Green synthesis of $BaCrO_4$ nanoparticles using Glycyrrhiza glabra extract

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Abstract

In the present study, we have reported the green synthesis and characterization of barium chromate nanoparticles using Glycyrrhiza glabra extract as a natural surfactant, which -to the best of our knowledge- is the first report. The formed $BaCrO_4$ NPs were characterized by Ultraviolet-Visible (UV–Vis), Fourier-transform Infrared (FT-IR) spectroscopy, X-ray diffraction (XRD) and scanning electron microscopy (SEM) analyses.

Keywords: Green synthesis; Surfactant; Barium chromate, Nano particles

1. Introduction

Nanotechnology is a field that is making a mark in research day by day and making an impact in all spheres of human life. Biological methods of synthesis have paved way for the "greener synthesis" of nanoparticles and these have proven to be better methods due to slower kinetics, they offer better manipulation and control over crystal growth and their stabilization [1].

Many preparations of the building blocks of nanotechnology involve hazardous chemicals, low material conversions, high energy requirements, and difficult, wasteful purifications [2]. The 'greener' environmentally friendly processes in chemistry and chemical technology are becoming increasingly popular and are much needed as a result of worldwide problems associated with environmental contamination [3]. Thus, there are multiple opportunities to develop greener processes for the manufacture of these materials [2].

Plant mediated synthesis of nanoparticles is a green chemistry approach that interconnects nanotechnology and plant biotechnology [4]. The techniques for obtaining nanoparticles using naturally occurring reagents such as plant extracts could be considered attractive for nanotechnology, because the complex process of maintaining cell cultures are removed in this technique and it is also suitable for large-scale synthesis of nanoparticles [5]. Plant parts such as leaf, root, latex, seed, and stem are being used for nanoparticle synthesis [3].

Synthesis of Barium chromate nanoparticles is of much interest to the scientific community because of their unique properties and potentional applications such as oxidation agent, catalyst for enhancing vapor-phase oxidation reaction and excellent photo-physical properties. Barium chromate is a naturally occurring chromate analogue of barite which is widely used as a model system for morphosynthesis and kinetic crystallization studies as they crystalize only in a single modification [6,7].

2. Experimental

The powder extract of Glycyrrhiza glabra was purchased from Ebn-e-Masouyehpharmaceutical company. Sodium chromate (Na_2CrO_4) and barium chloride ($BaCl_2$) was purchased from Merck, Inc. All experiments were carried out under air atmosphere.

In a typical experiment, 0.081 g of Glycyrrhiza glabra extract and 0.647 g of Na_2CrO_4 were dissolved in distilled water in a beaker. Vigorous stirring was necessary to ensure that all the reagents were dispersed homogeneously in the solution at room temperature. 4 mmol $BaCl_2$ was dissolved in distilled water in the other glass beaker. $BaCl_2$ aqueous solution was then added dropwise to above solution under continuous stirring. The yellow precipitate were produced during the addition of $BaCl_2$. After the addition was completed, the mixture was deposited under continuous stirring at room temperature, which was advantageous to the formation of $BaCrO_4$ nanocrystals. Before the precipitates were collected for characterization, all precipitates were carefully washed repeatedly with distilled water and absolute ethanol to remove the remaining surfactant and then dried in an oven at 80 C for 5 h.

X-ray diffraction pattern (XRD) was obtained on a JEOL X-ray diffractometer with Cu Kα radiation (λ=1.5418 Å). The morphology of the samples was observed by scanning electron microscopy (SEM), performed on a Hitachi F-4160 scanning electron microscopy. Fourier transform-infrared (FT-IR) spectroscopy was carried out on a Shimadzu 8400S Fourier transform spectro-photometer, using KBr disk method.

3. Result and discussion

In the FT-IR spectra of $BaCrO_4$ nanoparticles (Fig. 1), the intense peaks located at 863, 894 and 948 cm^{-1} are assigned to the characteristic absorption bands of chromate group in $BaCrO_4$.

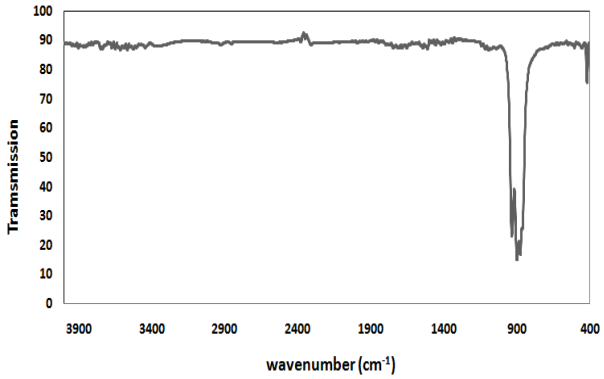


Fig. 1. IR spectra of $BaCrO_4$ nanoparticles

Fig. 2 shows the typical XRD pattern of the $BaCrO_4$ nanoparticles. The sharp diffraction peaks indicate the well crystallization of $BaCrO_4$. All the diffraction peaks can be perfectly indexed as the orthorhombic phase of $BaCrO_4$ (JCPDC 35-0642, cell constants: a=9.112 Å, b=5.541 Å and c=7.343 Å). No characteristic peaks from other impurities can be detected from the XRD data, which indicates that the product has high phase purity.

