realized that dissolved metals in water pose a series of health hazards on human due to the accumulation in biological tissues. As trace elements, some of the heavy metals such as Copper, Selenium, and Zinc are essential to maintain the metabolism of human body. But when they exceed the specific levels, significant alterations of biochemical cycles in living beings could be occurred.[2]

Though there are many methods for heavy metal treatments, most of them could not be used due to high cost. Therefore the development of a low cost and effective solution is required for the developing countries. The use of adsorbents is a well-known and simple method for domestic usage. Kaolin is a locally available low cost clay that has a significant heavy metal adsorbing property due to its overall negative properties.[3] Rice husk was used as a low cost pore forming agent. Minimum amount of iron oxide nanoparticles were incorporated into the kaolin matrix for the enhancement of heavy metal adsorbing characteristics due to its excellent heavy metal adsorption property.[4]

MATERIAL AND METHODS

All chemicals used were of analytical grade. Salts used in preparation of iron oxide nanoparticles were $(NH_4)Fe(SO_4)_2.6H_2O$ and $NH_4Fe(SO_4)_2.12H_2O$. Diluted ammonia solution was prepared by 25% ammonia solution. Double distilled water was used at each step of nanoparticle preparation. Salts used in preparing synthetic contaminant bearing solutions were $Pb(NO_3)_2$, $CdSO_4.3H_2O$, and $ZnSO_4.7H_2O$. Pure metals of lead, cadmium and zinc were dissolved in concentrated acids for the preparation of AAS standards. Water washed type of kaolin was used. Rice husk was taken from a rice mill and sifted through a 500 µm size mesh to obtain a fine powder.

EXPERIMENTAL PROCEDURE

Optimum ratio of kaolin: rice husk and, drying and burning conditions were found out after number of tests. Granules were dried in the oven and burnt in the muffle furnace. Iron oxide nanoparticles were synthesized and incorporated in to above optimized composition of kaolin and rice husk to obtain a material with enhanced adsorption properties.

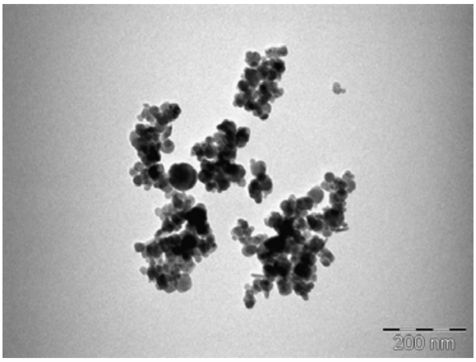

Figure1. Transmission electron microscopy (TEM) Image of prepared iron oxide nanoparticles (Particle size range 6nm-25nm)

The metal ions uptake from aqueous solutions by both type of materials were measured by placing 50.00 mL of ion solution in to contact with 5.000 g of granules separately in series of 150 ml plastic bottles. Initial metal ion concentrations of one series of bottles were 10.00 ppm to 100.0 ppm. Adsorption properties were studied at four different contact times as 2, 4, 6, and 24 hours. Remaining metal ion concentrations were analyzed by AAS. Freundlich adsorption isotherm was employed for data analysis.

RESULTS AND DISCUSSION

Optimum composition of kaolin to rice husk in first type of granules was 30g to 4g. The second type has the ratio of kaolin: rice husk: Iron oxide nanoparticle, 30g: 4g: 3g. Drying conditions were 120 °C for 4 hours. Optimized burning conditions were at

650 °C for 3 and 1/2 hours. Adsorbed amount of each metal ion was measured against their initial concentrations. A linear relationship was resulted for Freundlich adsorption isotherm. The maximum adsorption was observed at a contact time of 24 hours. Adsorption capacities of kaolin granules, which were indicated after 24 hours for 50 ppm initial ion concentrations of Pb^{2+}, Cd^{2+}, and Zn $^{2+}$ were 440.8, 329.0, and 205.5 mg/ kg respectively. The adsorption capacities for the granules with iron oxide nanoparticles were 456.8, 283.1, and 134.6 mg/ kg respectively. Adsorption capacity of the material for a particular metal ion is dependent on its initial concentration and contact time.

CONCLUSION

The nanoparticle incorporated composite granules are excellent candidates for removing Pb^{2+} ions from aqueous solutions by having an adsorption capacity of two fold with compared to kaolin granules. Kaolin granules are suitable for the removal of Cd^{2+} and Zn^{2+} ions from the aqueous solutions. Therefore the use of both types of granules together will be effective for removal of Pb^{2+}, Cd^{2+} and Zn^{2+} from the contaminated water.

REFERENCES

1.Kelesoglu, S., M.Sc. Thesis., Izmir Institute of Technology, (2007).
2.Saidi, M., (2010) Experimental studies on effect of Heavy Metals presence in Industrial Wastewater on Biological Treatment, International Journal of Environmental Sciences, 1: 666-676.
3.Trevino, J. C. M., and Coles, C. A., (2003) Kaolinite properties, structure and influence of metal retention on pH, Applied Clay Science, 23: 133-139.
4.Cheng, Z., Tan, A. L. K., Tao, Y., Shan, D., Ting, K. E., and Yin, X. J., (2012) Synthesis and Characterization of Iron Oxide Nanoparticles and Applications in the Removal of Heavy Metals from Industrial Wastewater, International Journal of Photoenergy, 2:1-5.

COST-EFFECTIVE METHOD FOR REDUCING SALINITY IN WATER

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ABSTRACT

The current study focuses on exploration of a low cost, efficient, eco-friendly and sustainable physical method for desalination. The studies have been carried out using coconut coir (red coir, pith free coir and activated coir) and Murunkan clay, which contains a high concentration of montmorollinite clay. It was observed that all three types of coir and Murunkan clay displayed a high sodium removal capacity. The highest removal of sodium ions was observed within the first10 min for all the materials. The experiments repeated with the combination of columns containing filter materials were proven to be more efficient than a single column.

