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Different Methods, Novel Tools towards the Synthesis of Nanoparticles and Applications in Engineering, Chemical, Physical Sciences and Technology

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Abstract

Nano particles have gained special attention in recent years due to their remarkable electrical, magnetic, optical, and mechanical capabilities, and they offer a variety of uses in all sectors of engineering. Gold nanoparticles, for instance, are catalytic when they are 10 nm in size, whereas nanoparticles with a short radius of curvature and angular forms have better catalytic capabilities. Co-precipitation nanoparticle production is a simple approach that results in a wide range of nanoparticle sizes. Top-down and bottom-up techniques used to create mono-dispersed spherical bismuth (Bi) NPs. These Nanoparticles have outstanding colloidal characteristics. Sputtering is the technique for creating NPs that involves hitting solid surfaces with the high energy particles like gas or plasma. In an aqueous solution, gold nanoparticles were created by using a laser ablation approach. A zeta potentiometer is often used to assess surface charges and their dispersal constancy in a solution. Several industry and technology sectors, including IT, medicine, energy, transportation, homeland security, food safety, and environmental research, are being significantly improved, if not revolutionized, by nano-technology.

Keywords: Nanoparticles, Engineering technology, physical methods, chemical properties.

INTRODUCTION

Nano particles have piqued the attention of many people in recent years due to their remarkable electrical, magnetic, optical, and mechanical capabilities, and they offer a variety of uses in all sectors of engineering. Nanoparticles have numerous applications, including engineering and medical sciences [1-3]. Nanoparticles can also be used in environmental remediation. Because of their small size, nanomaterials have several unique features. They are excellent catalysts due to their large surface area. The nanotechnology explosion is regarded to have occurred at the junction of several scientific areas. The blurring of the borders will present several new opportunities and the new study directions [4, 5]. The most significant advances are expected in the convergence of biotechnology and nanotechnology, two prominent study topics for the twenty-first century. Nanoparticles frequently develop or are coated with compounds that are unique from both the particle's composition and surrounding media. Whilst only a single particle thick, these films can drastically alter the attributes of particles, like catalytic activity, chemical reactivity and the suspension stability [1, 4, 6].

Even though the structure and size of these particulate appear to be purely physical, their intricate impacts on chemical characteristics and the physical interactions are critical to their operation. Gold nanoparticles, for instance, are catalytic when they are 10 nm in size, whereas nanoparticles with a short radius of curvature and angular forms have better catalytic capabilities. The recent history of technological growth has demonstrated that the evolution in nano-technology and nano-science is a critical aspect. Nano-technology

is an interdisciplinary science that encompasses materials science, chemistry, physics and other engineering disciplines. Nano-technology applications are growing across practically all fields of technology and science [7-9].

Nanoparticles and applications in engineering and technology

The creation of nanomaterials is becoming increasingly important due to its ramifications in a wide range of technological fields. Nanomaterials, as a first general categorization, can be manufactured on a big or tiny scale, depending on the particular end uses. As just an example, in raw chemical process industries, one of most important procedures in the production of pigments, dyes and rubber products is the synthesis of inorganic nano-sized powders by flame pyrolysis [10-12].

Coprecipitation nanoparticle production is a simple approach that results in a wide range of nanoparticle sizes. Several different ways for producing more uniformly sized nanoparticles have been proposed. A nano-emulsion containing the NaOH and iron source is used to create magnetite NPs. Top-down and bottom-up techniques used to create mono-dispersed spherical bismuth (Bi) NPs. These Nanoparticles have outstanding colloidal characteristics. Bottom-up, bismuth acetate was boiled in ethylene glycol, whereas top-down, bismuth was transformed in to the molten form and then molten droplet was emulsify within the boiling diethylene glycol to make the Nanoparticles. The Nanoparticles obtained by both procedures ranged in size from 100-500 nm. The production of chemical compounds in an electro-chemical cell is known as electrochemical synthesis. The main benefit of electro-chemical synthesis over traditional chemical reactions is rejection of potentially wasteful alternative half reactions and the ability to precisely control the chosen potential [13-15].

