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Photodegradation and removal of organic dyes using cui nanostructures, green synthesis and characterization

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ABSTRACT

In this research, watermelon, cherry and carrot juices were utilized not only as green reductant, but also as green capping agent for preparation CuI nanostructures for the first time. Watermelon, cherry and carrot juices were applied as green reductant because of the presence of lycopene, beta-carotene and anthocyanin molecules in their components. Besides watermelon, cherry and carrot juices, Cu $(NO_3)_2{\cdot}3H_2O$ and LiI were utilized as copper and iodide precursors for the preparation of CuI nanostructures via a simple, low cost, fast and efficient precipitation approach at ambient situations. By utilizing various amounts of watermelon, cherry and carrot juices, various morphologies of CuI have been gotten. The as-synthesized nanostructures were characterized by X-ray diffraction (XRD), Fourier transform infrared (FT-IR) spectra, Energy Dispersive X-ray microanalysis (EDX), Transmission electron microscopy (TEM), and Scanning Electron Microscopy (SEM). The photocatalytic activity of the synthesized nanostructures has been evaluated in the photodegradation activity of methyl orange, eosin, erythrosine and acid red 14.

1. Introduction

In the past few years, copper halides, particularly copper iodide, have involved enormous interest due to their hopeful applications in high-frequency high power electronics and optoelectronic tools [1–5]. These compounds reveal various unusual properties, such as large band gap, negative spin orbit splitting, large temperature dependency of resistivity, and analogous diamagnetic performance [6].

In recent times, enormous attempts were made to utilize green and environmentally friendly procedures for the preparation of nano-sized materials. These attempts include the use of plant or fruit extracts as stabilizer and capping agent to control crystal progress [7,8]. These green procedures are low cost, fast, efficient, and usually lead to the construction of crystalline nanostructures with a diversity of shapes. In this work, we offer a green, one step, and cost efficient procedure for the preparation of CuI nanostructures using watermelon, cherry and carrots juices for the first time. In addition, the quantity of watermelon, cherry and carrots juices was changed to form various morphologies of CuI nanostructures. The as-produced nanostructures were characterized with the assist of SEM, TEM, FT-IR, XRD, UV–vis and EDS.

CuI is an I–VII compound semiconductor which is crystallized into three various phases at atmospheric pressure; these are α, β, and γ phases [3]. The low temperature γ phase is a broad band gap semiconductor whose energy gap is near to E_g - ~ 3.1 eV and exciting binding energy is logically high that is ~62 meV, hence it is potential candidate for optoelectronic requests [1]. The γ phase is also recognized as a potential ultrafast scintillation material with short decay time 90 ps at room temperature [9,10].

Dye is a vital chemical used in several industries such as those involved in producing fabric, food, furniture and paint, representing a major threat to the environment due to its toxicity and potentially carcinogenic nature [11,12].

Water purification is one of the most important issues in environmental science [13–19] and synthetic dyes are the main pollutant groups of wastewater [20–23]. Even in low quantities, presence of dyes can cause serious environmental problems, for instance, growth of aquatic bacteria can be inhibited by interference of penetration of sunlight into water by organic dye molecules [20–23]. Therefore, much effort has been made to reduce the concentration of organic dyes in the wastewater

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[20–27]. Use of photocatalysts has been considered as one of the most promising ways of removing organic compounds from water [18,22–34].

Methyl orange, eosin, erythrosine and acid red 14 are water-soluble dyes, which are widely used in the textile, printing, paper manufacturing, pharmaceutical, food industries and also in research laboratories. The safe removal of these kinds of dye is the first aim of our present research. In the present paper, methyl orange, eosin, erythrosine and acid red 14 were chosen as the model dyes.

