Prospects Toward the Development of Nanomaterials for Advanced Applications

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Abstract In this chapter, the expectations toward development in technological advancements of nanomaterials is projected through highlighting their multifunctional characteristics which enables their applications in diversified areas and key challenges in their synthesis or usage. The brief outlook about the existing applications of nanomaterials discussed in different chapters of this book provides opportunities to the researchers working toward the development of nanotechnology for explore potential of nanomaterials using multidisciplinary knowledge of science and technology. Simultaneously, efforts may also be directed to overcome existing challenges in synthesis and use of these nanomaterials in selective applications.

Keywords Nanomaterials · Opportunities · Challenges · Application areas · Perspective

Nanomaterials have become very popular in technology due to their multifunctional properties which invites their usage in diversified applications. Specially, in last two decades, the application-oriented research in nanotechnology has been growing exponentially. Their potential use in preparation of structural components, energy storage devices, sensors, biomedical and biomechanical applications, etc. has shown immense opportunities for their exploration. The bloom of nanotechnology is unexpectedly moving very fast toward medical treatments, sensor technologies, self-healing materials, big data storage and processing, weather forecasting, etc. Exposing the newer ways in medical science using wearable fitness technology using tiny

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Table 1 Some popular nanomaterials and of their explored applications areas

Nanomaterial	Application areas
Gold	Medicine, food industry, water purification, etc.
Platinum	Energy storage, magnetic nanopowders cancer therapy, polymer membranes, nanocoatings, etc.
Silver	Biomedical, sensors, water/air filters, etc.
Copper	Antibiotic/antimicrobial/antifungal agent, EMI shielding, thermal conductive, conductive coating, nanometal lubricant additives, etc.
Zinc oxide	Nano-electronic/nano-optical devices, energy storage, cosmetic products, nanosensors, etc.
Carbon-based nanomaterials	Biomedical, sensors, packaging, energy storage and production, water and wastewater treatment, etc.
Titanium dioxide	Toxicity reduction in drugs, wastewater treatment, reproduction of silkworm, space applications, food industries, etc.

sensors for an intensive, accurate, and safer medical examination of living bodies is one of the important growing interests in the field of nanotechnology. Use of sensors has profound applicability in medical treatment, energy storage and harvesting, flexible manufacturing, and the development of sustainable high temperature materials. Even though the use of nanomaterials in sensing technology has introduced significant opportunities for improvement in big data analysis and whether forecasting using typical hybrid composites/nanocomposites. Table 1 comprises of some significant technological developments in diversified areas owing to the multifunctional characteristics of nanomaterials. Moreover, the potential of nanomaterials as nanofluids, nanoalloys, and self-healing materials invites researcher to explore further possibility in studying the effects of change in texture/micro-structure of the tailored materials.

Nevertheless, the expected use of nanomaterials in various high-end applications is limited due to incompetent behavior arisen by their toxic nature, compatibility issues, uniformity and repeatability in synthesis, chemical stability, and various hazardous effects to environment and living beings. Kostarelos et al. (2009) have highlighted the toxic effects of using carbon-based nanomaterials in antitumor therapies. Similarly, the effects of different nanomaterials in distortion of biological cells have been proved by various researchers (Zhang and Karn 2005; Lanone and Boczkowski 2006; Hoshino et al. 2011; Proffitt 2004; Lam et al. 2004). It has also been found that the severe effects of certain nanomaterials block the arteries in living beings and damage the central nervous system (Service RF 2004; Lam et al. 2006; Nel et al. 2006). Different aspects of challenges for realistic applications of nanotechnology are shown in Fig. 1.

The above-mentioned features and challenges in the nanomaterial's technological applicability provide an idea to explore and corelate more of such information and identify further opportunities toward the development of new/surface-modified nanomaterials or improving the existing processing methods in order to utilize their multifunctional features efficiently.

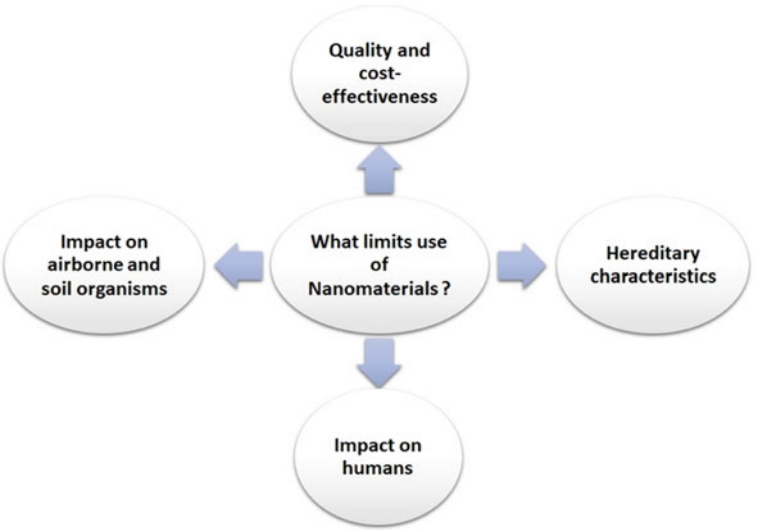

Fig. 1 Considerable challenges in application of nanomaterials for characteristic applications

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