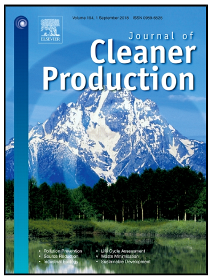
Accepted Manuscript



An eco-friendly process for zerovalent bismuth nanoparticles synthesis

Andrea Pietro Reverberi, Petar Sabev Varbanov, Simone Lauciello, Marco Salerno, Bruno Fabiano

PII: S0959-6526(18)31978-4

DOI: 10.1016/j.jclepro.2018.07.011

Reference: JCLP 13465

To appear in: *Journal of Cleaner Production*

Received Date: 24 October 2017

Accepted Date: 02 July 2018

Please cite this article as: Andrea Pietro Reverberi, Petar Sabev Varbanov, Simone Lauciello, Marco Salerno, Bruno Fabiano, An eco-friendly process for zerovalent bismuth nanoparticles synthesis, *Journal of Cleaner Production* (2018), doi: 10.1016/j.jclepro.2018.07.011

An eco-friendly process for zerovalent bismuth nanoparticles synthesis

Andrea Pietro Reverberi[1,*], Petar Sabev Varbanov[2], Simone Lauciello[3], Marco Salerno[4], Bruno Fabiano[5]

[1] DCCI - Department of Chemistry and Industrial Chemistry, Genoa University, via Dodecaneso 31, 16146 Genoa, Italy
[2] Pázmány Péter Catholic University, Faculty of Information Technology and Bionics, Práter u. 50/a, 1083 Budapest, Hungary
[3] Istituto Italiano di Tecnologia, Electron Microscopy Facility, via Morego 30, 16163 Genoa, Italy
[4] Istituto Italiano di Tecnologia, Materials Characterization Facility, via Morego 30, 16163 Genoa, Italy
[5] DICCA - Department of Civil, Chemical and Environmental Engineering, Polytechnic School, Genoa University, via Opera Pia 15, 16145 Genoa, Italy

* corresponding author

Abstract

A two-pot bismuth nanoparticle synthesis based on a combination of a bottom-up method and a disaggregation technique is proposed. These steps are sequential in time and are operated in an aqueous and organic solvent, respectively. In the first phase, a cementation process with aluminium and zinc as sacrificial metals in compact form is carried out using mannitol, saponin and maltodextrin as eco-friendly capping agents for bismuth nanoparticles. In the second phase, a wet ball-stirring process allows obtaining a primary particles release in propylene glycol with a satisfactory stability. The products are characterized by dynamic light scattering and transmission electron microscopy for the size and by X-ray diffraction for both size and chemical composition. The diameters of bismuth nanoparticles obtained using both zinc and aluminium as reductants lie in the range of 10-120 nm independently of the capping agents. With respect to conventional one-pot processes using sacrificial metals in powder, this technique allows obtaining a high purity metallic bismuth at the end of the cementation step without requiring further purification treatments, thus avoiding a waste of chemical reagents in view of a cleaner production and sustainability. All stages of preparation are carried out at room temperature for a better energy saving and safety management. This process may represent a valid alternative to standard techniques based on noxious reductants or high temperature synthesis, thus promoting a shift towards a green nanoparticle synthesis.

Keywords: bismuth, bottom-up, cementation, green chemistry, inherent safety, nanoparticles

1. Introduction

The production of nanoparticles (NPs) and nanostructured materials has got an impressive development in the recent years, owing to their versatility in a variety of technical applications. Examples are offered by their use in cancer therapy as carriers for antimitotic drugs (Sun et al., 2014), in the fabrication of nanocapsules for bio-medical applications (Pastorino et al., 2016), in the manufacture of catalysts with enhanced selectivity and conversion such as in the ethylene oxidation process (Fabiano et al., 2015) and in the production of high-performance photocatalysts for pollution abatement and hydrogen recovery (Reverberi et al., 2016 a). The broader production and application of nano-materials cause a demand for new approaches in process safety, possibly towards prevention by inherent safer features of the process (De Rademaeker et al., 2014). Many different strategies, generally based on physical and chemical processes or a combination thereof, can be adopted in nanomaterials production according to the intrinsic