Colloids and Surfaces A: Physicochem. Eng. Aspects 497 (2016) 35–40

Contents lists available at ScienceDirect

Colloids and Surfaces A: Physicochemical and Engineering Aspects

journal homepage: www.elsevier.com/locate/colsurfa

A novel method to synthesize copper oxide nanoparticles by using colloidal gas aphrons

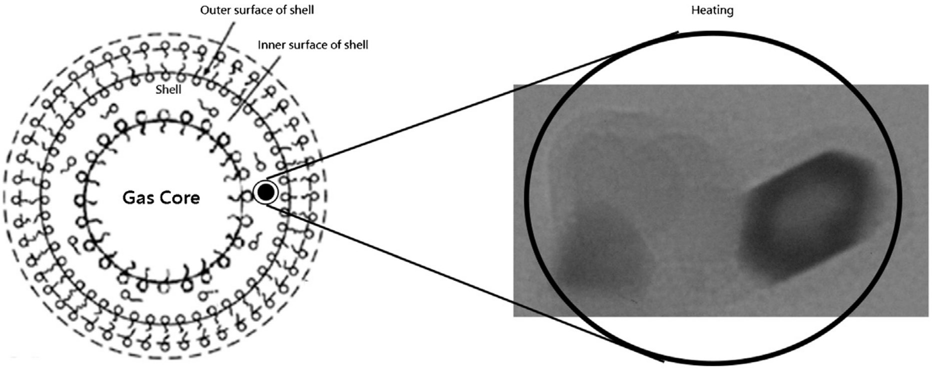
S.S. Banifatemi, H. Mohammadifard, M.C. Amiri*

Chemical Engineering Dept., Isfahan University of Technology, Isfahan 84156–83111, Iran

HIGHLIGHTS

- Colloidal gas aphrons (CGAs) have been used for synthesizing CuO nanoparticle.
- The generated particles have been characterized by advanced methods.
- The core-shell structure of particles made them nanosize.
- This is a novel effective method for mass production of CuO NPs.

GRAPHICAL ABSTRACT



ARTICLE INFO

Article history:
Received 30 November 2015
Received in revised form 17 February 2016
Accepted 18 February 2016
Available online 22 February 2016

Keyword:
Copper oxide (CuO) synthesis
Mass production
Nanoparticles
Morphology characterization
Colloidal gas aphron
Nanotechnology

ABSTRACT

There is a great interest to synthesize copper oxide nanoparticles (CuO NPs) because of their wide usage in various applications such as manufacturing antibacterial materials, solar cells, gas sensors, photovoltaic cells; as well as drag reduction, and catalysis. Different techniques such as sol–gel, microwave irradiation, microemulsion, and thermal decomposition of precursors have been developed to produce CuO NPs. In this work, CuO NPs were prepared in colloidal gas aphron substrates and subsequently their structure and morphology were characterized using various techniques. Data analysis of experimental results revealed that the generated CuO NPs were crystalline, corresponding to the monoclinic phase of 15–30 nm average crystallite size. This technically simple and promising procedure provides a roadmap for mass production of CuO nanoparticles.

1. Introduction

Nano materials (NMs) have drawn considerable interest in recent years for playing an important role in science and technology because of their unique properties such as large surface to volume ratio, increased activity, and special electronic optical properties [1,2]. NMs are used in a wide range of applications, such as medicine, cosmetics, food packaging, electronics/optics (in semiconductor and optoelectronic devices), aerospace, construction, textile manufacturing, magnetic devices/instruments or magnets, and catalysis [3–8].

Among various NMs, there is a great interest to synthesize CuO nanoparticles (CuO NPs) due to their p-type metal oxide semiconductor activity. This property as well as previously men-

---

* Corresponding author.
E-mail address: amir33@cc.iut.ac.ir (M.C. Amiri).

http://dx.doi.org/10.1016/j.colsurfa.2016.02.025
0927-7757/© 2016 Elsevier B.V. All rights reserved.

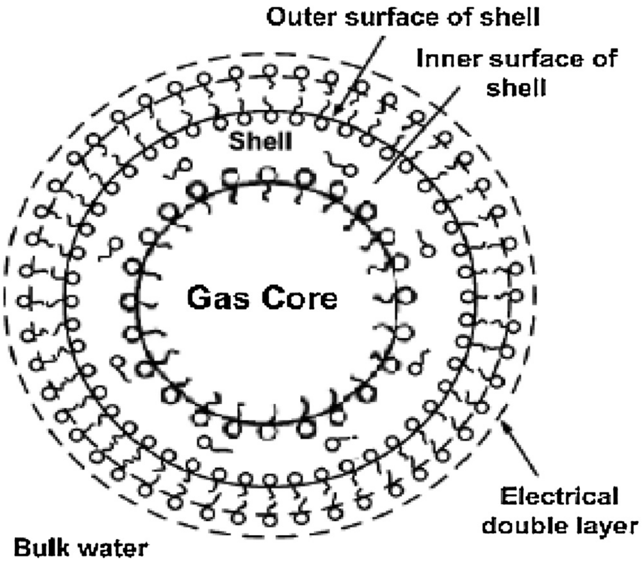


Fig. 1. Proposed structure of a colloidal gas aphron by Sebba [19].

tioned features make CuO NPs widely used in various areas such as manufacturing antibacterial materials, solar cells, gas sensors, photovoltaic cells, and catalysts [9–13].

