Aluminum Nanoparticles Introduction

Introduction

Aluminum (Al) nanoparticles have unique optical, physical, and chemical properties that make them candidates for use in a variety of applications, ranging from nanophotonics and catalysis, to the preparation of high energy composites. The large specific surface area and energy density and their associated high reactivity of aluminum nanoparticles have made them unique combustible additives in propellant formulations for significantly higher and faster energy release. Nanoscale aluminum may also offer significant opportunities in the development of high-capacity hydrogen storage materials, either directly or through other reactive compounds such as aluminum hydrides. Through precise control of the synthetic process, Abvigen has the ability to fabricate a variety of shapes and sizes and to optimize properties for your application[1-3].

Abvigen can provide a range of high quality Aluminum nanoparticles with different shapes, including concave cubes, cubes, spheres, octahedra, triangular prisms, and wires. The product has high repeatability between batches, which can meet the needs of different personalized materials such as research and development, testing and production of various customers.

Preparation Method

Through a reduction of aluminum acetylacetonate [$Al(acac)_3$] by lithium aluminum hydride ($LiAlH_4$) in mestitylene at 165°C[2]: Aluminum acetylacetonate [$Al(acac)_3$] (10 mmol) was added to the mesitylene which was already placed in a two neck round—bottom flask (RBF) equipped with a magnetic stirring bar. Then, 30 mmol of lithium aluminum hydride ($LiAlH_4$) was added into the reaction flask. A reflux condenser connected with a nitrogen inlet was fitted onto the RBF. The reaction mixture was then refluxed continuously with stirring. Evolution of a gas was observed during refluxing. When the gas evolution was ceased after approximately 72 h, the reaction mixture was cooled down to room temperature. A gray-colored precipitate was settled down. Most of the solvent was distilled out by applying vacuum. The crude product was further dried under low pressure for 3–4 h. The crude product obtained was divided into three equal portions and each portion was washed with 20 ml of dry, ice cold methanol at least for four times. This division was to avoid any difficulty during the filtration of Al-NPs and also to avoid any exothermic mixing of solvent with Al-NPs. Most of the organic part and the unreacted starting materials were washed away with methanol. The product was filtered through a glass frit with grade 3 porous size. The final product was again dried under low pressure. The entire process was carried out under a standard nitrogen schlenk line.

Modified chemical aerosol flow synthesis (CAFS) technique[4]: A solution containing trimethylamine aluminum hydride (TMAH) in toluene was sonicated at 1.65 MHz to produce a fine mist of micrometer-sized droplets. The mist was carried by flowing argon into a heated glass tube where it combined with $TiCl_4$ vapor; $TiCl_4$ has been shown previously to catalyze the decomposition of alane (AlH_3) into metallic aluminum particles. The resulting product was collected in bubblers filled with toluene, which are relatively inefficient: the collection efficiency of the system was ~30% based on aluminum with typical yields of 200-500 mg of Al particles from 25 mL of precursor solution; the use of an electrostatic precipitator would significantly improve the collection efficiency.

Pulsed sonoelectrochemical method[5]: The sonoelectrochemical synthesis was performed in one-compartment, three-electrode cells consisting of an aluminum metal (40 mm × 20 mm) counter electrode, an aluminum metal (40 mm × 5 mm) reference electrode, and an ultrasonic tip as a working electrode. In the synthesis, a cathodic current density of 100 $mAcm^{-2}$ was applied to a solution of 4 g of $AlCl_3$ dissolved in 80 mL of a 1.0 M solution of $LiAlH_4$ in THF for 4 h. The duration of the current pulse was 600 s, and the off time of the current pulse was 60 s. The duration of the ultrasonic pulse was 240 ms. The ultrasound power intensity was 76 W. The resulting metallic aluminum product was washed several times with THF and dried under vacuum. The need for such a long duration for the electric pulse was dictated by the low current.

Solvated metal atom dispersion approach[6]: Highly monodisperse colloidal aluminium nanoparticles (3.1 $\pm$ 0.6 nm) stabilized by a capping agent, hexadecyl amine (HDA), have also been prepared by the solvated metal atom dispersion (SMAD) method. They are stable towards precipitation of particles for more than a week. The Al–HDA nanoparticles are not as pyrophoric as the Al–THF samples.

Applications

Fuel in propellants and pyro techniques;

Hydrogen production;

Light-weight and high-strength materials;

Biomarker;

Drug delivery carrier;

Photothermal therapy agent

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Advantages

Large specific surface area;

Large energy density;

High reactivity;

Flexible optical properties

Ordering Information

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