Ecotoxicology and Environmental Safety 147 (2018) 852–860

Contents lists available at ScienceDirect

Ecotoxicology and Environmental Safety

journal homepage: www.elsevier.com/locate/ecoenv

Insights into the CuO nanoparticle ecotoxicity with suitable marine model species

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ARTICLE INFO

Keywords:
Nanomaterial toxicity
Rotifer
Shrimp
Copepod
Sea urchin
Nanoparticle behavior

ABSTRACT

Metal oxide nanoparticles, among them copper oxide nanoparticles (CuO NPs), are widely used in different applications (e.g. batteries, gas sensors, superconductors, plastics and metallic coatings), increasing their potential release in the environment. In aquatic matrix, the behavior of CuO NPs may strongly change, depending on their surface charge and some physical-chemical characteristics of the medium (e.g. ionic strength, salinity, pH and natural organic matter content). Ecotoxicity of CuO NPs to aquatic organisms was mainly studied on freshwater species, few tests being performed on marine biota.

The aim of this study was to assess the toxicity of CuO NPs on suitable indicator species, belonging to the ecologically relevant level of consumers. The selected bioassays use reference protocols to identify Effect/Lethal Concentrations (E(L)C), by assessing lethal and sub-lethal endpoints. Mortality tests were performed on rotifer (*Brachionus plicatilis*), shrimp (*Artemia franciscana*) and copepod (*Tigriopus fulvus*). While moult release failure and fertilization rate were studied, as sub-lethal endpoints, on *T. fulvus* and sea urchin (*Paracentrotus lividus*), respectively. The size distribution and sedimentation rates of CuO NPs, together with the copper dissolution, were also analyzed in the exposure media.

The CuO NP ecotoxicity assessment showed a concentration-dependent response for all species, indicating similar mortality for *B. plicatilis* ($48hLC_{50}$ = 16.94 ± 2.68 mg/l) and *T. fulvus* ($96hLC_{50}$ = 12.35 ± 0.48 mg/l), followed by *A. franciscana* ($48hLC_{50}$ = 64.55 ± 3.54 mg/l). Comparable EC_{50} values were also obtained for the sub-lethal endpoints in *P. lividus* (EC_{50} = 2.28 ± 0.06 mg/l) and *T. fulvus* (EC_{50} = 2.38 ± 0.20 mg/l). Copper salts showed higher toxicity than CuO NPs for all species, with common sensitivity trend as follows: *P. lividus* ≥ *T. fulvus (sublethal endpoint)* ≥ *B. plicatilis* > *T. fulvus (lethal endpoint)* > *A. franciscana*.

CuO NP micrometric aggregates and high sedimentation rates were observed in the exposure media, with different particle size distributions depending on the medium. The copper dissolution was about 0.16% of the initial concentration, comparable to literature values.

The integrated ecotoxicological-physicochemical approach was used to better describe CuO NP toxicity and behavior. In particular, the successful application of ecotoxicological reference protocols allowed to produce reliable L(E)C data useful to identify thresholds and assess potential environmental hazard due to NPs.

1. Introduction

In the last few decades, the rapid growth of nanotechnology applications, including electronics, optics, textiles, medical devices, drug delivery systems, chemical sensors, biosensors, and environmental remediation, has increased the release of nanoparticles (NPs) into the environment (Bondarenko et al., 2013). This rapid increase in NP release has not been accompanied by accurate investigations of their environmental safety (Corsi et al., 2014). Concerns have been raised on the toxic impact of NPs on the environmental compartments (Khosravi-Katuli et al., 2017). Aquatic ecosystems are the major sink of NPs, ending into the marine environment, through several direct and

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http://dx.doi.org/10.1016/j.ecoenv.2017.09.053
Received 17 May 2017; Received in revised form 13 September 2017; Accepted 18 September 2017