Traditionally a variety of methods have been used to produce CuO NPs such as sol–gel technique, microwave irradiation method, microemulsion technique, precursors thermal decomposition, etc. [14–17].

Colloidal gas aphrons (CGA) or gas aphrons for short, first described by Sebba in surface phenomena literature, are surfactant stabilized micrometer size gas microbubbles [18]. A CGA dispersion is generated by intense shearing force of a fast spinning disc, e.g. 6500 rpm, immersed in a surfactant solution [19].

Gas aphrons consist of a relatively thick protective aqueous shell filled with air. They appear to have an average diameter of about 50 μm and a soapy shell of more than a few μm in thickness. Despite existing knowledge, unresolved questions remain regarding the structure of a gas aphron: for instance the nature and thickness of its soapy shell, orientation of surfactant molecules at the gas–liquid interface, and the number of surfactant layers [20]. The most widely accepted structure was suggested by Sebba as shown in Fig. 1.

Many applications of CGAs have been reported: the production of cells, proteins and other biological molecules, enhancement of gas transfer in bioreactors and bioremediation, removal of fine particles from dispersion, and removal of toxic wastes from soil [18,20–24]. Moreover, CGAs uniform structure makes them an excellent media for preparing nanosized materials: for instance,

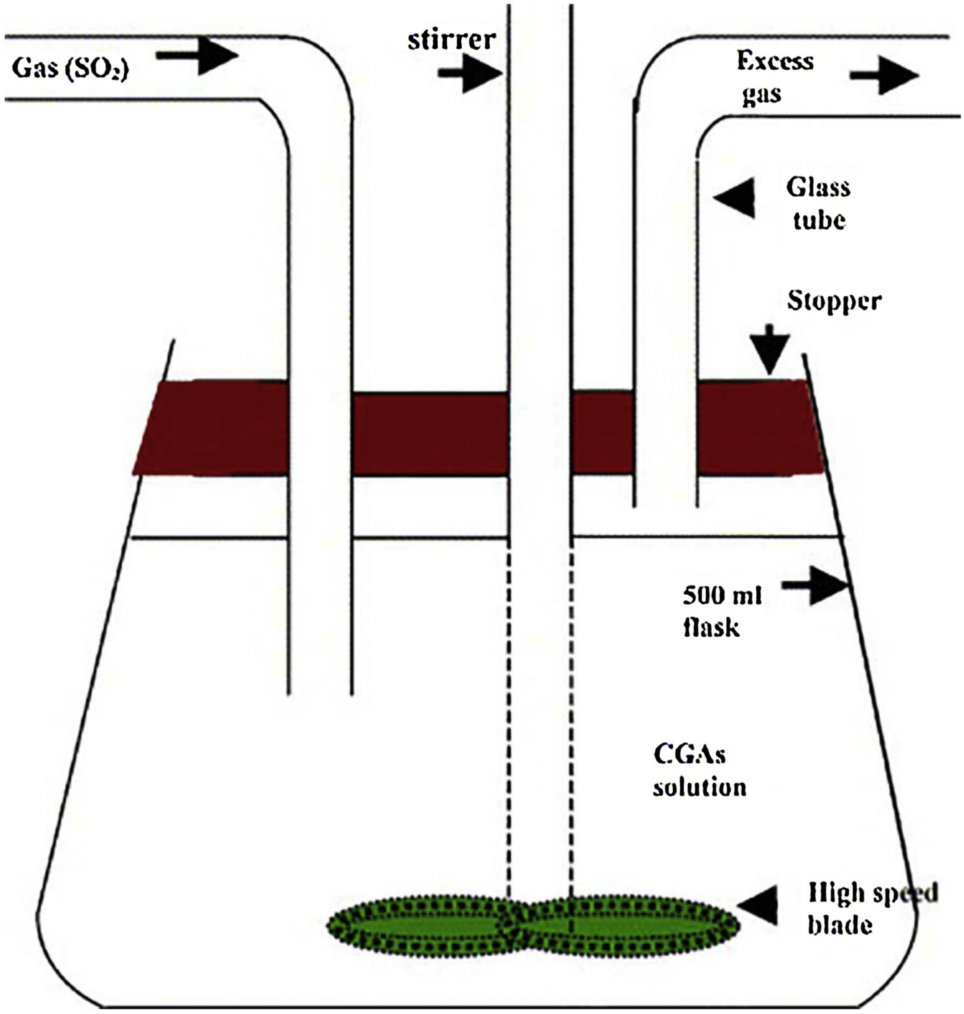


Fig. 2. A schematic diagram of the reactor that Abdullah et al. used to produce tungsten (VI) oxide dihydrate ($WO_3{\cdot}2H_2O$) nanorods [25].