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Cytotoxicity and genotoxicity of CuO nanoparticles in sea urchin spermatozoa through oxidative stress

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ABSTRACT

Copper oxide nanoparticles (CuO NPs) are extensively used in various industrial and commercial applications. Despite their wide application may lead to the contamination of marine ecosystem, their potential environmental effects remain to be determined. Toxicity assessment studies have primarily focused on investigating the effects of CuO NPs on fertilization success and embryo development of different sea urchin species while the impact on sperm quality have never been assessed. In this line, this study aims to assess the effects of CuO NPs on the spermatozoa of the sea urchin *Paracentrotus lividus*.

After sperm exposure to CuO NPs, biomarkers of sperm viability, cytotoxicity, oxidative stress, and genotoxicity as well as morphology were evaluated. Results showed that CuO NPs exposure decreased sperm viability, impaired mitochondrial activity and increased the production of reactive oxygen species (ROS) and lipid peroxidation. Furthermore, CuO NPs exposure caused DNA damage and morphological alterations. Together with the antioxidant rescue experiments, these results suggest that oxidative stress is the main driver of CuO NP spermiotoxic effects. The mechanism of toxicity is here proposed: the spontaneous generation of ROS induced by CuO NPs and the disruption of the mitochondrial respiratory chain lead to production of ROS that, in turn, induce lipid peroxidation and DNA damage, and result in defective spermatozoa up to induce sperm cytotoxicity. Investigating the effects of CuO NPs on sea urchin spermatozoa, this study provides valuable insights into the mechanism of reproductive toxicity induced by CuO NPs.

1. Introduction

Nanotechnology allows the production of engineered nanoparticles (NPs) with peculiar characteristics which led to their wide employment in many industrial sectors as electronics, catalysis, cosmetics, medical diagnostics and pharmaceuticals. Although industrial nanoparticulate materials may exert some positive health effects (Buzea et al., 2007), health and environmental concerns on NPs have been highlighted in several reports (Commission, 2009; Pollution, 2008). Marine environments act as a sink for most contaminants and thus likely receive NPs from wastewater and trough the degradation of products containing NPs. Several studies highlighted the toxic effects of various NPs on the physiological processes of marine organisms (Baker et al., 2014; Baun et al., 2008; Canesi et al., 2012; Matranga and Corsi, 2012; Wong et al., 2010). In particular, the impact of NPs on fertilization success and embryo development has been widely investigated.

Copper oxide nanoparticles (CuO NPs) are widely used in several applications. They are employed as antifungal and antimicrobial additives in textiles, water treatment, and paints (Maisano et al., 2015). In particular, their use in anti-fouling paints is one of the most direct routes of entry into marine environment (Adeleye et al., 2016). It has been well documented that Cu ions are extremely toxic to marine animals (Tornero and Hanke, 2016); however, information on the impact of CuO NPs on marine organisms are still limited. Among them, it has been reported a reduction of bioluminescence or culturability on marine bacteria (Rossetto et al., 2014; Rotini et al., 2017), genotoxicity in bivalve molluscs (Gomes et al., 2013; Ruiz et al., 2015), body burden and behavioural disorders in marine worms (Buffet et al., 2013a; Dai et al., 2015), reproductive impairments in echinoderms (Minetto et al., 2016) and survival and moulting release in marine rotifers and crustaceans (Rotini et al., 2018).

Reproduction is the highly specialized process of cell interaction

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