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Calcium Carbonate Nanoparticles' Toxicological Profile for Use in Industry

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Abstract

The CO2-derived calcium carbonate nanoparticles (CaCO3NPs) are promising materials for a variety of industrial applications. Understanding their toxicological profile in biological systems is crucial given that increased synthesis of CaCO3NPs exposes more people and the environment to them. Here, we examine two cell lines and zebrafish in vivo to determine the cytotoxicity of CaCO3NPs made from a CaO slurry (Danio Rerio). Our findings show that CaCO3NPs are safe when used in vitro because they don't kill cells or have any genotoxic effects. Zebrafish exposed to CaCO3NPs also grow and develop normally, supporting the safety and biocompatibility of this nanomaterial.

Keywords: Calcium carbonate; Nanoparticles; Environment toxicity

Introduction

The use of various nanomaterials to enhance the capabilities and mechanical qualities of cement is currently generating a lot of scientific attention [1]. Numerous nanoparticles, such as carbon nanotubes (CNTs) titanium dioxide nanoparticles (TiO2 NPs), silica nanoparticles (SiO2 NPs), alumina nanoparticles (Al2O3 NPs), and silica nanoparticles (SiO2 NPs) have been added to cement-based materials, each of which has potential advantages and disadvantages. In this context, calcium carbonate nanoparticles (CaCO3NPs) made from CO2 are being researched as possible nanomaterials to be used in these industrial applications, with the aim of assisting in CO2 capture and utilisation directly in the industrial site in which CO2 is available or produced. As one of the main sources of anthropogenic CO2 emissions in this regard, the cement industry raises the possibility [2].

Synthesis of CaCO3NPs

Slurry made with analytical-grade CaO (Merck, purity 99%), deionized water, and CO2 (quality: 99.9%, supplied by SIAD, Italy) was used to create CaCO3. The CaCO3NPs were created by carbonating a CaO slurry with only pure CO2. Raschig rings were packed randomly in a Packed Bed Reactor (PBR) as part of the experimental setup, which is depicted in Fig. 1. The slurry is pumped into the PBR using a peristaltic pump, where it comes into touch with the CO2 and precipitates. The vessel, which is kept at a constant stirring speed, received the precipitated particles right away. In this fashion, two zones are distinguished: the crystallisation zone, which is located inside the PBR. the stabilisation process, which takes place inside the feed tank where the pH is kept high enough to create a stable environment for the CaCO3 particles because the growth and agglomeration processes of the CCnP are not favoured by alkaline circumstances. The CO2 supply was halted once the pH fell below 10.5, which, in accordance with the carbonate equilibria, discourages CO3-formation and lowers the CaCO3 saturation. After the procedure was complete, the synthesised particles were quickly filtered by vacuum (pore size = 0.45 m), and the excess ions were then removed by repeatedly washing the particles in deionized water. The CaCO3 powder was ultimately ready for assessment of their size, shape, and crystal after being dried at 60 °C for an overnight period [3, 4].

Due to their special characteristics, such as a high surface area to volume ratio and high porosity, calcium carbonate nanoparticles are thought to strengthen cement. The kinematic of the C single bond is accelerated by CaCO3. Since they serve as the initial building blocks for the cement's hydration, which the CaCO3 turns out to speed up, single bondH bonds form. Thus the early age compressive and flexural strengths of the cement are increased. CaCO3 also improves mechanical properties due to its filling qualities [5].

An urgent need for a thorough toxicological examination of these nanoparticles' effects on ecosystems and human health arises from the massive increase in the manufacture and use of CaCO3NPs, exposure of industry workers to them, and the effects of their discharge. In order to solve this problem, we tested the toxicity of CaCO3NPs on two different cell lines, a human breast cancer cell line and a mouse embryonic fibroblast cell line (NIH 3T3) (MCF7). By measuring survivability, reactive oxygen species (ROS) production, and DNA damage in vitro and after treatment with various concentrations of CaCO3NPs, the cytotoxic assessment was carried out. Our findings showed that CaCO3NPs were not harmful to either NIH 3T3 or MCF7 cells, showing that they did not promote cell mortality, reactive oxygen species, or oxidative DNA damage [6, 7, 8].

Conclusion

The creation of calcium carbonate nanoparticles from CO2 and tests of their toxicity on cultured cells and more sophisticated biological systems are described in this paper. We have demonstrated that CaCO3NPs may be produced quickly and easily from CaO slurry. Additionally, we have shown that both normal and cancer cell lines exhibit high cyto-biocompatibility for our CaCO3NPs. On the two separate cell lines, the cell viability showed high values and there was no evidence of cell death, an increase in reactive oxygen species levels, or DNA damage. We looked at the precise interactions of the nanoparticles with zebrafish, which are vertebrate models, to determine the safety of CaCO3NPs with regard to human exposure. We showed that CaCO3NPs are very biocompatible with zebrafish at the early. [9, 10].

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Potential Conflict of Interest

The authors affirm that they have no known financial or interpersonal conflicts that would have appeared to have an impact on the research presented in this study.

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