***Keywords**: Desalination, coir, montmorollinite, cation exchange capacity*

BACKGROUND

Water is a basic need for the survival of life on the earth and is currently becoming a limited resource with a high population growth reaching 7 billion in 2012. Therefore, the available portable water mass is becoming insufficient to fulfill the needs of the current world population. With the predicted water crisis in 2050 it is timely to explore for the alternative fresh water sources. One such possibility would be desalination of sea water, which covers a large mass of the earth's crust. In addition, a number of problems have also arisen due to salinity in lagoon water and mixing of sea water with fresh water resources making them unsuitable for drinking purposes and as well as for agricultural purposes. Many attempts for desalination of sea water such as reverse osmosis and distillation have been reported. However, none of them has proven to be successful up to date[1,2].

Considering the current global and local need for an efficient physical method for desalination it is timely to explore the low cost, efficient, eco-friendly and sustainable materials suitable to be used in domestic level or preferably regional level desalination plants. Coconut coir (coco coir) and Murunkan clay have been selected as the filtering materials to test the sodium removal capacity of saline water.

MATERIALS AND METHODS

Materials

Coir (red coir, pith free coir and activated coir) received from Silver Mills (Ltd) and Murunkan clay.

Methods

The cation removal capacity was measured by preparing columns using the above materials and standard sodium ion solutions. The time required for maximum removal of Na ions were investigated by withdrawing samples at different time intervals. The amount of material required for 1 l of saline water was also calculated. The experiments were repeated using sea water.

RESULTS AND DISCUSSION

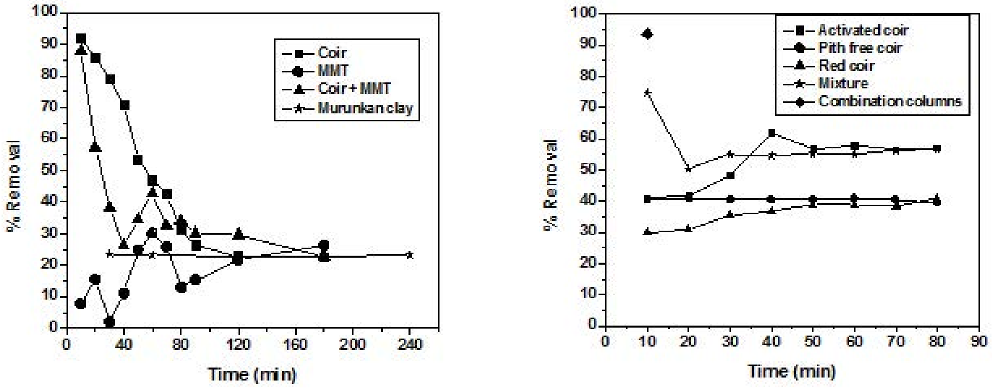

Figure 1. Percent removal of sodium from 0.4 M NaCl solution (a) different types of coir and (b) coir, MMT and Murunkan clay

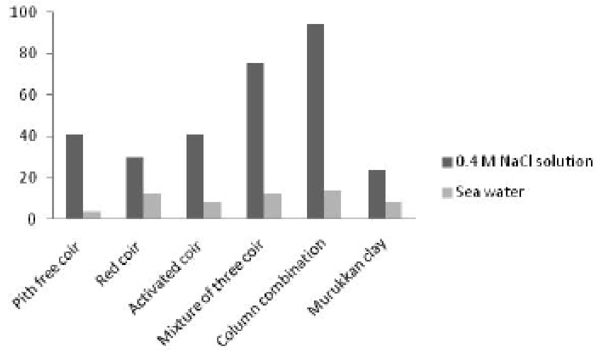

Figure 2. Maximum % removal of Na+ from 0.4 M NaCl and sea water for 1 g of filter material

The coconut coir was chosen as a suitable material in this research due to its high ion holding capacity and porosity. Red coir, pith free coir and activated coir were used as different sources of coir. Murunkan clay, which consists of high amount of montmorillonite (MMT), also was selected as a suitable filtering material considering its high cation exchange capacity.

It was found that all three types of coir have a greater sodium ion removal capacity, whereas, activated coir having the highest surface area shows the highest sodium ion removal capacity. The highest removal of sodium ions was observed within the first10 min for all three types of coir. Murunkan clay also displayed efficient sodium ion removal capacity although it's lower than coir. Experiments were repeated with combination of columns containing filtering materials were proven to be more efficient than a single column. As both materials are readily available at a low-cost, using a combination of Murunkan clay and coco coir would be ideal for domestic level or even a regional level desalination plant. The suggested methods in this project do not involve any energy or chemicals leading to a sustainable solution for reducing salinity in water.

REFERENCES

1. Penny W., Geoff S., Ian S. and Scott S. (2003) 'Removal of metal contaminants from contaminated saline waters using iminodiacetic acid ion-exchange resin, Thala Valley Tip, Casey Station, Antarctica'. J. Ion Exchange, Vol. supplement: 205-208.
2. U.S. Congress (1988). Using desalination technologies for water treatment': 1 – 59. U.S. Congress, Office of Technology Assessment, Washington, DC: U.S. Government Printing Office.

CFL LAMP COATED WITH NANO TiO_2 AND ITS CHARACTERISTICS AS AN INDOOR AIR PURIFIER BY PHOTOINDUCED REDOX REACTIONS

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ABSTRACT

Initial interest in photoinduced redox reactions was prompted by Fujishima and Honda's 1972 discovery that water could be split (simultaneously oxidized and reduced) upon illuminating a TiO_2 single crystal electrode to which a small electrochemical bias had been applied (Fujishima – Honda Effect).

Since then, extensive research had been done focusing on TiO_2 Nano particles and its characteristics on Photoinduced redox reactions. Various paths were evaluated to increase and accelerate the reaction intensity and the speed. Particle structure, particle size, types of dopants and particle formation mechanisms are discussed.

