REVIEW ARTICLE ON SYNTHESIS AND APPLICATIONS OF ALUMINIUM OXIDE NANOPARTICLES

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Abstract – *Aluminium oxide Nanoparticles have been considerable research interest due to large number of applications of these nanoparticles. It improves commercial demand of Aluminium oxide nanoparticles. In this review article, we have investigated different methods of synthesis of Aluminium oxide nanoparticles. We try to search the cheap and eco – friendly method to synthesize Aluminium oxide nanoparticles so that the best method can be used for commercial synthesis of these nanoparticles. In the present review article, we concluded that green synthesis of Aluminium oxide nanoparticles is better than other chemical methods. By this method Aluminium oxide nanoparticles with high yield rate can be synthesized at very low cost and there is no harm to environment. Further, Applications of Aluminium oxide nanoparticles are summarized in this review article.*

Key Words* – *Alumina Nanoparticles, synthesis, applications

1. INTRODUCTION

Technology has changed during last few years due to use of nanoparticles. The size of particles decreases up to atomic level and this is used for the convenience of mankind. Now, nanoparticles are used widely because the size of many things used by society become very less and these things become more and more useful. The branch of science which deals with these nanoparticles is known as nanotechnology. It involves the production and application of ultra fine particles ranging from 1nm to 100nm. At least, one dimension of these particles is in nanometer range. Due to their large surface-to-volume ratio, these particles are of great interest of research in physics, chemistry and engineering.

NPs show unusual physicochemical, optoelectronic and catalytic properties. These properties are shown by nano-sized particles due to their shape and size [1, 2, 3]. Thus, these particles show unique properties compared to their bulk counter parts.

The properties of these nanoparticles depend on their size. These particles can be used as membranes and hard materials. These materials can be used to make super-fast computers, dirt-repellent surfaces, scratch proof coatings, eco-friendly cells, etc.

Many metal oxide nanoparticles are manufactured at the industrial level. These metal oxide nanoparticles can be used in a large number of applications such as water treatment, medicine, cosmetics, engineering etc.

For these purposes, nanoparticles should be produced on a large scale. There are two approaches for the production of nanoparticles namely, top-down and bottom-up. In the first method, metal decreases its size from large to nano scale and in the second method; nanoparticles are produced starting from atomic level [4].

Aluminum oxide or Alumina is a compound of Aluminum and Oxygen. Its chemical formula is Al_2O_3. It is an electrical insulator having high thermal conductivity. They show a large number of physical and chemical properties because of which these can be used for many applications. Aluminum related materials have high hardness, high stability, high insulation and transparency [5].

Therefore, methods of synthesis of Alumina nanoparticles are studied and the cheap and eco – friendly method of synthesis of Alumina nanoparticles was also investigated.

2. SYNTHESIS OF ALUMINIUM OXIDE NANOPARTICLES

Alumina nanoparticles can be synthesized by many methods which can be categorized into physical, chemical and biological methods. Some of which are

2.1 Direct precipitation method

In this method nano precursor of Aluminium hydroxide are prepared by aluminum nitrate and sodium hydroxide in the presence of polyethylene glycol. Al_2O_3 nanoparticles

(AON) were prepared by calcinations of the precursor at 850^{0}C for 10 h. [6]

2.2 In – flight oxidation method

The commercial Aluminium powders are fed into the flame which contains oxygen and acetylene gas (O_2:C_2H_2). The commercial Aluminium powders melt and react with the atmospheric oxygen and the flame oxygen resulting in the formation of Alumina nanoparticles on the surface of a powder collector [7].

2.3 Laser ablation method

The Nd:YAG laser was used in the synthesis of Alumina nanoparticles. The first harmonic Nd:YAG has a wavelength of 1064 nm with a pulse duration of 5 ms and a repetition rate of 2 Hz. The beam was focused using a 5 cm focal-length lens onto the aluminium tablet, which is located at the bottom of a glass vessel. Deionized water was poured into the vessel until its level is about 5 mm above the target. The laser energies used were 1, 3, and 5 J. At each laser energy, the target was ablated for 5,000 pulses [8,9].

