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Research Article

Green synthesis of nickel oxide nanoparticles using Eucalyptus leaf extract: Optical and Morphology Characterization

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ABSTRACT

In the present study, NiO–NPs have been synthesized via the green method and using Eucalyptus leaf extract as a reducing and limiting agent. The morphology and structure of the NiO–NPs have been investigated via FE-SEM, FTIR, XRD, and EDX/ MAP. The results of the achieved XRD and FT-IR analyses have confirmed the formation of pure and crystalline NiO–NPs. The results showed that NiO nanostructures with smaller crystal sizes are formed using lower calcination temperatures.

Keywords: Green synthesis, Nickel oxide, Nanoparticles, Eucalyptus leaf extract.

1. Introduction

Nanotechnology has been researched intensively by researchers across the globe in recent years because of its unique properties. Nanomaterials are useful compared to bulk materials in terms of their properties. The Recent approach focuses on economically alternative methods for the construction, manipulation of material at nanometre scale level. In the last decade, metal nano-oxides have played an important role due to their amazing and distinctive properties such as electronic, optical, sensor, chemical, magnetic, and mechanical properties [1]. Synthesis of metal-oxide nanoparticles using plants, so-called Green synthesis, has

received a great deal of attention due to its easy and cheap synthesis condition concerning chemical and physical routes. The synthesis of nanoparticles using biomaterials is more environmentally friendly, safer, and more cost-effective methods than conventional chemical methods [2]. Plant extracts have contained various metabolites with the ability to act as reducing and capping agents in the synthesis reaction of metal nanoparticles. The main materials involved are terpenoids, flavones, ketones, aldehydes, amides, and carboxylic acids [3-4]. Some plants have achieved success in the synthesis of nickel oxide nanoparticles, such as Aloe vera leaf [5], Avicennia Marina [6], Calotropis gigantea [7], Aegle marmelos [8], Ageratum conyzoides [9], and Aspalathus linearis [10]. Among these, eucalyptus leaves contain a wide range of active components and the research is still on the hunt for their potential uses as they are rich in polyphenols, including flavonoids and tannic acids, organic acids, and volatile oils [11].

Therefore, the main purpose of this paper was to improve an economical and environmentally friendly method for green synthesis of NiO-NPs through the use of eucalyptus leaf extract as a stabilizing agent and template to prevent the accumulation of nanoparticles [12]. We changed the calcination temperature to investigate the effects on crystallinity and nanoparticle size. The product was determined using FTIR, XRD, FESEM, and EDX / MAP.

2. Experimental

2.1. Chemicals and apparatus

Nickel nitrate hexahydrate, NaOH, was purchased from Merck Chemical company with a purity of over 99%. The leaves of Eucalyptus were collected from the local areas of Khuzestan province, Iran. All reagents for synthesis were analytical grades and double distilled water was used throughout the experiments.FT-IR spectra were recorded on Perkin-

Elmer (RX 700) FT-IR spectrophotometers as KBr pellets. The crystallinity of nanoparticles was investigated by Holland Philips Xpert X-ray diffraction (XRD) (Cu Kα, radiation, k = 0.154056 nm), from 10^{o} to 80^{o} (2θ). The morphology of the nanoparticles was considered by The SEM images and EDX-Map were recorded by TESCAN MIRA III FESEM.

2.2. Preparation of extract

The Eucalyptus leaves extract was prepared by the following procedure: Eucalyptus leaves were cleaned with tap water followed by distilled water and dried in the shade. The dried leaves were powdered using an electric grinder. The extract was prepared by the soaking method. 10 g of dry leaves powder was soaked in 100 mL of water at 30–33 ^{o}C for 3-4 days. The solution was prefiltered through Whatman No. 42 filter paper and refiltered through Whatman No. 1 filter paper. The obtained extract was collected and stored in the refrigerator.

2.3. Green synthesis of nickel oxide nanoparticles

For the fabrication of nickel oxide NPs, 1.74 g of Ni $(NO_3)_2$ $6H_2O$ and 0.95 g of NaOH was dissolved in 60 mL of deionized water in a round bottom flask under constant stirring using a magnetic stirrer. Then 5 mL of extract was added dropwise to the solution and after complete dissolution, the mixture was stirred with a magnetic stirrer for 3 hours in an oil bath at a constant temperature of 80 ° C. The collected precipitate was allowed to cool, centrifuged twice at 4500 rpm for 15 min, and washed by H_2O/EtOH. After washing, the remaining product was dried in an oven at 120 ºC for 12 h and was divided into 3 parts. Finally, the components were calcined at 400, 500, and 600 ° C for 4 h to give a black powder known as NiO nanoparticles. The green synthesis steps of the product are shown in Figure 1.