***Keywords**: Nano Tio2, Photocatalysis, Air Purification, CFL Lamps*

INTRODUCTION

Photocatalysis by semiconductors is the result of the interaction of electrons and holes generated in an activated solid with the surrounding medium. Activation is the consequence of UV/VIS absorption. Electron hole pairs are formed in the solid particle that can recombine or participate in reductive and oxidation reactions that lead to the decomposition of contaminants in the proximity. This phenomenon was used to decompose air borne microorganisms, volatile organic compounds etc., to obtain purified air for breathing.

Further evaluation of domestic light sources indicated that, the compact fluorescent lamps and the linear fluorescent lamps are the highest irradiators of illumination and consist of a considerable amount of UV in the 380nm Band. UV emission is not healthy for human and it creates various dermatological disorders. Then the CFL lamp was selected as the Exciter and the carrier of TiO_2 Nano particles to be performed as an indoor air purifier.

EXPERIMENTAL

In the process of the TiO_2 immobilization on the CFL lamp surface, SiO_2-TiO_2 composite was used by SOL-GEL method using Nitric acid and Hydrofluoric acid as catalysts to increase the hydrolysis in the initial stages. After coating the glass surface with Silica-Titania composite, the photocatalytic activity was evaluated according to three main ISO protocols with proposed dyes.

ISO 10678:2010 was introduced to the test protocol to determine the intensity of redox reactions. ISO 10678:2010 specifies a method for the determination of the photocatalytic activity of surfaces by degradation of the dye molecule methylene blue (MB) in aqueous solution using artificial ultraviolet (UV) radiation, and characterizes the ability of photoactive surfaces to degrade the dissolved organic molecules on ultraviolet radiation.

ISO 27447:2009 was introduced to the test protocol to characterize the capabilities of microorganism removal. ISO 27447:2009 specifies a test method for the determination of the antibacterial activity of materials that contain a photocatalyst or have photocatalytic films on the surface, by measuring the enumeration of bacteria under irradiation of ultraviolet light.

RESULTS AND DISCUSSION

Both ISO Standards were studied and tailor made to execute the test on glass surfaces instead of ceramic surfaces. Both tests were done on Philips 24 Watt CFL lamps, which emits lesser UV in comparable to most of the other CFL lamps available in the local market. The open agar plate air sampling was done against air borne microbes in an enclosed room and obtained airborne Bacteria removal efficiency of 99.6% (CFU reduction counted before and after CFL irradiation).

CONCLUSIONS

This paper describes an investigation on the use of a nano titania coated CFL lamp in a indoor environment to effectively reduce the air borne microorganisms, volatile organic gases and other human detectable parameters such as odors dampness due to aforementioned substances. Reduction of 99+% of air borne microorganisms and VOCs can be an impactful result in order to deploy the above experimented lamp as an indoor air purifier.

REFERENCES

1.T. Watanabe, K. Hashimoto and A. Fujishima: in Photocatalytic Purification and Treatment of Water and Air, eds. D. F. Ollis and H. Al-Ekabi (Elsevier, Amsterdam, 1993).

2.Fujishima, K. Hashimoto and T. Watanabe: TiO_2 Photocatalysis: Fundamentals and Applications (BKC, Tokyo, 1999).

3. T. Watanabe, K. Hashimoto and A. Fujishima: Proc. 1st Int. Conf. TiO_2 Photocatalyst, ed. H. Al-Ekabi, 1992.

4.Kazuhito HASHIMOTO1;2, Hiroshi IRIE2 and Akira FUJISHIMA3 TiO_2 Photocatalysis: A Historical Overview and Future Prospects

PREPARATION OF GRANULAR ACTIVATED CARBON (GAC) HYDROXYAPATITE NANO COMPOSITE (C-HAP) AND COMPARE ITS EFFECTIVENESS OVER PURE GAC AND NEAT HYDROXYAPATITE (HAP) TO ADSORB HEAVY METAL IONS

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ABSTRACT

Developing a new method to synthesis C-HAp nano composite by incorporating nano crystals of hydroxyapatite (HAp) into activated carbon, and compare its effectiveness to adsorb heavy metal ions over neat HAp and activated carbon (GAC) were investigated in this work. Neat HAp was synthesized by a modified method of an existing procedure. The GAC-Hap nanocomposite was prepared. The samples were characterized by Fourier-transformed infrared spectroscopy (FT-IR), and scanning electron microscopy (SEM). Adsorption properties were mainly tested for Pb^{2+} in different pH and for Fe ions. Both neat HAp and GAC-HAp nano composite showed adsorption of both Pb and Fe over GAC at predetermined contact times.

***Keywords** : hydroxyapatite (HAp), activated carbon*

INTRODUCTION

Hydroxyapatite (Hap) with the chemical formula $Ca_{10}(PO_4)_6(OH)_2$ has been widely used in different fields. It is widely used in biomedical applications due to its excellent bio compatibility.[1] In addition, it has shown a high efficiency in adsorbing heavy metal ions.[2] Hence it was thought that incorporating neat Hap in to GAC will improve the heavy metal ion adsorption properties in GAC which is widely used as a water purification agent and a detoxification agent in clinical application.

MATERIALS AND METHODS

Synthesis of neat HAp was carried out according to literature with some modifications. The nanocoposite comprising HAp was prepared with GAC using a recently developed procedure.

Both HAp and GACC-HAp samples were characterized by SEM and FTIR. Comparison of adsorption properties of Neat HAp, C-HAp, and GAC for Pb^{2+} and Fe^{3+} at different pH was carried out. The solutions were analyzed by Atomic Absorption Spectrophotometer (AAS) for remaining concentrations after the necessary dilutions.

RESULTS AND DISCUSSION

SEM of the neat HAp shows (Figure 1) the synthesized HAp particles that are in the nano range in diameter. The SEM of the C-HAp nano composite (Figure2) confirms the successful synthesis of the C-HAp nano composite as it shows nicely coated HAp nano particles over GAC. The FT-IR spectrum of HAp and GAC-HAp nano composite exhibits the characteristic peaks of HAp3 proving that GAC is incorporated with HAp.

