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13. Emerging Sustainable Nanotechnology

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Abstract:

Green Nanotechnology is an emerging sustainable nanotechnology as it combines the techniques of Green Chemistry and Green Engineering. The usage of energy and fuels are saved in this method due to the fewer intakes of materials and also using renewable raw materials. No harm to the human health and environment is caused by the utilization of Green nanotechnology in the process of manufacturing of nanomaterial and is the main factor which promotes the use of this technology as an emerging trend in this field. In this chapter we will discuss the core areas in which the emerging sustainable nanotechnology is being mostly employed.

13.1 Introduction:

The concept of nanotechnology was first suggested at by Richard Feynman in 1959 and later the word nanotechnology was coined by Norio Taniguchi in 1974.Two main approaches are used in nanotechnology. In the "bottom-up" approach, materials and devices are built from molecular components which assemble themselves chemically by principles of molecular recognition [1]. In the "top-down" approach, nano-objects are constructed from larger entities without atomic-level control [2]. The bottom-up approach promises the minimization of waste products. The combination of Green chemistry along with the nanotechnology has a promising future as it emphasizes the sustainability of environment as well as it promotes a healthy life for human beings. The important applications of the emerging sustainable nanotechnology in various fields are depicted in Figure (1).

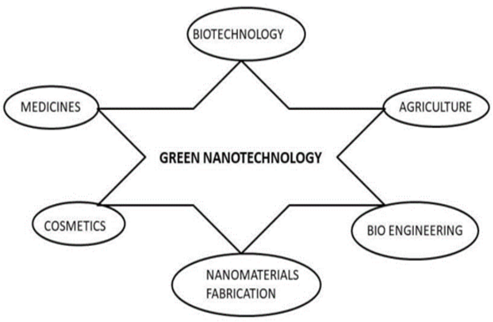

Figure 13.1: Applications of emerging sustainable nanotechnology in various fields

Reduced greenhouse gas emission, wastes, increased energy efficiency and decreased consumption of non-renewable raw materials are the main merits of green nanotechnology. Green nanotechnology offers a great chance to stop the adverse effects before they occur [3, 4]. Researchers, however, continue to move further, engaging themselves to conquer the challenges ranging from managing, producing, funding, regulatory and technical aspects of this emerging sustainable nanotechnology [5].

13.2 Agriculture and Food Industry:

Various promising opportunities have been identified for nanomaterial-based technologies which are intended for the improvement of sustainability in agriculture and food systems [6, 7] which includes sensors for testing chemicals, measuring physical, chemical, or biological properties, advanced techniques for detection and control of harmful pathogens and to increase food safety; technology for water treatment in agricultural fields; nanomaterial-based fertilizers, etc. [8]. Recently, various types of nano-based antimicrobial agents have been tested as food packaging materials, and have been proven to show enhanced properties such as thermal stability, pH resistance, and other physico-chemical potentials [9]. There are several methods of using the antimicrobial compounds as packaging materials in food packaging systems. The first method includes the addition of a packet of volatile antimicrobial agents in the packing system which will diffuse slowly into the packet and provide protection to the food from external contaminations. Second method is to directly mix the antimicrobial agents into the polymers used as packaging materials. Third method is to coat the antimicrobial compounds on the surface of the packaging materials or utilize antimicrobial packaging materials directly [10, 11]. However, an effective safety management technique is used in order to protect human health and the environment [12].

13.3 Nanomaterials Fabrication:

Green synthesis of nanomaterial is more beneficial than traditional chemical synthesis because it costs less, decreases pollution, and improves environmental and human health safety [13]. The typical method for green synthesis of Gold Nanoparticles is to reduce gold ions by reducing agents from plant extracts or microorganisms. The extracts are usually obtained by soaking ground plants in solvents (water, ethanol) under suitable environmental conditions. The extracts are then mixed with a solution containing gold ions, and Gold nanoparticles are produced when the solution turns red [14, 15].