Sputtering is the technique for creating NPs that involves hitting solid surfaces with the high energy particles like gas or plasma. Sputtering is thought to be an efficient process for creating thin films of nanostructures. Sputtering-deposition involves the bombardment of the target surface with strong gaseous ions, which causes the physiological ejection of tiny atom clusters dependent on incident gaseous ions energy. Nps have a wide range of uses in biological and physio-chemical domains. They can be employed in biomedical research for medication administration, bio-sensing, biomolecular and bio-imaging recognition. Because of their anti-microbial capabilities, nanoparticles are used in a variety of daily items like cosmetics, deodorants, humidifiers, water purifications systems and toothpaste. They play an essential role in agricultural technology, like detecting and controlling the plant diseases and reduce the leaching of nutrients to boost crop output. They are also utilized to store energy in oxide and solar batteries [16-18].

A nanoparticle's connections with the target are determined by its charge or surface charge. A zeta potentiometer is often used to assess surface charges and their dispersal constancy in a solution. The charge of the NPs in gaseous phase is determined using a DMA (Differential Mobility Analyzer). The sol–gel technique is an abbreviation for the phrase's sol and gel. Sol is colloid composed of solid particles dispersed in a continuous liquid. A gel is solid macromolecule that dissolves in a liquid. Because of its flexibility, the sol–gel approach is most common used bottom-up technique for the creation of NPs. It is a technique in which an appropriate chemical solution serves as a precursor. Chloride and metal-oxide are common precursors utilized in the sol gel technique [19-22].

Solvent systems are an important part of the synthesis method, whether that is green synthesis or not. Water has traditionally been regarded as an optimal and appropriate solvent solution for the synthesis operations. In an aqueous solution, gold nano- particles were created by using a laser ablation approach. The oxygen in the water causes partial oxidation of created gold NPs, which improves their chemical reactivity and has a significant impact on their growth [11, 15, 19].

Table 1: Shows the nanoparticles and applications in engineering and technology

Type of System/Technology	Advantages	Characteristic features
Nanotechnology	Coprecipitation nanoparticle production is a simple approach that results in a wide range of nanoparticle sizes.	in raw chemical process industries, one of most important procedures in the production of pigments, dyes and rubber products is the synthesis of inorganic nano-sized powders by flame pyrolysis
Physiochemical	Sputtering is the technique for creating NPs that involves hitting solid surfaces with the high energy particles like gas or plasma.	Sputtering is thought to be an efficient process for creating thin films of nanostructures.
Advanced systems	Carbon nano-tubes are near to replace silicon as material for making faster smaller and the more well-organized devices and micro-chips, as well as the more conductive, lighter and sturdier quantum nano-wires.	The features of graphene make it perfect for the construction of flexible touch-screen devices. Several industry

Carbon nano-tubes are near to replace silicon as material for making faster smaller and the more well-organized devices and micro-chips, as well as the more conductive, lighter and sturdier quantum nano-wires. The features of graphene make it perfect for the construction of flexible touch-screen devices. Several industry and technology sectors, including IT, medicine, energy, transportation, homeland security, food safety, and environmental research, are being significantly improved, if not revolutionized, by nano-technology [16, 19, 20].

By changing structures, systems and materials at the smallest level, the growing field of nano-engineering is revealing endless possibilities for breakthroughs in manufacturing, energy, health care, robotics and other areas. Nanomaterials are used to generate ultrathin protective coatings that reinforce the surfaces on which they are applied. Nano-repel is a device that improves the surface elasticity and flexibility while preventing stress damage by using a fine layer of pure-quartz glass that is resilient to temperatures and the corrosive elements. Similar products may also have antiadhesive characteristics, making it simpler to remove any dirt, spots, and oily compounds off surfaces [21-23].

Nanotubes have shown potential in the treatment of cardiovascular disease. They could have a significant function in blood vessel cleaning. Nano-tubes with SHP1i particles attached would alert macrophages to clean-up plaque in blood arteries without harming the healthy tissues. Researchers evaluated this form of modified nano-tube in mice with considerable plaque buildup; the animals that got the nano-tube therapy had statistically significant decreases in plaque build - up compared to mice in placebo group. More study is required before this medication can be administered to humans [24-27].

Aside from the numerous benefits of nano-technology to the food business, the safety concerns related with nanomaterials must not be overlooked. Many studies claimed nano - materials safety concerns, with concentration on the likelihood of NPs migrating from packed material in to food and their influence on the health of consumer. NPs are bio-synthesized when micro-organisms capture targeted ions from their surroundings and subsequently convert metal ions in to elemental metal using enzymes produced by the cell activities. This can be divided into intra- and extracellular biosynthesis based on where the nanomaterials are produced. The intracellular technique entails transferring ions inside the microbe cell in the presence of enzymes to produce NPs. Extracellular production of NPs includes retaining metal ions on the surface of cell and reducing ions in the presence of enzymes. Biosynthesized Nps have been employed in a wide range of uses, such as medication carriers for active targeting, DNA analysis, gene therapy and biosensors, anti-bacterial agents, cancer treatment, increasing response rates, separation science and MRI [1, 9, 10, 18, 19].