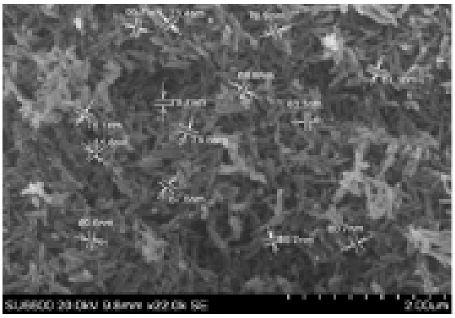

Figure 1: SEM of neat HAp

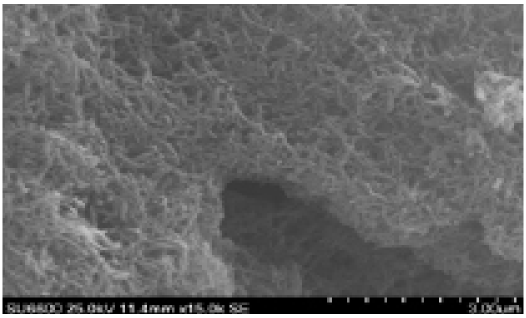

Figure 2: SEM of C-HAp nano composite

The results of the adsorption of Pb2+ (Figure 3) confirm GAC-HAp nano composite has better affinity for adsorption of heavy metals over pure GAC and the optimum adsorption is shown after pH 5. However neat HAp shows a better adsorption than the composite and further modification of the composite can be done to improve its properties. But using the GAC-HAp nano composite in heavy metal ion adsorption can be more cost effective as a low amount of neat HAp is present in it.

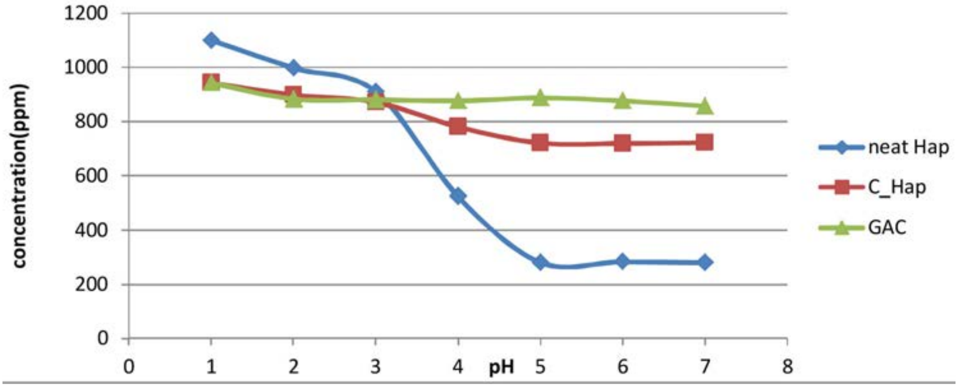

Figure 3. Adsorption of Pb^{2+} by neat HAp, C-Hap and with GAC

GAC-HAp nano composite exhibited better adsorption for iron solutions in comparison to the neat GAC. The isotherm studies were also performed.

CONCLUSION

In the present work, a novel GAC-HAp nano composite was prepared by a simple chemical route. This nano composite was effective in removing heavy metals and a comprehensive work is being carried out to apply these materials in the water purification.

REFERENCES

1. Stotzel C., Muller F.A., Reinert F., Niederdraenk F., Barralet J.E., and Gbureck U. (2009) Ion adsorption behavior of hydroxyapatite with different crystallinies Colloids and Surfaces B:Biointerfaces 74: 91-95
2. Alobeedallah H., Ellis J.L., Rohanizadeh R., , Coster H., and Dehghani F. (2011) Preparation of nano structured hydroxyapatite in organic solvents for clinical application. Trends Biomater. Artif.Organs, 25(1): 12-19.
3. Sadat-Shojai M., (2009) Preparation of Hydroxyapatite Nano particles:Comparison between hydrothermal and Solvo-Treatment Processes and Colloidal Stability of produced Nano particles in a dilute Experimental dental adhesive, J.Iran.Chem.Soc, 6: 386-392

Session J

Nanocomposites and Nanostructures

PREPARATION AND COMPARISON OF POLYURATHANE NANO COMPOSITES

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ABSTRACT

Main objective of this study was to identify the role of different nano structures playing the part as reinforcement material for polyurethane nano composites. Different nano structures were selected as organic/inorganic and layered/sheet/fiber form of nano structures. The composites were analyzed mechanically and chemically to identify the interaction of the nano structures within the composite, which contributes towards a change in the mechanical properties of the polyurethane. Montmorilonite nano clay, carbon nano fibers, graphite oxide and exfoliated reduced graphite oxide were used as the nano structures for the nano composite. From the aforementioned four nano composites PU/ carbon nano fiber composite showed the highest modulus increment. Structural form of the reinforcement and chemical interaction between reinforcement and PU has a high contribution towards the final property of the composite.

Keywords*: nano composites, modulus, nano structures, polyurethane*

INTRODUCTION

Polymer nano composites are being widely used in many industries due to their unique properties, which can be obtained through construction and composition. In a nano composite the reinforcing phase dimensions are in the order of nanometers. Light weight and economic effectiveness using a minimal amount of reinforcing material are a few the advantages of nano composites. Nano meter scale structures used in polymer nano composites include silicate (phyllosilicate or layered silicate), POSS (nano structured polyhedral oligomeric silsesquioxanes), carbon nano tubes, carbon nano fibers and metal or inorganic nanoparticles[1,2].

The preparation, characterization and properties of polyurethane–clay nano composites have been reported by various researchers. MMT with having its nano structure defined by nano spacing between layers of the clay material is a useful candidate as a filler material to improve the mechanical properties of polyurethane (PU). Intercalation of PU in MMT is important to achieve a cohesive composite which will contribute toward improved mechanical properties of the final composite. MMT is being widely used as a reinforcement material for composite due to its unique feature of multilayer construction, which can lead to many mechanical property enhancements such as improved fracture stuffiness, modulus, and breaking strength. An uniform dispersion of MMT over the PU composite is important to achieve aforementioned properties.