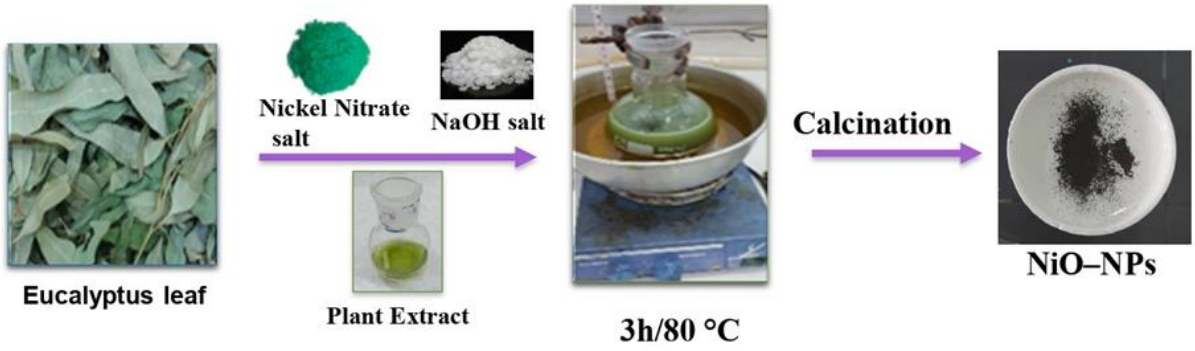


Fig 1. Green synthesis of NiO-NPs.

3. Result and discussion

3.1. Catalyst characterization

The FT-IR spectrum of NiO-NPs that has been calcined at the temperature of 500°C is shown in Fig. 2. The obtained spectra exhibit Ni - O bands at 478 cm^{-1} which confirmed the presence of NiO-NPs. The strong absorption bands at 3423 cm^{-1} and 1632 cm^{-1} show the OH stretching and bending vibration, which confirms the adsorption of water molecules on the surface of NiO-NPs during the preparation of the samples by the KBr pellet technique [13]. The bands at 1428 (C–H) and 1117 (C–O) cm^{-1} are due to the plant extract used [14].

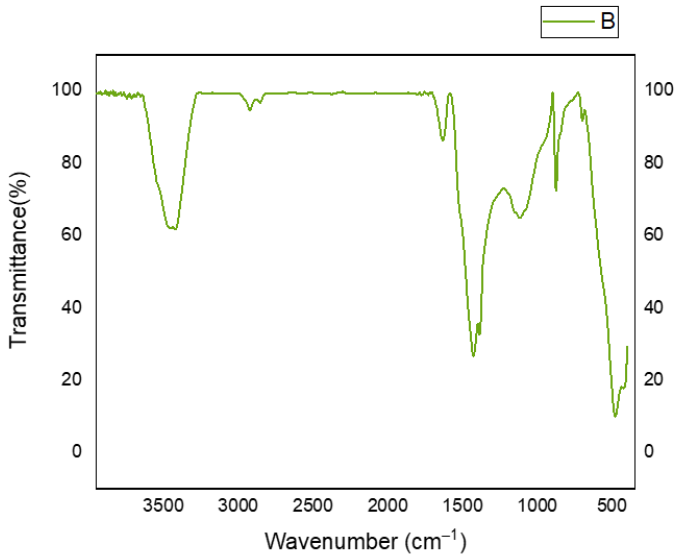


Fig. 2. FTIR spectra of prepared NiO–NPs at 500 °C.

