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Green Fabrication of MgO Nanostructure for Morphology and Optical Studies

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ABSTRACT

Green synthesis of multifunctional magnesium oxide nanoparticles (NPs) were prepared by low temperature solution combustion route employing *Aloe vera* leaves extract as a fuel. The *Aloe vera* leaf extracts acts as a fuel in the preparation of MgO nanoparticles. The obtained MgO NPs were further characterized by various techniques such as PXRD, SEM, TEM and UV-visible spectroscopic studies. The surface morphologies of the prepared samples were studied with the help of scanning electron microscopy (SEM). The PXRD pattern confirmed the cubic (halite) structure of the product. The particle size was calculated by means of PXRD profile and it was found to be in the range of 20-25 nm by using the Debye-Scherrer relation. SEM images indicated the formation of various shaped MgO NPs. The NPs exhibited prominent green emission due to the presence of intrinsic defect centers. Also, the results found that the optical band gap is 4.46 eV.

1. Introduction

Current development in nanotechnology has engineered nanomaterials that are possibly safe toward human welfare. The application of nanotechnology is endless with a multidisciplinary facet comprising molecular diagnostics, catalysis, electronics, drug delivery, sensing and surfaces-enhanced Raman scattering [1]. The early phase of this technology amalgam both physical and chemical methods for the synthesis of nanomaterials using toxic chemicals and harsh reaction conditions. These nanostructures have the affinity to release harmful by-products into the environment leading to toxicological issues. To overcome this, there is a need for clean, non-toxic, bio-compatible and environment friendly materials synthesized via 'green' approach.

Magnesium oxide (MgO) is one of the most appropriate semiconducting materials with a wide band gap (3.37 eV), because of its non-toxic nature and low-cost. Further, it exhibits excellent electrical, optical, and chemical properties as a result it is widely applied in optical devices, piezoelectric devices, sensors, solar cells, etc., [2]. In general, their physical and chemical properties are greatly dependent on the shape, crystalline structure, and size of the MgO structures [3]. As a result, a variety of MgO structures with different morphologies and dimensions have been fabricated. Self-assembly of micro/nano/super structures of MgO have wide practical/potential applications.

In this paper we report the green synthesis of MgO NPs by using *Aloe vera* leaves extract as fuel. The various applications of MgO NPs were explored.

2. Experimental Methods

2.1 Preparation of Aloe vera Leaves Extract

Freshly collected leaves of *Aloe vera* (AV) plant were first washed thoroughly with pure water several times before extraction. The gel part of the AV leaves was taken and collected in a beaker. Then it was mixed with double distilled water until the solution becomes homogenous. Further it is filtered using Whatman No.1 filter paper. The filtrate was collected in a closed container and stored in refrigerator at 4 °C for further use. This filtrate was used as the fuel for the green combustion synthesis.

2.2 Green Synthesis of MgO Nanoparticles

The magnesium oxide nanoparticles were synthesized by 'self-propagating low temperature combustion method', employing magnesium nitrate ($Mg(NO_3)_2.6H_2O$)) as precursor and *Aloe vera* gel as a fuel (Fig. 1). In fact, 2.14 g of magnesium nitrate was taken in 300 mL petri-dish and 10 mL of *Aloe vera* gel was added to the petri-dish and kept on a magnetic stirrer for ~10 min. The uniform mixture of both oxidizer as well as the fuel was then introduced into the pre-heated muffle furnace kept at 450 °C. The mixture boils with froth yielding finally a white powder of MgO nanoparticles. The average particle size of the MgO was found by Debye-Scherrer method to be ~20 nm.

Fig. 1 Flowchart of synthesis of MgO nanoparticles

2.3 Characterization

Phase purity and crystallinity of MgO structures were studied using a powder X-ray diffractometer (XRD, Shimadzu 7000), Cukα (1.541 Å) radiation with magnesium filter was used. Scanning electron microscopy (SEM) measurements were performed on a Hitachi table top, Model TM 3000. The diffuse reflectance spectroscopy of the samples was recorded on spectrometer PerkinElmer (Lambda-35) and UV-visible spectroscopy studies were carried out using T90+ Spectrometer in the range 200-800 nm at room temperature.

3. Results and Discussion

3.1 Structural Analysis

It is observed from Fig. 2 that the PXRD patterns of MgO NPs prepared with green method. The characteristic diffraction peaks of MgO including

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(111), (200), (220), (311), and (222) were observed for all the samples. In addition, all the diffraction peaks are well assigned to the cubic crystal structure (halite) phase MgO (JCPDS card No.74-1225) [2-6]. The presence of the high intensity peaks inferred that the products were highly crystalline in nature. Additionally, the XRD patterns confirm that no extra peaks were detected under the different sonication conditions.