Nano-technology as a research topic is advancing day by day, making an impact in practically every aspect of human life and producing great interest in the bio-science field, notably bio-technology and bio-medical sciences. Nano-crystalline particles have found enormous uses in the fields of high-sensitivity biomolecular detection and diagnostics, treatments and antimicrobials catalysis, and microelectronics due to their increased qualities on certain features such as distribution, size, and form. Aside from these exceptional uses of NPs, there is an urgent need to discover clean techniques (biological routes) for the nanomaterials that are financially viable and environmentally acceptable in nature [28-32].

Whereas nano-technologies development is up-to-date multi-disciplinary science including the many fields like physics, engineering, biology and chemistry, the manufacturing of NPs, both by naturally or by the humans, times from pre-Christian era. For instance, the Romans presented amalgams with the nanometric magnitudes in glass making; the well-known Lycurgus-cup (at this time displayed at the British-Museum), that shows many colors depends on whether it is or internally (red) or illuminated externally (green) contains nanoparticles of gold and silver. In the preparation for nanoparticles of the manufacturing of colloidal gold (and some other metals like Cu, Sn, Fe and Zn) and its interface with the light [23, 29, 30].

It is worth noting that the use of nano-technology to biological materials is quite simple due to their intense features. These biological materials are assembled in an exceedingly controlled manner to make them suitable for the production of metal NPs that have been found to be reliable and environmentally benign. Furthermore, the technique of production of semiconductor NPs has become an emerging focus of study due to its unique uses in a variety of sectors, which leads to the development of innovative. Furthermore, nano-technology as a research topic brings up new avenues of investigation, particularly in the realm of materials engineering [22, 28].

CONCLUSION

Nano-technologies has now been considered to have capacity to fetch assistances in the areas of development of drugs, decontamination of water, IT and in communication technologies, and the manufacture of lighter and the stronger materials. Nano-technologies include the manipulation and creation of ingredients at nanometer scale, either by grading-up from only groups of atoms or by sanitizing or plummeting bulk constituents.