The X-ray diffraction spectra of NiO-NPs are presented in Figure 3. This diagram shows five different peak types at the surfaces, including (111), (200), (220), (311), and (222), which suggests that the face-centered cubic (fcc) NiO–NPs contain a cubic crystal structure [15]. The particles size has been estimated using the Debye–Scherrer formula Eq. 1:

$$\boldsymbol{D = \frac{k\lambda}{B\cos\theta}}$$

where D is the particle size (nm), k = 0.94 stands as the fixed number, λ would be the wavelength (0.154 nm), β represents the full-width half maximum of the metal oxide diffraction peaks (rad), and θ is the diffraction angle. Figure 3 shows that increasing calcination temperature resulted in heightening the intensity of peaks and decreasing their width. An increase in the strength of mountains is indicative of an increase in the crystalline degree of nanoparticles, while a decrease in their width is suggestive of an increase in crystalline particle size that can be caused by the particle joining and their growth at high temperatures [12]. The results obtained from the XRD pattern are presented in Table 1.

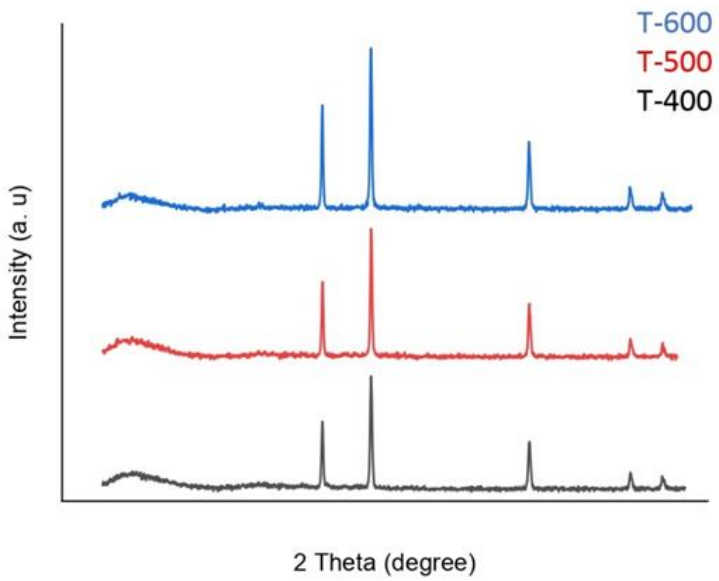
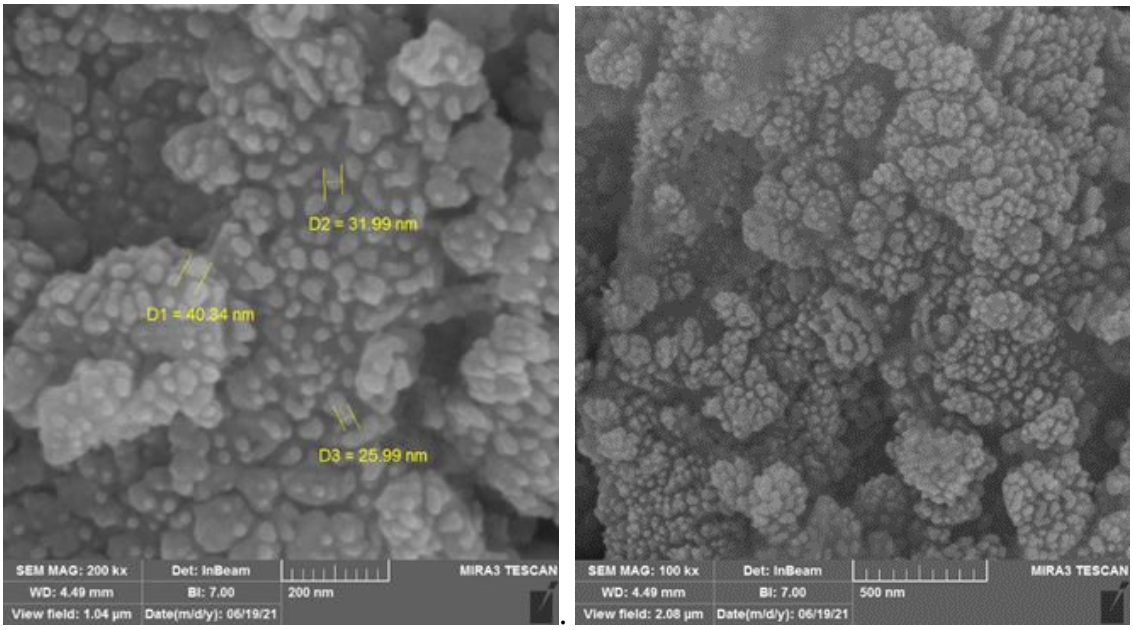


Fig. 3. XRD spectra of synthesized NiO-NPs at different temperatures (400-500-600°C).

