Flower-shaped CuO nanostructures: Structural, photocatalytic and XANES studies

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Flower-shaped CuO nanostructures consist of triangular-shaped leaves, having sharpened tips with the wider bases, have been grown by simple aqueous solution process. Detailed structural observations exhibited the nanocrystalline nature with monoclinic structure for the as-synthesized nanostructures. The photocatalytic activity of the nanostructures was evaluated by examine the degradation of methylene blue. The photocatalytic property of the as-grown structures was probably due to the recycling of CuI ion under light on the CuO interface and large surface area of the flower-like moieties. The XANES studies revealed that properties of as-synthesized products are closer to that of CuO, rather than those of Cu metal and Cu2O.

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I. Introduction

Controlled synthesis of inorganic nanostructures in terms of size and shape has been strongly motivated by their size and shape dependent properties and to achieve their desired practical applications [1-2]. Therefore, from the last decades, many efforts have been made to synthesize desired-shaped inorganic nanostructures with significantly improved physical and chemical properties for their possible applications in the fabrication of efficient devices [3-5]. As an important p-type semiconductor metal oxide with a narrow band gap, copper oxide (CuO) is an exotic material both in terms of fundamental studies as well as practical applications. The excellent properties of CuO made it as a fantastic material for the diverse application which includes heterogeneous catalysts, gas sensors, optical switch, magnetic storage media, lithium–ion electrode materials, field emission devices, solar cells, etc. [6-10]. In addition to this, CuO-based materials are also well-known with regard to their high-temperature superconductivity and giant magnetoresistance [11,12]. Thus, due to various properties and vast applications, variety of CuO nanostructures such as nanorods, nanowires, nanosheets, etc. have been fabricated by a range of fabrication techniques and reported in the literature [5-12]. There are also few reports in the literature on the synthesis and structural properties of complex CuO nanostructures, for instance Liu et al., reported the formation of honeycombs and flower-like assemblies of CuO onto copper foil using (NH4)2SO4, Na2WO4, NH3, NiO, and NaOH via hydrothermal process at 100 °C in 24 h [13]. Synthesis of nanoplatelets, leaflets and nanowires of CuO by two step reaction process was demonstrated by Lu et al., in which first step involves the synthesis of Cu(OH)2 while the next step was the formation of CuO using KOH, NH3, CuSO4 and poly(acrylic) acid (PAA) in sealed vessel at 180 °C for more than 24 h [14]. The dandelions of CuO was prepared by mesoscale organization of Cu nanoribbons using copper nitrate, ammonia, NaOH and NaNO3 in Teflon coated autoclave at 180 °C in 24 h by Liu et al. [15]. However, it was observed from the previous reports that to obtain complex CuO nanostructures higher temperature, pressure and longer reaction time is required. Thus, it is needed to develop a simple and effective method to synthesized complex CuO nanostructures in large-quantity at low temperature and short time. Moreover, even the CuO nanostructures have exotic properties and vast applications but, as best of our knowledge, the photocatalytic application of pure CuO nanostructures is not reported yet in the literature.

In this paper, we present a very simple and effective method to synthesize good-quality complex flower-shaped CuO nanostructure via simple aqueous solution method by using copper nitrate, hexamethylenetetramine and NaOH. The detailed structural characterizations were performed to understand the structural properties of the as-grown complex CuO nanostructures. Moreover, the photocatalytic activity of the flower-like CuO nanostructures, for the first time, was also evaluated by examine the degradation of methylene blue.