Polyurethane nano composites with carbon nano structures is a widely studied area in the research arena, where the unique property of polyurethane combined with chemical and structural properties of carbon nano structures provide an interesting candidate for many application. The reinforcing carbon nano structure can include carbon nano tubes, carbon nano fibers, graphite oxide, reduced graphite oxide, graphene etc. Graphite Oxide platelets can be chemically reduced to generate a material that resembles pristine graphene, using reducing agents such as hydrazine monohydrate or sodium borohydride. Chemically reduced Graphite Oxide platelets can exhibit C: O ratios of over 10:1. graphite oxide and reduced graphite oxide, which bare oxygen containing functional groups, provides suitable sites to develop a good adhesion with polyurethane to provide a compatible nano composite[3].

MATERIALS AND METHODS

A) PU preparation

Polymer synthesis was carried out in a four neck flask equipped with mechanical stirrer, under Nitrogen environment. MDI, Polytetramethylene ether glycol (4000 molecular weight), and Ethylene glycol mol ratio was used as 1.3: 1 : 0.3. The prepared PU is finally diluted with DMF to obtain 40% polymer solution. For the preparation of polymer sheet, an appropriate amount of polymer solution was poured to premade glass mold and the solvent was evaporated using a vacuum oven (48h at 80°C, 24h at 105°C) to obtain thin films of approximately 1mm thickness.

B) PU/MMT preparation (5% PU/MMT composite)

Organic MMT (Sigma) was dispersed in DMF (MMT concentration was 2.5g/100ml). Solution was sonicated for 6 hours (50^{o}C, 35kHz) .To prepare MMT/PU composite, a calculated amount of MMT dispersion was mixed with PU solution and stirred for 1hour

C) PU/Carbon nano fiber preparation (1.5% PU/C-nano fiber composite)

Carbon nano fibers were prepared using pyrolysis of electro spun poly acrylo nitril (PAN) nano fibers. The prepared carbon nano fibers were laid in parallel form and PU solution was poured on the nano fiber sheet. The PU/C-nano fiber composite was casted to a thin sheet.

D) PU/GO preparation (2.8% PU/GO composite)

Graphite oxide was prepared using improved hummers method. GO is dispersed in

DMF (1.5mg/100ml) and ultra sonicated for 1hour. To prepare GO/ PU composite, the calculated amount of GO dispersion was mixed with PU and stirred for 1hour.

E) PU/reduced GO preparation (2.8% RGO/PU composite)

Graphite oxide was prepared using improved hummers method. GO is dispersed in DMF (1.5mg/100ml) and ultra sonicated for 1hour.To prepare GO/ PU composite, a calculated amount of GO dispersion was mixed with PU and stirred for 1hour. To reduce GO, 20µl volume of Hydrazene was added to the polymer solution and kept 2days with occasional stirring.

F) Nano composite characterization

Dynamic mechanical analyzer (DMA), Differential scanning calorimeter (DSC) and Fourier transform infrared (FT-IR) spectrophotometer were used to analyze the composite's thermal behavior and chemical interaction between PU and the reinforcement of the composite. X-ray diffraction analysis was carried out to identify the change of the interlayer spacing of MMT structure in the nano composite and to observe the crystal phase arrangement of the composite due to the specific nano structure as reinforcement.

RESULTS AND DISCUSSION

PU/Carbon nano fiber composite showed the highest modulus increment (120%). High moduli of the carbon nano fiber have mainly contributed towards the final modulus increment in the nano composite. PU/MMT nano composite showed the second highest modulus increment (98%) where the layered structure of the nano reinforcement has mainly contributed towards the modulus increase. XRD analysis of the composite revealed the intercalation of PU inside MMT nano layers, which was evident through the increment in layer spacing of the MMT nano structure. When compared PU/ Graphite oxide nano composite and PU/reduced graphite oxide nano composite, the latter showed the highest modulus increment. The chemical interaction of reduced graphite oxide with PU has contributed towards the relatively high modulus increment compared to PU/Graphite oxide nano composite. Glass transition temperatures of the four nano composites did not show a significant difference where a conclusion can be arrived such that no or less significant chemical bond (cross linking) or structural change (crystalline to amorphous ratio) has been occurred in the nano composite.

REFERENCES

1. Rehab A, Salahuddin N. Nanocomposite materials based on polyurethane intercalated into montmorillonite clay. Materials Science and Engineering A399(2005) 368–376.
2. Chun B, et al. Mechanical Properties of Polyurethane/Montmorillonite Nano composite Prepared by Melt Mixing. J Appl Polym Sci 106: 712– 721, 2007.
3. Jeffrey R, et al. Graphene-based polymer nano composites. Polymer 52 (2011) 5-25.

EXTRUDED POLYPROPYLENE-LAYERED SILICATE NANOCOMPOSITE SHEETS PREPARED BY THE CO-INTERCALATION OF SHORT CHAIN AMIDES

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ABSTRACT

A new preparation method for polypropylene (PP)-layered silicate nanocomposite (PPLSN) by the co-intercalation of short chain amides and functionalised polypropylene based compatibilizer is reported, with an enhanced degree of exfoliation and with similar flow properties as pure PP.

PPLSN sheets were prepared by melt extrusion of PP and organically modified montmorillonite (OMMT) clay in the presence of functionalised PP and short chain amides. Improved clay exfoliation and dispersion in the PPLSN material characterized with X-ray diffraction (XRD) and transmission electron microscope (TEM) analysis have shown the effectiveness of the co-intercalation method for preparing extruded PPLSN sheets. A significant enhancement in low strain modulus is achieved whilst maintaining the similar strength characteristics, relative to the unmodified PP. Experimental data, particularly tensile modulus, modelled with Halpin-Tsai approach using the morphology of OMMT in the nanocomposite sheets obtained from image analysis of TEM is generally in agreement at lower volume fractions of OMMT.

