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ORIGINAL ARTICLE

Microwave Prepared Oxidation Resistant Cu Microstructures with Tailored Morphologies

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Abstract
Copper has attracted considerable interest due to its significant potential for a wide range of applications. The synthesis of copper (Cu) nanoparticles is tedious as they are prone to oxidize even in atmospheric conditions. Surfactant-free microwave-assisted synthesis of Cu microstructures with different morphologies has been accomplished here in the presence of only an antioxidant (ascorbic acid). The size and morphology of the synthesized Cu microstructures were varied by tuning the microwave power, reaction time and concentration of ascorbic acid. Oligoclusters of Cu were isolated through an optimized post-synthesis processing step, and investigations over a period of months of XRD data revealed remarkable stability against oxidation of the synthesized microstructures. TEM and other morphological analyses support a detailed and comparative study on the influences of MW irradiation as well as of the different concentrations of reducing agent, from which metrics for the synthesis of stable Cu microstructures have been established.

Keywords Copper Microstructures · Microwave Synthesis · Antioxidant · Oxidation Stability

1 Introduction

Plasmonic materials have the ability to interact with electromagnetic waves, the result of which can be a significantly modified scattered light. This interaction for metallic nanoparticles is considerably influenced by Surface Plasmon Resonance (SPR) property. The manifestation of SPR can be remarkably changed by manipulating the morphology of the plasmonic material [1] or the chemistry of the medium [2]. Metallic nanoparticles have been frontrunners in this highly active research area compared to other plasmonic materials due to their high electron density and the associated field enhancements and tunability of absorption, resulting in their exploitation for numerous applications like optoelectronics [3], biosensors [4], optical waveguides [5], photocatalysis [6], photovoltaic [7] and photothermal therapy [8]. For Vis-NIR applications, Au and Ag have excellent plasmonic properties which are widely explored due to their tunability of morphologies and stability at higher temperatures [9] although new candidates such as ZrN, HfN, TaN with absorbances in the visible regions are ever-evolving to challenge them.

Alternatively, the ugly duckling of coinage metals, Cu, though with a similar plasmonic nature (in fact a greater free electron density than Au) has often been ignored largely due to being highly lossy and susceptible to oxidation. Most of the research efforts on copper have to unavoidably address the elephant in the room that is oxidation [10], with the steps taken to avoid it leading to a significant unwanted modification of the plasmonic property. Yet, Copper nanoparticles (CuNPs) and microparticles have become increasingly prominent in applications such as imaging, catalysis, displays, photothermal heating [11] etc. Plasmonic Cu compounds like CuS have diverse applications like seawater desalination, photocatalysis, and other Cu compounds have been utilised for dye degradation, SERS, N_2 photo fixation and so on. Various approaches have been explored for the synthesis of CuNPs including hydrothermal [12], sonochemical reduction [13], microemulsion technique [14], metal vapour synthesis [15], electrochemical deposition method [16], reverse micelles [17], microwave irradiation [18] and chemical reduction [19] usually under inert environments. Microwave (MW) irradiation is one of the prominent techniques that can accelerates the reduction rate, and

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