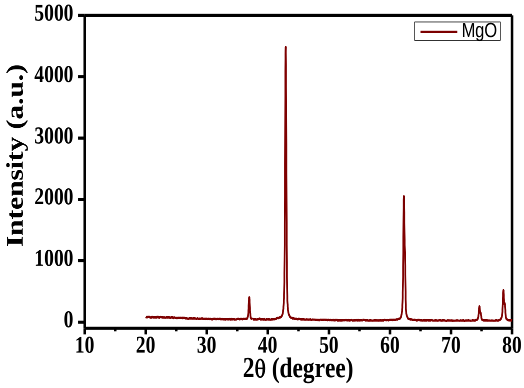

Fig. 2 PXRD Pattern of synthesised MgO NPs

The X-ray diffraction peaks of the material was analyzed by using Debye–Scherrer equation,

$$D = \frac{k\lambda}{\beta \cos\theta} \qquad (1)$$

where, D is crystalline size, λ is wavelength of X-ray, β is full-width at half-maximum and θ is angle of diffraction. The average crystallite size of synthesized MgO was found to be in range 20-25 nm [7-8].

3.2 Studies of Surface Morphology

The surface studies using SEM and TEM micrographs of MgO nanoparticles are given in Figs. 3(a, b) and (c, d) respectively. It can be seen from the figure that the prepared MgO NPs were agglomerated in nature and this agglomeration was due to trapping of MgO into the network formed by *Aleo vera* extract. From TEM micrographs the crystal size of MgO NPs was found to be in the range of 20 – 25 nm. It was also found that the crystal size calculated from PXRD data was in agreement with the value obtained by Debye-Scherer method [1-6].

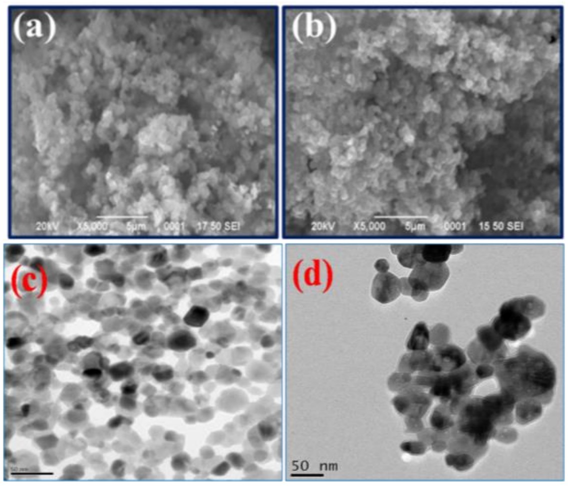

Fig. 3 (a, b) SEM micrographs and (c, d) TEM micrographs of synthesised MgO NPs

3.3 Studies of UV-Visible Spectra

The optical properties of surface reflectance for the MgO nanoparticles are studied and the optical spectrum is given in Fig. 4a. The absorbance UV-Vis spectra of MgO nanostructures recorded with the range of 200-800 nm at room temperature. It shows an absorption inflection point at around 268 nm, which should be assigned to the absorption feature of MgO nanoparticles. Also, Fig. 4b shows Tauc plot relation optical band gap of absorbance spectra with photon energy. The direct band gap energy (E_g) calculated from absorbance spectra was ~ 4.46 eV (Fig. 4b), which was in good agreement with the reported values [7-9].

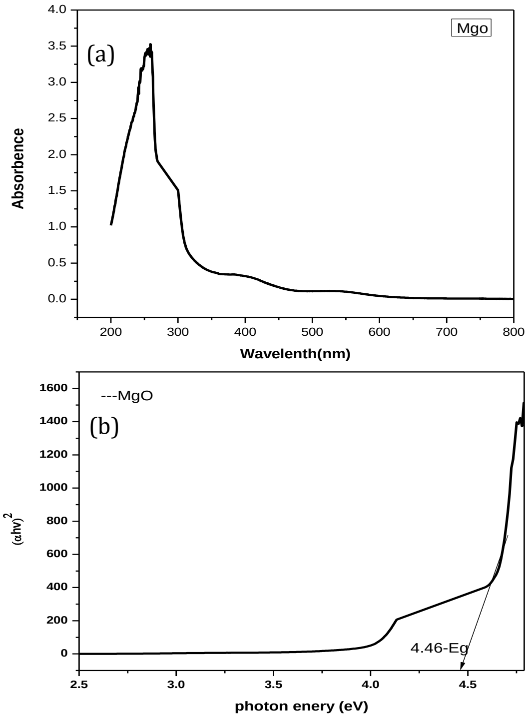

Fig. 4 (a) The UV-Vis absorbance spectra and (b) optical band gap of MgO NPs

4. Conclusion

The MgO nano-structures were synthesized by green combustion route using *Aleo vera* leaf extract as a fuel to study optical properties. From the SEM and TEM micrographs the crystal size of MgO NPs was found in the range of 20-25 nm. It was also found that the crystallite size that was calculated using the Debye-Scherrer method was in good agreement with the value obtained from TEM and the optical properties from absorbance pattern are found at 268 nm with optical band gap is 4.46 eV which is good results to MgO NPs formation reported values by green method.

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