Keywords: *Layered silicate, polypropylene, amides, co-intercalation, Halpin-Tsai*

INTRODUCTION

PP is an extremely prominent and important class of thermoplastic material; versatility is afforded by the ability to be synthesised or modified according to end-use criteria. However, it is difficult to disperse inorganic clay particles in a non-polar PP matrix, due to limited incompatibility, even if the mineral is organically modified by pre-treatment[1]. Although PPLSN has been successfully synthesized by using the functionaled PP based oligomers and organoclay[2], more recent work suggests that fully exfoliated nanocomposite structures have not been achieved[3]. Our previous studies reported a new way of preparing PPLSN with improved clay dispersability in the PP matrix usinga a secondary intercalant[4] and the effect of this nanostructred materials on processability of the nanocomposite material[5].

The objective of the studies reported here is to evaluate the suitability of the co-intercalation method that was developed to prepare extruded products of PPLSN material. Mechanical properties of the PPLSN sheets have also been investigated.

MATERIALS AND METHODS

PP, homopolymer grade HB671 and montmorillonite (OMMT) clay modified with dimethyl dihydrogenated tallow quaternary ammonium chloride, has been used to prepare the PPLSN. Maleic anhydride-grafted PP copolymer and erucamide were also used in the formulation of functionalized compatibilizer and co-intercalant respectively.

The extruded products were prepared by extrusion of PPLSN materials using Haake rheomix 600 with an attachment of extruder.

RESULTS AND DISCUSSION

X-ray diffraction and TEM analysis of extruded PPLSN sheets revealed that both the functionalized PP and the short chain amide effectively facilitate the intercalation of PP molecules into the galleries of organoclay, which resulted higher interlayer spacing, and the OMMT clay dispersion in the PP matrix during the melt extrusion process. Figure 1 shows TEM image of the PPLSN sheets prepared with clay loading levels of 2 wt. % and 6 wt. % (PPLSN2 and PPLSN6).

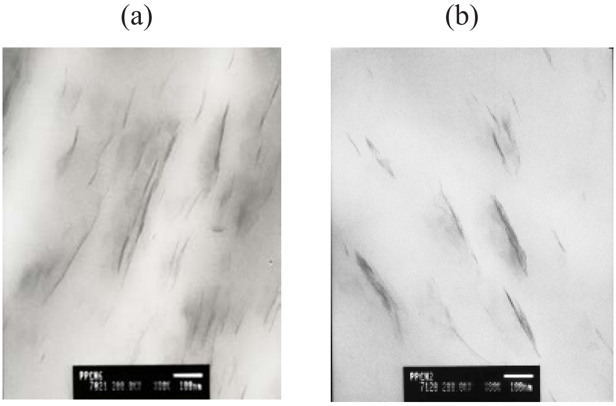

Figure 1: TEM micrographs of extruded PPLSN sheets (80 k), (a) PPLSN6 (b) PPLSN2

It can be seen from the TEM images (Figure 1) that clay particles consist of either single platelets or thinner stacks containing 2–3 platelets. This indicates when compounded PPLSN material was extruded into sheets, the clay particles were exfoliated effectively.

Figure 2 shows the tensile modulus of PPLSN as a function of organoclay loading levels. All extruded PPLSN sheet samples showed a higher tensile modulus in comparison to that of pure PP. However, when clay content is increased beyond 4 wt. % the improvement in tensile modulus is gradually less. The improvement of tensile modulus of the nanocomposite sheets is achieved due to the fact that co-intercalation method significantly improves the organoclay exfoliation and subsequent dispersion. Exfoliation of clay particles into nano-meter scale, resulting in higher aspect ratio, is the key factor for this improvement.

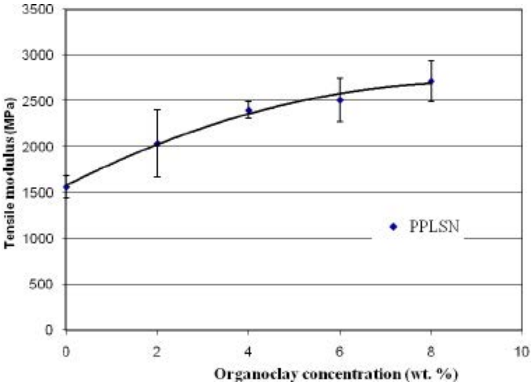

Figure 2:Tensile modulus of extruded PPLSN sheets with increasing clay concentration

Further, Halpin-Tsai model has been used to predict tensile modulus of extruded PPLSN sheets prepared with the co-intercalation method and to compare the experimental data. The experimental tensile modulus values of PPLSN are generally in agreement, at lower clay volume fraction but actual values show a significantly lower tensile modulus than the predicted values at higher clay volume fractions.

REFERENCES

1.Hasegawa N., Kawasumi M., Kato M., Usuki A. & Okada, A. (1998). Preparation and mechanical properties of polypropylene-clay hybrids using a maleic anhydride-modified polypropylene oligomer. J. Appl. Poly. Sci., 67: 87-92.

2.Usuki A., Kato N., Okada A. & Karauchi, T. (1997). Synthesis of polypropylene-clay nanocomposites. J.Appl. Poly. Sci., 63: 137-138.

3.Perrin-Sarazin F., Ton-That M. T., Bureau M.N. & Denault J. (2005). Micro and nano-structure in polypropylene / clay nanocomposites Polymer 46: 11624-11634.

4.Ratnayake U. N. Haworth, B. & Hourston, D.J. (2009). Preparation of polypropylene-clay nanocomposites by the co-intercalation of modified polypropylene and short chain amide molecules. J. Appl. Poly. Sci., 112:320-334.

5.Haworth B. & Ratnayake, U.N. (2011). Co-intercalation in PP clay nanocomposites: effect of short chain additives on rheological properties. International Polymer Processing. 26(1): 91-99.

