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TWO DAY NATIONAL CONFERENCE on Advances in Agriculture and Environmental Studies" (NCAE)

on 3rd & 4th Dec, 2021

ABSTRACTS

Organized by

Departments of Botany (UG & PG) and Agriculture and Rural Development

ANDHRA LOYOLA COLLEGE (AUTONOMOUS) VIJAYAWADA-520 008, ANDHRA PRADESH, INDIA

ISBN : 978-93-85818-93-7

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INVITED TALKS
&
ABSTRACTS

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8. Green Nano Technology for Sustainable Environment

Dr.P.B.Sandhya Sri[1], Dr.K.A.K.Raj Kumar[2], R.Uday Kumar[3], and Dr.S.V.G.V.A.Prasad[4*]

[1]Department of Physics, Government Degree College, Avanigadda-521122,A.P.

[2]Department of Chemistry, LB College, Visakhapatnam -530004,A.P.

[3]Department of Physics & Electronics, K.B.N.College, Vijayawada-520001,A.P.

[4*]Department of Physics, Pithapur Rajah's Government Autonomous College,Kakinada-533001,A.P.

Corresponding author e Mail: somarouthu13@yahoo.co.in

Abstract

In a world of finite resources and ecosystem capacity, the prevailing model of economic growth, founded on ever-increasing consumption of resources and emission pollutants, cannot be sustained any longer. In this context, the "green economy" concept has offered the opportunity to change the way that society manages the interaction of the environmental and economic domains. To enable society to build and sustain a green economy, the associated concept of "green nanotechnology" aims to exploit nano-innovations in materials science and engineering to generate products and processes that are energy efficient as well as economically and environmentally sustainable. These applications are expected to impact a large range of economic sectors, such as energy production and storage, clean up-technologies, as well as construction and related infrastructure industries. These solutions may offer the opportunities to reduce pressure on raw materials trading on renewable energy, to improve power delivery systems to be more reliable, efficient and safe as well as to use unconventional water sources or nano-enabled construction products therefore providing better ecosystem and livelihood conditions.

Introduction

Green nanotechnology aims for products and processes that are safe, energy efficient, reduce waste and lessen greenhouse gas emissions. Such products and processes are based on renewable materials and have a low net impact on the environment. Green nanotechnology is also about manufacturing processes that are economically and environmentally sustainable[1]. The principles of green chemistry can be applied to produce safer and more sustainable nanomaterials and more efficient and sustainable nano manufacturing processes. Conversely, the principles of nanoscience can be used to foster green chemistry by using nanotechnology to make manufacturing more environmentally friendly[2].

Green nanotechnology can have multiple roles and impacts across the whole value chain of a product and can be of an enabling nature, being used as a tool to further support technology or product development. Significant advances have been made in the field of nanotechnology in the past decade and more, helping it to move closer to achieving its green potential. However, the economic and environmental sustainability of green solutions involving nanotechnology is in many cases as yet unclear and some novel solutions bring with them environmental, health and safety (EHS) risks. These risks must be mitigated in advancing green nanotechnology solutions[3]. Green nanotechnology is expected to increasingly impact on a large range of economic sectors, ranging from food packaging to automotives, from the tyre industry to electronics. Nanotechnology is also increasingly being applied in conjunction with other technologies, such as biotechnology and energy technologies, leading to products incorporating multiple green technological innovations.

Methodology

1. Green Nanotechnology for Efficiency of Electronic and Optical Components

Until recently, electronic devices were not considered as major consumers of energy compared with engines or heating systems. However, as more devices are being used, energy consumption by these devices has become a larger issue. The dramatic increase in performance of electronic components, resulting from improvements in both manufacturing efficiency and semiconductor design (MOS transistors, LED and laser diodes), has resulted in greater usage among the general population, leading to increases in energy consumption. This can be observed in the energy consumption of super-computers used for high-performance or cloud computing as well as in the countless number of devices like smart phones, TVs, sensors, etc. used by the general population, each of which uses very little energy but which, as a whole, have a significant impact on global energy consumption[4]. Likewise, a modern television uses more energy than older cathode ray tubes because their screens are wider and brighter and have better resolution and contrast. The demand for energy efficiency in mobile devices first started because of the limited capacity of batteries. The desire for greater mobility was the main driver of the success of small and less powerful processors used in smart phones or notepads, to the detriment of major manufacturers such as AMD or Intel. Efforts to optimise energy consumption have even resulted in software engineers trying to code programmes to reduce energy use, even at the cost of reducing processing speed.

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Nanotechnology has made lower energy consumption per-bit possible with a concurrent increase in the performance of the whole electronic component more than compensating for any diminution of other properties. Today the energy performance of an electronic chip is limited mostly by the power lost through thermal dissipation typically 200 W/cm2. However, the reduction in the energy and raw materials usage per device has not been sufficient to offset the global energy consumption caused by new functionalities and performance which increasingly require greater use of energy[5]. New "zero-power" systems are being developed in which low-energy electronics use energy harvesters to convert ambient energy into electrical energy.

Nanotechnologies are at the forefront of the race for low energy consumption through modifications in the technologies used in electronics. Novel devices are being developed based on spintronics, on electromechanical nanosystems (NEMS) and using optical rather than metallic interconnections. LED-based new technologies have the potential to revolutionise lighting, which to date has mainly been based on gas discharge lamps using an electric arc in vaporised mercury[6,7].

2. Carbon nanotubes for green innovation

There are many potential applications for carbon nanotubes, the most relevant to green innovation being for applications relating to transport and electronics.

