One-pot room temperature and microwave-assisted synthesis of $Ce_xZr_{1-x}O_2$ nanoparticles

Chuanli Zhang, Juan Pellico, Muling Zeng, Anna Roig
Materials Science Institute of Barcelona (ICMAB-CSIC), Bellaterra, 08193, Barcelona, Spain

czhang@icmab.es

Abstract
Cerium oxide nano-enzymes have emerged as highly promising candidates for biomedical applications, offering superior stability, lower production costs, and enhanced environmental adaptability compared to natural enzymes. Their main advantage arises from their intrinsic redox activity, driven by the reversible cycling between Ce^{3+} and Ce^{4+} oxidation states. [1] Metal doping, particularly with Zr4+, can improve their antioxidant efficiency further, increase oxygen vacancy concentration, and enhance redox performance.[2-3] However, despite extensive research on doped systems, there remains a lack of methodologies for synthesizing $Ce_xZr_{1-x}O_2$ nanoparticles across different compositions to optimize and compare their relative scavenging capability of the reactive oxygen species (ROS).
Here, we developed two simple and economical one-pot synthesis methods, room temperature (RT) and microwave-assisted (MW), to produce hydrophilic (RT) and hydrophobic (MW) $Ce_xZr_{1-x}O_2$ nano-enzymes with different Ce:Zr ratios. [3-4] By controlling precursor ratios and fine-tuning parameters such as temperature, reaction time, and addition rate, we achieved different levels of Zr doping within the CeO_2 framework. Characterization by Transmission electron microscopy (TEM) revealed average particle sizes of 3.3 nm and 2.6 nm for RT and MW CeO_2 NPs, respectively (Figure 1 A). X-ray diffraction (XRD) analysis confirmed the successful incorporation of Zr into the CeO_2 NPs, as evidenced by the systematic shift of diffraction peaks toward higher angles, indicative of lattice contraction (Figure 1B and C). For the MW sample, we calculated a lattice constant (a') of 5.306 Å corresponding to the theoretical value for $Ce_{0.5}Zr_{0.5}O_2$ (a' = 5.305 Å). In the case of hydrophilic RT $Ce_xZr_{1-x}O_2$ nanoparticles, the progressive shift of XRD peaks with varying precursor ratios further validated the formation of $Ce_xZr_{1-x}O_2$ with distinct Ce:Zr compositions.
Future work will focus on their encapsulation within poly (lactic-co-glycolic acid) (PLGA) nanoparticles for targeted application in cancer.

References

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Figures

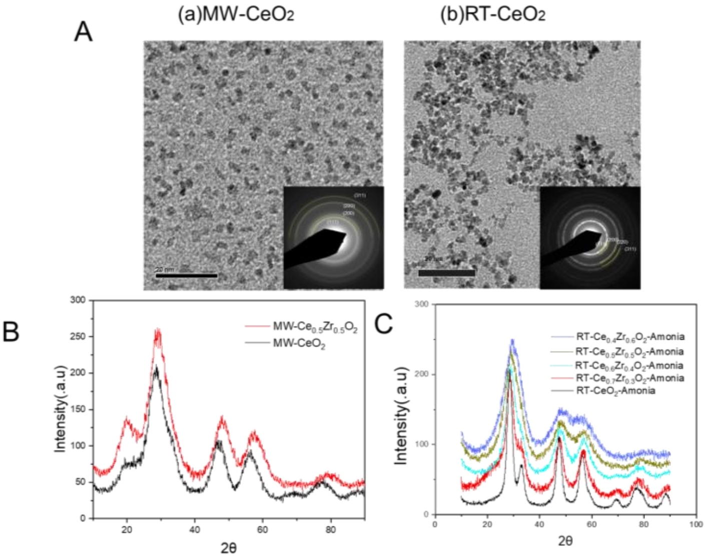

Figure 1. (A) TEM MW CeO_2 and RT CeO_2, (B) XRD of MW $Ce_xZr_{1-x}O_2$, (C) XRD of RT $Ce_xZr_{1-x}O_2$