SYNTHESIS OF MULTILAYERED CARBON NANO STRUCTURES USING COCONUT SHELLS

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ABSTRACT

A mixture of hydrocarbons is produced during the coconut shell charcoal production, and the average amount of gas production per year is estimated to be 90,000 – 100,000 MT. Most of the coconut shell based charcoal producers release these gases into the atmosphere thereby polluting the environment. We report an attempt to synthesize carbon nanotubes (CNTs) via the Thermal Chemical Vapor Decomposition (TCVD) technique, at a relatively lower reaction temperature of 600 ^{0}C, using the waste hydrocarbon gas emitted by the controlled heating of coconut shells. An apparatus was designed and according to the SEM images obtained for the carbon material synthesized showed layered carbon nanostructures. Further experimental attempts are being followed in order to modify the catalyst and the conditions to obtain CNTs.

***Keywords**: Coconut Shells, Graphene, Carbon nano tubes (CNT)*

INTRODUCTION

Carbon nanotubes (CNTs) are considered to be a major material of interest due to various applications related to nanotechnology. CNTs are being applied almost in all the industries from polymers to astronomy1. In our work, CNTs were attempted to be synthesized using a waste material available in Sri Lanka viz., coconut shells, as the feed stock. Fe, Co, Ni metals and their amalgams with support substrates were experimented as catalysts. Multi layered carbon nanostructures were synthesized during the project, instead of CNTs. Layered carbon structures could be graphene nanofilms.2 Because of its electrical conductivity, which has been obtained due to the specific structure, the carbon layered structures are widely used in industries related to electro chemistry.3 Advanced techniques as Pulsed Laser Ablation (PLA) 4, and Plasma enhanced deposition are used for the synthesis of carbon nano layers. However, the sysnthesis of graphene sheets from TCVD technique, using coconut shells as the feed stock has not been reported.

METHODOLOGY

There are two components of the TCVD apparatus (Figure 1), one for the generation of hydrocarbon gas by the heating of coconut shells and the other one as the reactor chamber, in which the catalyst is placed under a temperature of 600 ^{0}C (muffle furnace) in an inert, nitrogen environment.

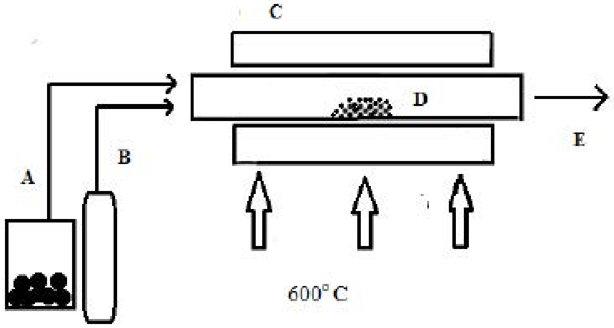

Figure 01.Schematic diagram of the TCVD reactor (A) hydrocarbon gas flow emitted by heating coconut shells (B) Nitrogen gas flow (C) muffle furnace (D) catalyst chamber which maintains at 600oC (E) gas outlet

In addition to neat metal catalysts, iron oxide nanoparticles were also used as a catalyst and these were synthesized according to the already published data. The catalyst was placed in the catalyst chamber. The hydrocarbon gas was passed over the catalyst for two hours. After the synthesis, the yield was refluxed with an acid mixture of Conc. H_2SO_4: Conc. HNO_3 (2:1). After the acid treatment, air etching was done at 500 ^{0}C for 6 hours. The sample was submitted for SEM pictures.

RESULTS AND DISCUSSION

The following SEM image was obtained for the product. Carbon nanotubes could be considered as scrolled up graphene sheets. It seems like the synthesized layer structures lack the energy to get rolled up into tubular structure. The experiments are in progress for developing a catalyst with much energy to enhance the formation of nano tubes. Fe, Co and Ni salt combinations are being tried out with support substrates like silica and alumina.

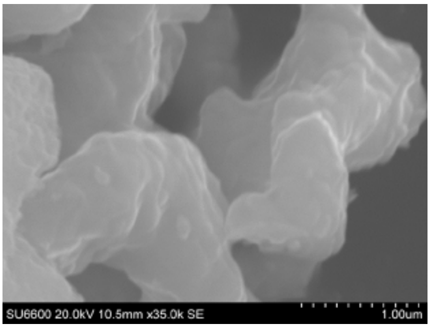

Figure 02: Carbon nano layers synthesized during the process

REFERENCES

1. Chu, p.k., Li, L. (2006). Characterization of amorphous and nanocrystalline carbon films. materials chemistry and physics, 96:253-277
2. Michael, N., R., Claeyssens, F., Fuge, G., M., Henly, S., J. (2004). Pulsed laser ablation and deposition of thin films. Chem. Soc. Rev. 33:23-31
3. Yang, Q., Tang, Y., Li, Y.S., Hirose, A. (2008). simultaneous growth of diamond thin films & carbon nanotubes at temperatures ≤ 5500C. Plasma sci. Technol. 46:589-595
4. Kumar, M., Ando, Y. (2010). chemical vapor deposition of carbon nanotubes , a review of growth mechanism and mass production. Journal of Nano science and Nano technology 10: 3739-3758

SYNTHESIS AND PROPERTIES OF METAL OXIDE/HYDROXIDE BASED NANOCOMPOSITES OF ACTIVATED CARBON

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ABSTRACT

In this study, the incorporation of Nano Magnesium Oxide in to Granular Activated Carbon (GAC) was investigated with the intension of using this Nanocomposite as an efficient gas adsorbent. Synthesized nanoparticles were characterized using TEM (Transmission Electron Microscope), SEM (Scanning Electron Microscope) and FT-IR. It was found that the GAC-MgO holds 1.570 % of MgO from the quantification of nanocomposites. With the results obtained from the experiment it was clear that GAC-MgO nanocomposite has the ability to catalytically destroy hydrogen sulfide and sulfur dioxide. Activated carbon purifiers are the most common gas purification method available today. Incorporation of nanoparticles into activated carbon will not only enhance its adsorption by ~90 % but also makes it a toxic gas neutralizer.