2.4 Mechanochemical process

The Alumina nanoparticles are synthesised via a solid state chemical reaction which is initiated inside a ball mill at room temperature between either lithium (Li) or sodium (Na) metal which act as reducing agents with unreduced Aluminium chloride ($AlCl_3$). The reaction product formed consists of aluminium nanoparticles embedded within a by-product salt phase (LiCl or NaCl, respectively). The LiCl is washed with a suitable solvent resulting in Aluminium (Al) nanoparticles which are not oxidised and are separated from the by-product phase [10].

2.5 Sol – gel method

Al_2O_3 nanoparticles were synthesized by ethanol solution of Aluminium Nitrate In this method, $Al(NO_3)_3$.9H2O was completely dissolved in pure water with stirring at room temperature. Then ethanol solution was added drop by drop to the solution and synthesis temperature was increased to 80°C. The color of solution changed from orange color to dark brown color. The pH was maintained between 2 and 3 during the synthesis. The white product was evaporated for 3 hours, cooled to room temperature and finally calcined at 500°C for 5 hours [11].

2.6 Green Synthesis

Nanoparticles can be synthesized by biological methods. Different green plants like Syzygium Aromaticum, Origanum Vulgare [12] and Cymbopogon Citratus [13] are used for this synthesis. Tea, coffee and triphala [14] can also be used for this purpose. Aerva Lanta and Terminalia Chebula extract [15] and leaf extract of Rosa [16] can also be used for the synthesis of Alumina nanoparticles. In this method, high pressure, energy, temperature and toxic chemicals are not required as in other chemical and physical methods. Synthesis by this method depends upon the choice of solvent, reducing agent employed and the capping agent.

Most of the chemical methods cannot be used because they have low yield rates. Nanoparticles can be synthesized on large scale by the use of plant extracts. Moreover, this method uses fewer resources, so is cheap and it is also eco-friendly [17, 18].

3. APPLICATIONS OF ALUMINA NANOPARTICLES

Alumina nanoparticles can be used in powder form or can be dispersed in suitable liquid. It is found that Alumina nanoparticles have better bactericide property and this is comparable to that of paper filters [19]. Alumina nanoparticles can be toxic to cancerous cell lines. It is found that these nanoparticles may disturb the power function of cell lines [20]. The influence of metal oxide NPs including Alumina NPs on the key enzyme activities involved in waste water treatment is compared. It is found that long-term exposure of these NPs affects the relative abundances of key functional bacteria. It is also found that catalytic activities of essential enzymes were decreased by long-term exposure of these NPs [21] Alumina nanoparticles are used as nanofillers in urea-formaldehyde resin. It is found that by the addition of nanofillers storage module of UF resin has been improved. It is also found that internal module strength of medium density fiberboards was also enhanced by Alumina nanoparticles [22]. The volume concentration and temperature dependence of viscosity of Alumina nanoparticles dispersed in commercial car coolant is investigated and it is found that particle concentration depends on nanofluid viscosity [23]. Young's modulus and fracture toughness of dry pressed powder compact of nanocrystalline Alumina powders was determined and it is predicted that interfacial energies are consistent with at least partially hydrated surfaces [24].

The effect of Alumina nanoparticles on microbial communities was studied. It is indicated that normal biological, chemical and nutrient cycles and changes in bacterial communities can be caused by nanoparticles [25]. The effect of different concentrations of Alumina NPs on growth and enzymatic antioxidant system of wheat seedlings was investigated. It is proposed that we can introduce oxidative damage as a way of inducing toxicity in plants through the uptake of NPs [26]. The effect of Alumina nanoparticles on microalgae was demonstrated. These microalgae are isolated from aquatic environment. By FTIR studies, the interaction of nanoparticles with cell wall was demonstrated [27]. Toxic effect of Alumina NPs on dunaliella salina was investigated. It is found that these NPs had a significant impact on topography of dunaliella salina cells. It is also found that when concentration of NPs increases, chlorophyll and carotenoid of algae decreases [28].

4. CONCLUSION

By the above review it is concluded that Alumina Nanoparticles are very useful in every field. Due to large and increasing demand of these nanoparticles we need a method of production of these nanoparticles by which we get good yield at low cost. In our view, biological synthesis is better than any other method of synthesis.

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