REFERENCES

1. Salata, O. V. (2004). Applications of nanoparticles in biology and medicine. *Journal of nanobiotechnology*, *2*(1), 1-6.
2. Kolahalam, L. A., Viswanath, I. K., Diwakar, B. S., Govindh, B., Reddy, V., & Murthy, Y. L. N. (2019). Review on nanomaterials: Synthesis and applications. *Materials Today: Proceedings*, *18*, 2182-2190.
3. Denkbaş, E. B., Çelik, E., Erdal, E., Kavaz, D., Akbal, Ö., Kara, G., & Bayram, C. (2016). Chapter 9-Magnetically based nanocarriers in drug delivery. *Grumezescu AMBT-N in DD, editor. William Andrew Publishing*, 285-331.
4. Wang, Y., & Xia, Y. (2004). Bottom-up and top-down approaches to the synthesis of monodispersed spherical colloids of low melting-point metals. *Nano letters*, *4*(10), 2047-2050.
5. Cele, T. (2020). Preparation of Nanoparticles. In *Engineered Nanomaterials-Health and Safety*. IntechOpen.
6. Son, H. H., Seo, G. H., Jeong, U., & Kim, S. J. (2017). Capillary wicking effect of a Cr-sputtered superhydrophilic surface on enhancement of pool boiling critical heat flux. *International Journal of Heat and Mass Transfer*, *113*, 115-128.
7. Wender, H., Migowski, P., Feil, A. F., Teixeira, S. R., & Dupont, J. (2013). Sputtering deposition of nanoparticles onto liquid substrates: Recent advances and future trends. *Coordination Chemistry Reviews*, *257*(17-18), 2468-2483.
8. Baker, C., Pradhan, A., Pakstis, L., Pochan, D. J., & Shah, S. I. (2005). Synthesis and antibacterial properties of silver nanoparticles. *Journal of nanoscience and nanotechnology*, *5*(2), 244-249.
9. Marsalek, R. (2014). Particle Size and Zeta Potential of ZnO. APCBEE Procedia. 9, 13–17.
10. Ramesh, S. (2013). Sol-gel synthesis and characterization nanoparticles Ag3 (2+ x) AlxTi4-xO11+ δ (0.0≤ x≤ 1.0). *J Nanosci*, *13*(9).
11. Sylvestre, J. P., Poulin, S., Kabashin, A. V., Sacher, E., Meunier, M., & Luong, J. H. (2004). Surface chemistry of gold nanoparticles produced by laser ablation in aqueous media. *The Journal of Physical Chemistry B*, *108*(43), 16864-16869.
12. Buot, F. A. (1993). Mesoscopic physics and nanoelectronics: nanoscience and nanotechnology. *Physics Reports*, *234*(2-3), 73-174.
13. Korvink, J. G., & Greiner, A. (2002). *Semiconductors for micro-and nanotechnology: an introduction for engineers* (p. 324).
14. Siddiqui, M. H., Al-Whaibi, M. H., & Mohammad, F. (2015). Nanotechnology and plant sciences. *Springer International Publishing Switzerland. DOI*, *10*, 978-3.
15. Srivastava, D., & Atluri, S. N. (2002). Computational nanotechnology: A current perspective. *Computer Modeling in Engineering and Sciences*, *3*(5), 531-538.
16. Poole Jr, C. P., & Owens, F. J. (2003). *Introduction to nanotechnology*. John Wiley & Sons.
17. Cheng, L., Bandarra Filho, E. P., & Thome, J. R. (2008). Nanofluid two-phase flow and thermal physics: a new research frontier of nanotechnology and its challenges. *Journal of Nanoscience and Nanotechnology*, *8*(7), 3315-3332.
18. Baleanu, D., Güvenç, Z. B., & Machado, J. T. (Eds.). (2010). *New trends in nanotechnology and fractional calculus applications* (p. C397). New York: Springer.
19. Uddin, M., & Chowdhury, A. R. (2001, August). Integration of nanotechnology into the undergraduate engineering curriculum. In *International Conference on Engineering Education* (Vol. 8, pp. 6-9).
20. Soukiassian, P. G., & Rao, M. R. (2010). Carbon-based nanoscience and nanotechnology: where are we, where are we heading?. *Journal of Physics D: Applied Physics*, *43*(37), 370301.
21. Ghosh, A., Ra, E. J., Jin, M., Jeong, H. K., Kim, T. H., Biswas, C., & Lee, Y. H. (2011). High pseudocapacitance from ultrathin V2O5 films electrodeposited on self-standing carbon-nanofiber paper. *Advanced Functional Materials*, *21*(13), 2541-2547.
22. Steyn, W. J. (2009). Potential applications of nanotechnology in pavement engineering. *Journal of Transportation Engineering*, *135*(10), 764-772.
23. Firoozi, A. A., Taha, M. R., & Firoozi, A. A. (2014). Nanotechnology in civil engineering. *EJGE*, *19*, 4673-4682.
24. Shastri, V. P., Altankov, G., & Lendlein, A. (Eds.). (2010). *Advances in regenerative medicine: role of nanotechnology, and engineering principles*. Springer.
25. Kung, H. H. (2006). Nanotechnology: opportunities for chemical engineering. *Journal of the Chinese Institute of Chemical Engineers*, *37*(1), 1-7.
26. Macnaghten, P., Kearnes, M. B., & Wynne, B. (2005). Nanotechnology, governance, and public deliberation: what role for the social sciences?. *Science communication*, *27*(2), 268-291.
27. Ledwani, L., & Sangwai, J. S. (Eds.). (2020). *Nanotechnology for Energy and Environmental Engineering*. Springer Nature.
28. Lu, K. (2009). A study of engineering freshmen regarding nanotechnology understanding. *Journal of STEM Education: Innovations and Research*, *10*(1).
29. Tolfree, D., & Jackson, M. J. (Eds.). (2007). *Commercializing micro-nanotechnology products*. CRC Press.
30. Nowack, B. (2008). Pollution prevention and treatment using nanotechnology. *Nanotechnology*, *2*, 1-15.
31. Hossain, A., Skalicky, M., Brestic, M., Mahari, S., Kerry, R. G., Maitra, S., ... & Islam, T. (2021). Application of Nanomaterials to Ensure Quality and Nutritional Safety of Food. *Journal of Nanomaterials*, *2021*.
32. Ellefson, P. V., Kilgore, M. A., Skog, K. E., & Risbrudt, C. D. (2010). Wood utilization research and product development capacity in the United States: a review.