***Keywords**: Metal hydroxide/oxide nanoparticles, Activated Carbon, Hydrogen sulphide*

INTRODUCTION

Toxic gases and solutes cause a significant impact on environment as well as its living. Many investigations on the removal of such toxic matter are being done and are of great importance. Since metal oxides such as Magnesium Oxide (MgO) and Calcium Oxide (CaO) have significant reactivity with many gases[1], an approach for the removal of toxic gases from the environment can be developed from such oxides. The bulk magnesium oxide is being used in the industry in conjunction with activated carbon to remove toxic gases. However these composites use very high amount of magnesium oxide per gram of carbon. The use of nano particles will reduce the amount of material, thereby reducing the cost for production of these composites in the industry. On the other hand due to the reactivity of nano material a very small percentage of nano materials will be required. Nano-MgO has been studied for its ability to remove various toxic gases. However removal of H_2S and SO_2 using Metal Oxide-Activated Carbon nanocomposite has not been reported. Unlike in conventional methods, the gas purification from Nano-crystalline metal oxides was found to be very efficient[2]. This is due to their higher surface area and elevated intrinsic reactivity.

MATERIALS AND METHODS

A) Synthesis of Nanocomposite

A known method[3] was modified to obtain hydroxide nanoparticles using combination of surfactants. Nanoparticles of $Mg(OH)_2$ was characterized using TEM and SEM. The metal hydroxide was converted to metal oxide and then impregnated into GAC. Chemical digestion followed by Atomic Absorption Spectroscopy was carried out for the quantification of nano coating on GAC. Obtained Nanocomposites were characterized using FT-IR and SEM.

B)Adsorption of Toxic Gases on to Nanocomposites (H_2S and SO_2)

The toxic gases were prepared according to the following equations using the apparatus given in Figure 1.

$$Na_2SO_3(s) + 2\,HCl(aq) \longrightarrow 2\,NaCl(aq) + SO_2(g) + H_2O(l)$$
$$PbS(s) + 2\,HCl(aq) \longrightarrow PbCl_2(s) + H_2S(g)$$

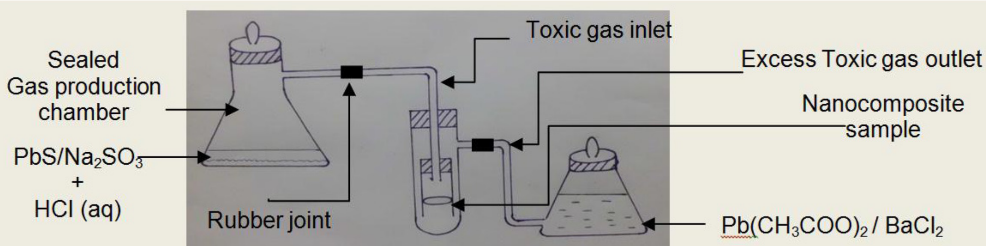

Figure 1: Apparatus designed in the study, for the quantitative analysis of toxic gas adsorption on to nanocomposite

This set up was kept undisturbed for several hours with and without the nanocomposite sample.

The produced gases were sent through the nanocomposite and the remaining gas passing through the gas outlet was bubbled into lead acetate solution or barium chloride solution. The adsorb amounts were calculated according to the standard gravimetric analysis.

RESULTS AND DISCUSSION

Preparation of the MgO-GAC Nanocomposites was a success. According to the TEM images the sizes of $Mg(OH)_2$ nanoparticles were in the range of 23 - 68 nm.

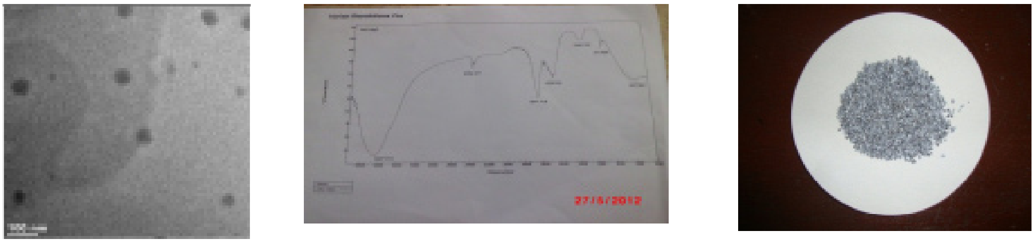

Figure 2: (a) TEM image of $Mg(OH)_2$ nanoparticles obtained during the study
(b) Synthesized Nanocomposite
(c) FT- IR spectrum of powdered MgO-GAC nanocomposite

This investigation showed that the Nanocomposites have the ability to trap gaseous H_2S and SO_2. Adsorption of SO_2 was 80 - 90% and adsorption of H_2S was 70 - 90%. Adsorption efficiency of the nanocomposites was several times higher than the pure GAC. Further studies are underway to explore possibility of commercialization.

REFERENCES

1.Zhang X., Zhuang G., Chen J., Wang Y., Wang X., An Z. & Zhang P. (2006). Heterogeneous Reactions of Sulfur Dioxide on Typical Mineral Particles. Journal of Physical Chemistry 110:12588-12596.

2.Stark J.V. & Klabunde K.J. (1996). Nanoscale Metal oxide particles/Clusters as chemical Reagents. Adsorption of Hydrogen Halides, Nitric Oxide, and Sulfer Trioxide on Magnesium Oxide nanocrystals and compared with Microcrystals. Journal of Chemistry of Materials 8:1913-1918.

3.Park J. Y., Lee Y. J., Jun K. W., Baeg J. O. & Yim D. J. (2006). Chemical Synthesis and Characterization of Highly Oil Dispersed MgO Nanoparticles. Journal of Industrial and Engineering Chemistry 12:882-887.