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Microwave-assisted synthesis and optical properties of cuprous oxide micro/nanocrystals

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ABSTRACT

Cuprous oxide micro/nanocrystals were fabricated by a facile and green microwave-assisted method using soluble starch as reductant and dispersant. It was observed that the addition amounts of NaOH had a prominent effect on the morphologies and size of cuprous oxide products, and microwave heating was proved to be a efficient method and was advantageous to the homogeneous nucleation. The as-obtained samples were characterized by X-ray diffraction (XRD), and field-emission scanning electron microscopy (FESEM). The results indicated that the samples were pure cuprous oxide. Spheres with the diameter of about 100 and 600 nm, octahedron and truncated octahedron with the edge length of about 0.8–3 μm cuprous oxide micro/nanocrystals were successfully obtained. Furthermore, the UV–vis diffuse reflectance spectroscopy was used to investigate the optical properties of the prepared cuprous oxide microcrystals, demonstrating that their band gaps of obtained samples were 1.96–2.07 eV, assigned to their different sizes and morphologies.

1. Introduction

In recent decades, there is an increasing emphasis on the topic of green chemistry. Low energy consumption, utilization of nontoxic, environmentally and renewable materials, minimization or even total elimination of generated waste are some of the key issues that merits serious consideration in a green synthesis strategy [1,2]. Microwave-assisted synthesis can be an efficient tool for the design of a green synthetic strategy [3,4]. Microwave chemistry has been extensively used for its unique advantages, such as increasing reaction efficiency, improving product yields, saving the processing time and energy, and decreasing the hazardous of by-products [5–7]. Researchers have shown that microwave-assisted method is a green and environmentally friendly method compared to traditional heating methods [8–11].

As an conventional P-type semiconductor, cuprous oxide (Cu_2O) has a direct band gap of 2.17 eV and has attracted much current research interest for its unique optical and magnetic properties [12,13]. This makes it a promising material with applications in solar energy conversion [14], negative electrode in lithium batteries [15,16], photocatalytic degradation of organic pollutants [17,18] and decomposition of water into O_2 and H_2 under visible light irradiation [19], magnetic storage and sensors [20–22]. Many methods have been employed for the preparation of cuprous oxide, however, most of the methods have the disadvantages, such as the use of poisonous reductant, requirement of external additives for surfactant and templates, long reaction time, the use of drastic synthesis conditions like high temperature and pressure, and the controllability of morphologies is not as well as expected [23–25].

Recently, it has been shown that water-soluble polysaccharides are powerful tools for controlling the particle shapes and sizes of inorganic materials [26,27]. Soluble starches are natural polymers, which have been applied for the synthesis of several inorganic materials for its advantages of low cost, renewable, environmentally friendly and widely available [28]. In the previous works, soluble starch can be used as the capping agent in the preparing of porous ZnO spheres [29], both the reducing and stabilizing agents in the synthetizing of stable silver [30] and gold nanoparticles [31], as well as a template for the preparation of uniform NiO and Ni/C composites [32].

In this paper, we report a microwave-assisted green synthesis of cuprous oxide micro/nanocrystals using soluble starch as reductant and dispersant. Starch is a very weak reducing agent for there are very few numbers of reducing terminals in the starch

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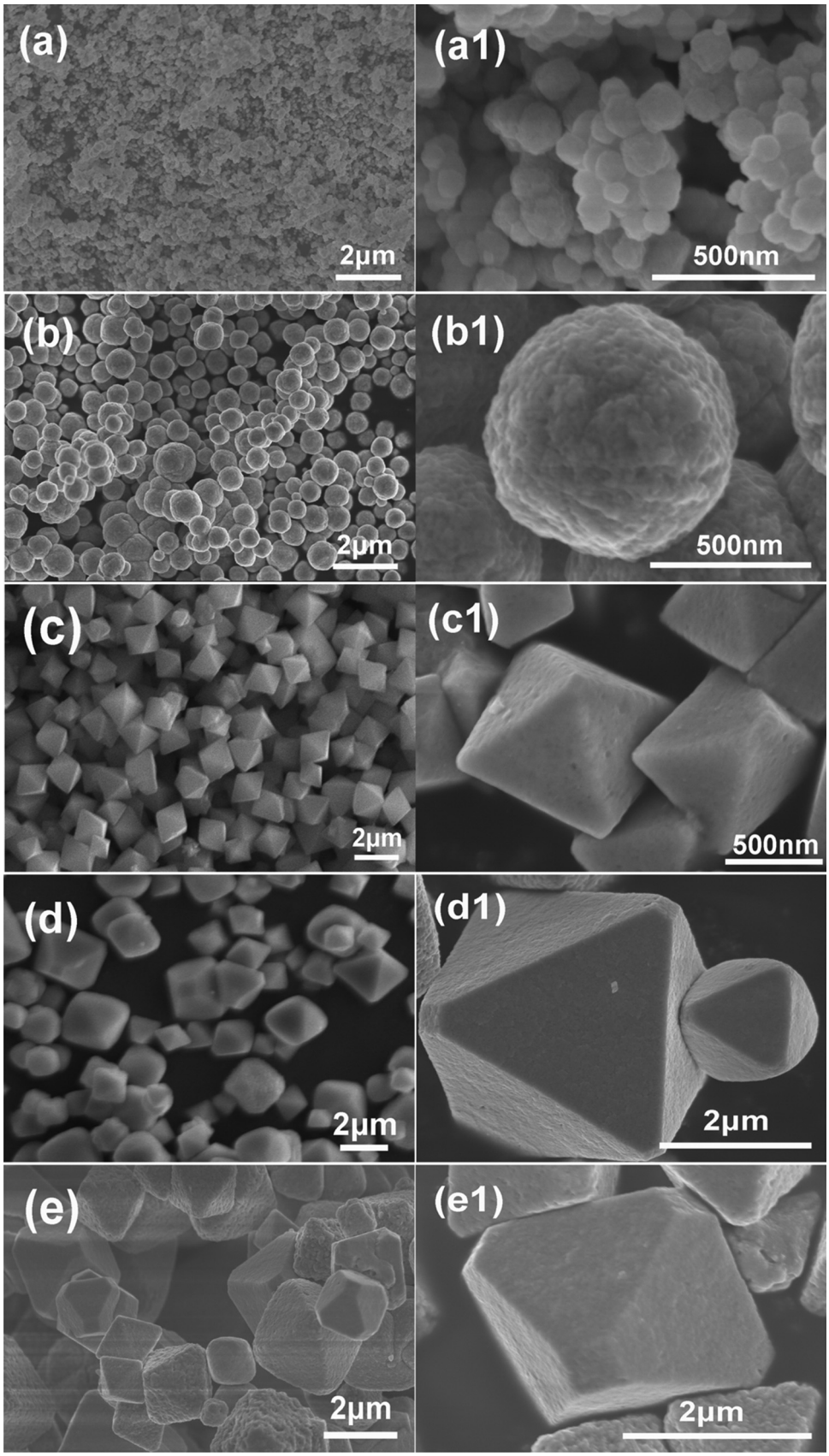

Fig. 1. SEM images of low- and high-magnification morphologies of Cu_2O microcrystals prepared under different concentrations of NaOH, (a) 1 mol/L, (b) 1.25 mol/L, (c) 1.5 mol/L, (d) 1.75 mol/L and (e) 2 mol/L.