2.1 Transport

Modern life would be inconceivable without mobility, but traffic and transport systems must be consistently adapted to the changing requirements of humans and markets. Increasingly, the focus of modern mobility is on requirements for environmentally-compatible approaches with a high level of safety. Materials technology plays a vital role in the development of energy-efficient concepts. High strength, low density synthetic materials and composites can be used to lower the weight of components, with that reduction translating into energy savings. CNT-based materials have great potential to improve the energy use of the transport sector including cars, lorries and trains. CNT-reinforced plastics and metals are especially lightweight, while offering high levels of stability and strength. These properties are also ideally suited to meet the extreme material requirements of the aviation and space industry. Conventional design materials currently used in aeronautical applications, the automotive industry and machinery are increasingly reaching the limits of passive structures. Lightweight construction concepts based on CNT offer enormous potential, including their use in situations with extraordinary structural stresses. High-strength, ultra-light materials being used for lower-weight designs of cars and aircrafts are making an important contribution to higher energy and resource efficiency and substantial amounts of fuel saving. Lightweight construction also offers potential benefits to other applications and industries. CNT based particle foams offer improved vehicle security, while specialised forms of concrete offer additional design options and improved earthquake protection.

2.2 Electronics

The success of nearly all sectors of industry today is closely associated with their electronic systems, without which many applications would not be feasible. At the same time, the complexity of these systems has increased tremendously over recent years. Innovative solutions that contribute to the control of demanding electronic applications and simultaneously conserve natural resources are of great significance for the entire economy. The development of increasingly-powerful electronic components, together with more cost-effective and application-specific production, will benefit from the opportunities offered by nanotechnology. Innovation based on CNTs with both outstanding electrical conductivity and mechanical properties are particularly promising[8-10]. They range from displays to X-ray and microwave generators to photovoltaic applications and high-resolution electron beam instruments. In all of the above case studies it is also important to cover the potential health, environmental and safety (EHS) aspects. These will be introduced in further detail in the next section.

3. Micro- and nanofibrillar cellulose

Cellulose fibres constitute an abundant, renewable and biodegradable raw material which can be used in paper production and other applications. Fibres have been used for the production of paper for almost 2000 years, with wood, which is abundant in many countries globally, having been used as a raw material in the form of fibres for approximately 150 years. The use of nanofibres from wood pulp may open up new opportunities for forest based industries. Globalisation and increased international competition within the pulp and paper industry demands new thinking: increased refinement ratios, new technology and new production methods. Next step innovation requires the production and refinement of micro- and nanosized materials from cellulose - micro- and nanofibrillar cellulose (MFC and NFC). While there has been great interest in such fibres for a long period of time, given the variety of potential applications in the form of paper and packaging materials, manufacturing has been a significant obstacle to commercial exploitation. The manufacturing process has been considered too energy-intensive and complex to apply but advances in research are now making headway in addressing these issues for fibrous nano materials.

4. Nanotechnology for the sustainable development of tyres

ISBN : 978-93-85818-93-7

Millions of people and industries rely today on road transport and the number of road vehicles is expected to double by 2030. Servicing this new demand will present a significant challenge in the area of tyres as current production relies greatly on natural rubber and petrochemicals. Modern tyres already incorporate nanotechnology and achieve their high mileage, durability and road grip through the use of nanoscale carbon black and silica. Although incremental improvements to current tyre technology can be expected, the industry is reaching the technical limits of tread compound development[11]. New nanotechnology applications could provide scope for dramatic improvements on existing technologies. The introduction of carbon black and silica has already allowed manufacturers to achieve performances that would not have been possible using conventional materials. Carbon black has been used for decades and recent scientific breakthroughs now allow both carbon black and silica to be economically produced at the nanoscale and incorporated into tyres consumer products.

Many predict that other nanomaterials will be introduced into manufacturing processes to increase performance, providing added environmental and socio-economic benefits. Potential fields of improvement include increased car and truck fuel efficiency and tyre durability and reduced greenhouse gas emissions and tyre weight. Whilst there are still concerns about the degree to which nanomaterials can leach into food from the packaging, and the effect they may have on the health of consumers, most research so far looks promising, and the benefits are highly tangible - several nano-enhancements for packaging are already on the market, helping to prolong the shelf life of food and making it easier to manufacture, process, and manage[12]. Whilst there are still concerns about the degree to which nanomaterials can leak into food from the packaging, and the effect they may have on the health of consumers, most research so far looks promising, and the benefits are highly tangible - several nano-enhancements for packaging are already on the market, helping to prolong the shelf life of food and making it easier to manufacture, process, and manage. Whilst there are still concerns about the degree to which nanomaterials can leach into food from the packaging, and the effect they may have on the health of consumers, most research so far looks promising, and the benefits are highly tangible - several nano-enhancements for packaging are already on the market, helping to prolong the shelf life of food and making it easier to manufacture, process, and manage. Some of the most promising nanomaterials for tyres include nanosilica, organoclay and carbon nanotubes used as fillers, substituting for traditional fillers like carbon black and silica. Composites reinforced with CNTs have been shown to have dramatically improved tensile strength, tear strength and hardness compared with more conventional materials. Silicon carbide has been used to produce tyres with improved skid resistance and reduced abrasion.

Nanoparticles of clay can be mixed with plastic and synthetic rubber to seal the inside of tyres, creating an airtight surface and allowing the amount of rubber required to be reduced.

Conclusions

Green nanotechnology aims to exploit the attractive physico-chemical properties of nano materials in a number of green-innovative applications that are energy efficient as well as economically and environmentally sustainable, expected to exert an exciting impact on a large range of economic sectors. These solutions may offer the opportunities to reduce pressure on raw materials trading on renewable energy, to improve power delivery systems to be more reliable, efficient and safe therefore providing better ecosystem and livelihood conditions.

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ISBN : 978-93-85818-93-7