ADVANCES IN SYNTHESIS OF NANOSIZED OXIDIC POWDERS USING ULTRASONIC SPRAY PYROLYSIS

Duško Kostić[1,2*], Srećko Stopić[1], Mitar Perušić[2], Vladimir Damjanović[3], Radislav Filipović[2,3], Bernd Friedrich[1]

*[1]IME Process Metallurgy and Metal Recycling, RWTH Aachen University, Aachen, Germany, dkostic@ime-aachen.de**
[2] University of East Sarajevo, Faculty of Technology Zvornik, Karakaj 34a, Zvornik, Republic of Srpska, Bosnia and Herzegovina
[3]Alumina d.o.o., Karakaj, Zvornik, Bosnia and Herzegovina

Abstract

The synthesis of oxide nanopowders through ultrasonic spray pyrolysis (USP) represents an innovative and sustainable approach for producing high-purity, spherical particles with advanced material applications. Advances in USP-synthesis are performed using continuous transport of aerosol from an ultrasonic generator to the furnace and collection of nanopowders via electrostatic precipitator. This research focuses on the ultrasonic spray pyrolysis of titanium and aluminum nitrate solutions derived from aluminum industry byproducts, emphasizing resource valorization and waste minimization. Titanium oxysulfate was synthesized by leaching of the slag (from reduction of red mud) with sulfuric acid in an oxidizing, high-pressure environment, followed by purification of the solution to ensure chemical stability and purity. This purified solution was then subjected to USP under a hydrogen reduction atmosphere, producing spherical titanium dioxide (TiO_2) nanopowders. The hydrogen reduction process facilitated precise control over the morphology and crystallinity of the TiO_2 nanoparticles, making them suitable for applications such as photocatalysis, pigments, and advanced coatings. In parallel, aluminum nitrate [$Al(NO_3)_3$] was prepared by leaching aluminum hydroxide oxide (AlOOH) with hydrochloric acid to generate aluminum chloride ($AlCl_3$), followed by the addition of nitric acid to convert the chloride into a nitrate solution. This aluminum nitrate solution underwent ultrasonic spray pyrolysis, leading to the formation of highly uniform, spherical alumina (Al_2O_3) nanopowders with excellent purity and consistent size distribution. The alumina powders possess versatile properties, making them ideal for applications in ceramics, catalysts, and high-temperature materials. This study showcases the potential of ultrasonic spray pyrolysis as an efficient and scalable method for synthesizing oxide nanopowders from industrially derived precursors. By utilizing byproducts of the aluminum industry, the process highlights the dual benefits of producing high-performance materials and promoting environmental sustainability. The resulting nanopowders with their controlled properties and diverse applicability has been significant advancements in oxide powder synthesis.

Keywords: *alumina, leaching, titanium dioxide, nanopowder reduction, ultrasonic spray pyrolysis.*