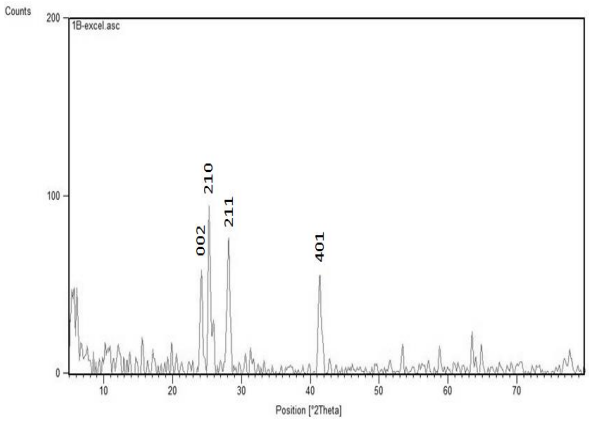
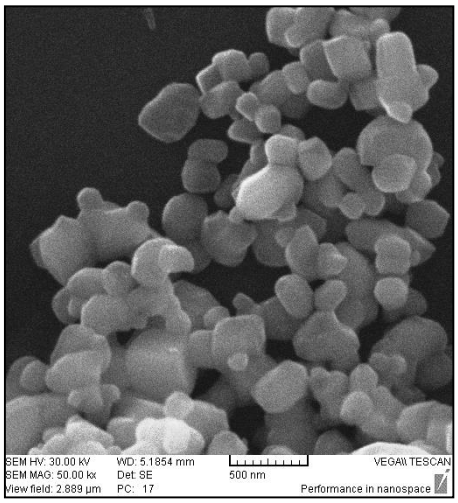


Fig. 2. The XRD pattern of $BaCrO_4$ nanoparticles

The morphology of the $BaCrO_4$ nanoparticles was characterized by scanning electron microscopy (SEM), as shown in Fig. 3. a clearly displays that the product contains a large quantity of $BaCrO_4$ nanoparticles, that the thicknesses of these nanoparticles are in a relatively narrow size distribution of 30–60 nm. The SEM image also indicates that almost 100% yield of $BaCrO_4$ nanoparticles can be achieved by this facile method.



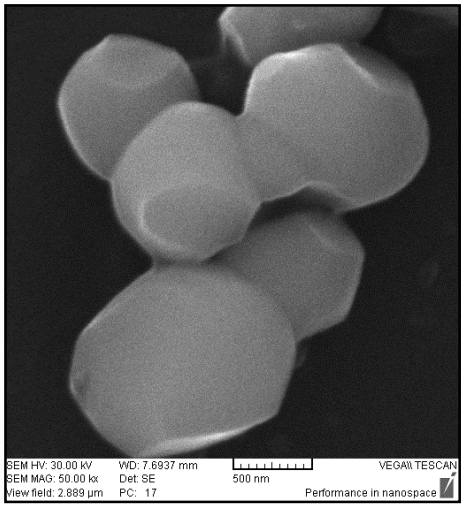


Fig. 3. The SEM images of the $BaCrO_4$ nanoparticles (a) in the presence of Glycyrrhiza glabra extract (b) in the absence of Glycyrrhiza glabra extract.

In order to investigate the influence of Glycyrrhiza glabra extract on the formation of $BaCrO_4$ nanoparticles, the experiment was carried out in the absence of Glycyrrhiza glabra while keeping other reaction conditions the same. The obtained $BaCrO_4$ are mainly composed of particles with irregular shapes and diameters ranging from 100 nm to 1 μm, as shown in Fig. 3b.

The results indicate that the Glycyrrhiza glabra extract play a significant role in the formation of $BaCrO_4$ nanoparticles. The extract mainly consists of macromolecules that contain ionic hydrophilic and hydrophobic domains. We presume that the hydrophilic ends may adsorb Ba^{2+} ions and provide suitable sites for the nucleation and the growth of $BaCrO_4$ nanoparticles. The intermolecular and intramolecular non-chemical effects among the macromolecules, such as hydrogen bonding and the electrostatic effect, could orientate these macromolecules, this may lead to extend these macromolecules and then induce the assembly of nanoparticles which is advantageous to the formation of $BaCrO_4$ nanoparticles.

4. Conclusion

In summary, we report the green synthesis of $BaCrO_4$ nanoparticles with uniform size and morphology using Glycyrrhiza glabra extract as a directing agent. $BaCrO_4$ nanoparticles are orthorhombic with space group *Pnma*. Although it requires in-depth research on the formation mechanism of $BaCrO_4$ nanoparticles, this facile, room temperature, solution-phase method might be useful for the formation of interesting superstructures of other inorganic materials.

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