Ceria nanocubes stabilized in Silica Aerogels

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Abstract

CeO2 based nanomaterials possess exceptional properties due to their ability of acting as an "oxygen buffer" releasing or storing oxygen atoms reversibly, while retaining the fluorite structure. This can be exploited in a variety of important industrial processes of great interest for energy and the environment, spanning energy conversion (fuel cells and renewable production of fuels from solar energy), energy storage (lithium-air batteries), and environmental protection and remediation (treatment of toxic contaminants in water). The exeptional reactivity originates from the labile and reversible redox cycle between Ce4+ and Ce3+, where oxygen ions are released and stored through the formation of oxygen vacancy defects. This is particularly enhanced at the nanoscale and the reactivity of ceria nanomaterials is also strongly dependent on the shape of the nanoparticles because it influences the amount of oxygen vacancies that are present. In particular, ceria nanocubes show an enhanced reactivity due to the large fraction of highly reactive {100} facets. However, the control of both size and shape of nanoparticles require the use of surfactants which act as an "organic armour" that makes those facets less accessible. Also, after thermal treatments needed to remove the surfactants and obtain clean surfaces the ceria nanoparticles undergo coalescence, leading to a drastic decrease in surface area and reactivity. These problems can be overcome by using porous matrices to host nanoparticles keeping them apart and avoiding coalescence. Silica Aerogels are used in this study to stabilise ceria nanocubes and maximise their reactivity taking advantage of their highly extended open porosity (up to 98%), and high surface areas.

Keywords: Nanostructures, ceria, oxygen storage capacity

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