The common green synthesis for Silver nanoparticles involves mixing of silver nitrate solution with reducing substances extracted from plants. Extracts are obtained from plants following same procedure of Gold nanoparticles as mentioned above, and then mixed with silver nitrate solution. The generation of Silver Nanoparticles is indicated by the solution turning to brownish color [16, 17]. Materials used for Palladium Nanoparticle syntheses are Black Tea leaves, Lithodor ahispidula leaf, Rosa canina fruit, and Sapium sebiferum leaf [18, 19, 20]. Turunc and co-workers in 2017 ground Lithodor ahispidula leaves and boiled them in ultra-pure water [21]. After cooling down and filtration, the leaves extract was mixed with K_2PdCl_4 solution. The Palladium Nanoparticles produced from this process were used in modifying glass carbon electrode, which could be applied to electro catalytic reduction of hydrogen peroxide. By following another method, Kora and Rastogi in 2016 selected a special renewable material called gum olibanum. Analysis had validated that the proteins and hydroxyl and carboxylate groups in the gum improved the stabilization of Palladium Nanoparticles [22].

The pre-washed citron fruits were squeezed and filtered by muslin cloth to obtain the citron juice. The Copper nanoparticles synthesized using citron juice exhibited antibacterial and antifungal activity against plant pathogenic fungi. Among the bacteria tested, Copper Nanoparticles were effective in inhibiting growth of E. coli, K. pneumoniae, P. aeruginosa, P. acne, and S. typhi in decreasing order. The Copper Nanoparticles synthesis by citron juice is very convenient and cost-effective that it is valuable to put into use [23]. Wei and coworkers in 2017 explored extract from Eichhornia crassipes (an invasive weed with extraordinary growth rate and fertility) for synthesis of Iron Nanoparticles. They tested the Nanoparticles for chromium removal, and reported that chromium can be removed by reduction, immobilization, and co-precipitation [24].

13.3 Medicinal Field:

Developing nanotechnology based medicine dosage-forms, Eg, Solid-lipid nanoparticles (SLNs), polymeric nanoparticles (nanospheres and nanocapsules), proliposomes, liposomes, nanoemulsions, etc., which are used in Phytoformulation has a great number of advantages for herbal drugs. These include enhancement of solubility and bioavailability, improvement of stability, suppression of toxicity, sustained delivery, and defense against physical and chemical degradation. Therefore, problems associated with plant medicines can be overcome with nano-sized drug delivery systems (NDDS) of herbal drugs. Hence, including nan carriers as an NDDS in conventional medicine systems would be a must to combat more chronic diseases like diabetes, cancer, asthma, and others, with the aid of herbal drugs [25,26,27].

13.4 Energy and Environment:

Reduction of CO_2 emission and energy cost reductions are critical societal needs for energy and the environment. Many nanomaterial based devices and advanced technologies play key roles in energy savings, generation, transport, and storage [28], including renewable energy generation by solar cells and fuel cells with green hydrogen. The development of technologies to generate hydrogen by solar energy and to utilize it as an energy carrier as well as battery technology development in energy transport and storage are important goals, and they depend on green nanotechnology. Few gaps remain in our understanding of the consequences of nanotechnology on humans and the environment [29]. The ability to assess and to mitigate these risks is necessary to ensure nanotechnology is safe and sustainable, and that “nano” can credibly be a driver of a sustainable planet and future [30].

13.4 Conclusion:

These green nanomaterials have countless applications in the field of bioenergy, environmental remediation, catalysis, sustainable materials, wastewater treatment etc. While the green nanotechnology seems very promising, it is very important for us to acquire more knowledge based on its interaction with the environment to ensure that the implementation is safe. Even though the Green nanotechnology involve a lot of challenging works in industrial level and other areas , it promotes sustainable environment and ethical values of nanotechnology thereby improve the quality of our lives. Further, nanotechnology has an immense potential to create sustainable techniques, products and processes to combat the.effects of climate change. Overall, the future of green nanotechnology is bright.

13.5 References:

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