Table 1. The results from the XRD pattern of NiO-NPs

Calcination Temp(°C).	2θ(deg.)	Diameter (nm)	Identification
400	43.3	34	fcc (NiO)
500	43.3	43	fcc (NiO)
600	43.3	51	fcc (NiO)

Figure 4 displays FE-SEM and EDX analysis of NiO-NPs synthesized via the utilization of Eucalyptus leaf extract at 600 °C. It can be perceived that the NiO-NPs were uniformly distributed while being homogenous and spherical as well [16]. Figure 4 shows FE-SEM image and the corresponding elemental mapping for NiO-NPs. Resulted spectra indicate the presence of Ni and O, elements in NiO-NPs. Table 2 summarizes the numerical analysis of EDX spectra for as-synthesized samples.



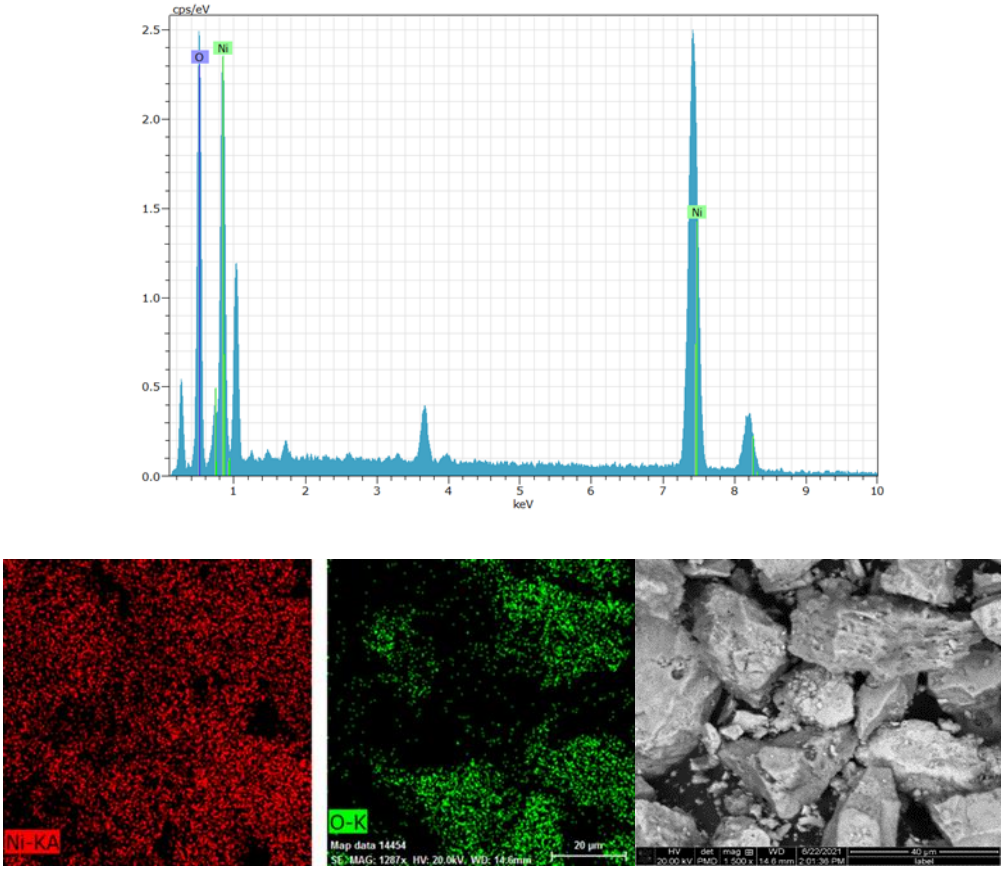


Fig. 4 The FESEM image, EDS spectra, and EDX/MAP image of prepared NiO–NPs at 600 °C

4. Conclusion

In this paper, we have reported NiO nanoparticles were prepared using Eucalyptus leaf extract. The structural and morphology characterization of these nanoparticles was characterized using techniques such as FESEM, XRD, IR, and EDX/MAP investigations to confirm the formation of pure, crystalline NiO nanoparticles at different temperatures. These results demonstrate that the green synthesized nickel oxide nanoparticles could be of use in a variety of applications.

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