2. Experimental

2.1. Materials and experiments

All the chemicals used in our experiments, $Cu(NO_3)_2{\cdot}3H_2O$ and LiI were of analytical grade, were purchased from Merck and were used as received without further purification. GC-2550TG (Teif Gostar Faraz Company, Iran) were used for all chemical analyses. XRD patterns were collected from a diffractometer of Philips Company with X'Pert Promonochromatized Cu K_α radiation

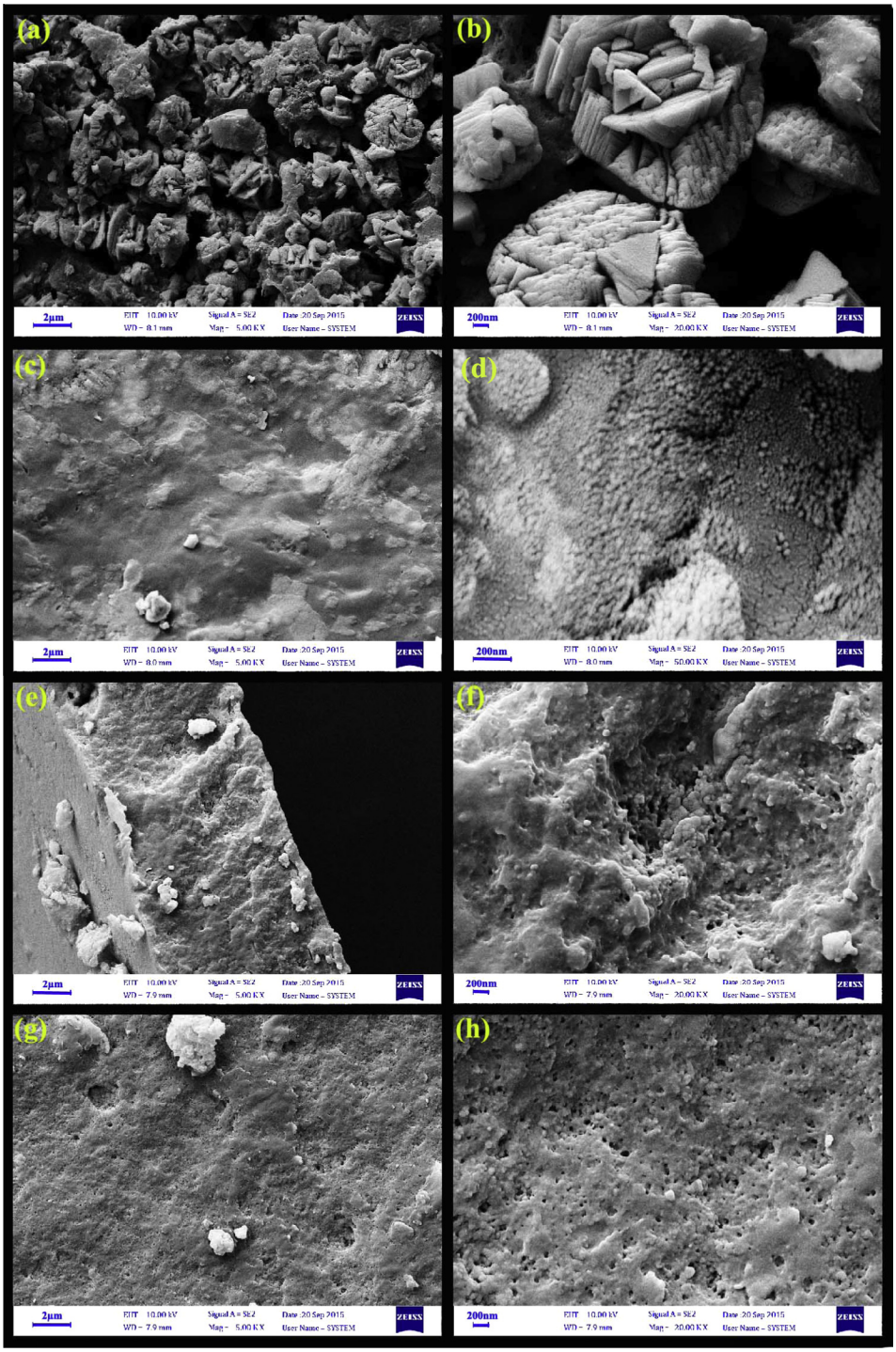

Fig. 1. SEM images of the nanostructures synthesized using (a, b) 1, (c, d) 5, (d, e) 10 and (f, g) 20 mL of watermelon juice (scale bar is 2 μm in left and 200 nm in right).