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A Review on Green Synthesis of Metal and Metal Oxide Nanoparticles

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ABSTRACT

Metal oxide nanoparticles have captivated scrupulous research interest because of its major relevance in the field of medicine, catalysis, pigment, electronics, biotechnology, sensors, optical devices, adsorption, DNA labelling, drug delivery, kinetics, spintronics and piezoelectricity. Nanoparticles (NPs) became more significant for its reasonable property as a heterogeneous non-toxic catalyst with environmental reimbursement. The biogenic innovation of metal oxide NPs is an enhanced alternative owing to eco-friendliness. In the biological field, the probable efficacy of NPs has been reported by scores of scholars in the treatment of cancer. Owed to munificent returns, NPs explored as a powerful catalyst for several organic transformations. This section unlocks with a short course on to synthesize metal oxide NPs on a natural scale.

INTRODUCTION

Nanotechnology is the greatest dynamic area of exploration in modern material science and has established as the great innovation of things at the nanoscale of 1 to 100 nm. Nano is a Greek word symbolizing "dwarf" in the one-billionth scale (10^{-9}). To synthesis nanomaterial of various shapes and dimensions, two different methods of approaches have been widely used namely bottom-up and top-down approaches (Fig. 1).

Building up of nanomaterials from an atom by atom is a bottom-up approach while trimming down bulk material to smaller nano size is a top-down approach. Some methods of bottom-up approaches are spray pyrolysis, laser pyrolysis chemical vapour deposition, atomic/molecular condensation and sol-gel processes. Mechanical milling, hydrothermal synthesis, photolithographic processing, electron beam lithography, laser ablation, micromachining, electron beam machining, etching and sputtering are the methods of top-down approaches in exploitation. The physical and chemical methods of synthesis utilize high reactive agents, high temperature, pressure, hazardous chemical vapours and defile environment. In general, different reducing agents such as sodium citrate, ascorbate, sodium borohydride, elemental hydrogen, polyol, Tollen's reagent, N, N-dimethylformamide (DMF) and poly (ethylene glycol)-block copolymers are used in NPs synthesis. The main factor about NPs is its surface to volume ratio, which makes NPs very primitive in the field of technology with specific applications in respective fields like catalysis, adsorption, drug delivery, biotechnology and DNA modelling. NPs are virtualized in its application by its dimension, shape, morphology and size (Vijayaraghavan et al. 2012, Khin et al. 2012, Dimkpa et al. 2012 and Ain et al. 2013) It can be one dimensional (1D), 2D or 3D. NPs used in electronic gadgets and sensing devices are thin-film 1D. 2D carbon nanotubes (CNTs) have more application in the field of catalysis because of its stableness and a high degree of adsorption. Quantum dots and clusters are grouped as 3D NPs. Metal NPs like Ag, Au, Pd, Pt, Zn, Fe are mainly formed from its salt solutions like $AgNO_3$, $AuCl_4$, $PdCl_4$, $PtCl_4$, $ZnSO_4$ by physical and chemical methods. Based on its chemical nature NPs are grouped as metals, metal oxides, silicates, non-oxide ceramics, polymers, organics, carbon and biomolecules. Correct exploitation of ecologically benevolent solvents and nontoxic chemicals are some of the core subjects in the green synthesis approach contemplations. This review implies the importance of green synthesis of metal NPs in a benign greener way following the 12 principles of green chemistry without defiling the environment (Fig. 2).

MATERIALS AND METHODS

Characterization of Metal and Metal Oxide NPs

Techniques used for structural characterization (size, shape, lattice constants and crystallinity) of NPs are X-ray diffraction technique, electron microscopy, scanning electron microscopy (SEM), transmission electron microscopy (TEM), high resolution transmission electron microscopy