GREEN SYNTHESIS OF IODINE DOPED NANO-COMPOSITES USING OCIMUM BASILICUM (BASIL) LEAF EXTRACT

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Abstract

Iodine, the heaviest of the stable halogens, has a diverse array of applications, including as a dietary supplement, an antiseptic in medicine, and in spectroscopy. Due to its versatility, iodine-doped nanocomposites have been synthesized through various methods. Among these, green synthesis is a particularly cost-effective and environmentally friendly technique. In this study, we utilized green synthesis to fabricate iodine-doped nanocomposites using leaf extracts from Ocimum basilicum (basil). The synthesized samples were characterized using several analytical techniques, including X-ray diffraction (XRD), UV-visible spectroscopy, field emission scanning electron microscopy (FESEM) with energy dispersive X-ray spectroscopy (EDX), and Fourier-transform infrared spectroscopy (FTIR). The analytical results confirm the successful formation of iodine-doped nanocomposites and reveal the presence of iodine (I) along with oxygen (O), carbon (C), magnesium (Mg), sodium (Na), calcium (Ca), and phosphorus (P) in the composites. Additionally, FTIR analysis indicates the presence of active biomolecules that function as reducing and capping agents.

Keywords: Iodine doped, Nano composites, green synthesis, Ocimum Basilicum (Basil), Leaf Extract.

1. INTRODUCTION

In recent decades, nanocomposite materials have become a highly intriguing field of scientific research. These materials exhibit unique chemical and physical properties that differ significantly from those of the pure elements from which they are composed. Their potential applications span various domains, including medicine, biotechnology, environmental science, food technology, information technology, and energy, leading to increased interest in their development [1-4]. Among the stable halogens, iodine is notable for its diverse applications, such as in dietary supplements, antiseptics, and spectroscopy [5,6]. Given its versatility, iodine-doped nanocomposites have been synthesized through various methods, including chemical vapour deposition, sol-gel processes, and lithography [7,8]. However, these traditional methods are often expensive, toxic, and hazardous, resulting in undesirable by-products.

To mitigate these challenges, green synthesis methods are gaining traction due to their cost-effectiveness, biocompatibility, and environmental sustainability [9,10]. Using plant extracts for nanocomposite synthesis is considered a particularly feasible approach. Plant extracts contain phytocompounds that act as capping and reducing agents, preventing the agglomeration of ions [11,12]. In this study, iodine-doped nanocomposites were synthesized using a green synthesis method involving Ocimum basilicum (basil) leaf extracts. The synthesized nanocomposites were characterized for their structural, optical, and morphological properties using X-ray diffraction (XRD), UV-visible spectroscopy, field emission scanning electron microscopy (FESEM), energy-dispersive X-ray spectroscopy (EDX), and Fourier-transform infrared spectroscopy (FTIR).

XRD analysis revealed that the composite crystals have an orthorhombic structure. The average crystal size of the iodine-doped nanocomposites was found to be approximately 82.3 nm, with a band gap of 5.42 eV. EDX spectra confirmed the presence of iodine (I) along with oxygen (O), carbon (C), magnesium (Mg), sodium (Na), calcium (Ca), and phosphorus (P) in the composites. FTIR analysis identified active biomolecules that function as reducing and capping agents. The synthesized composites exhibited a non-metallic nature.

2. MATERIALS AND METHODS

2.1 Chemical and Reagents

Sodium iodide (NaI) and sodium hydroxide (NaOH) were procured from Merck Life Science Private Limited, Maharashtra, India, and were used without further purification. All solutions were prepared with doubly distilled water obtained from a Milli-Q water purification system.

2.2 Preparation of Basil leaf extract

Fresh basil leaves were collected from the Vinoba Bhave University campus in Hazaribag, Jharkhand, India (Latitude: 24.0229468, Longitude: 85.3683894). The leaves were cleaned thoroughly by washing them four times with running tap water, followed by two rinses with doubly distilled water to remove any dust and residues. Ten grams of the crushed basil leaves were mixed with 100 ml of doubly distilled water and boiled for 20 minutes at 70°C. The basil leaf extract was then filtered through Whatman No. 1 filter paper and stored at room temperature for subsequent use. The pH of the leaf extract was measured at 6.4.

2.3 Green synthesis of Iodine doped Nano composites

A 90 ml portion of 0.3 M aqueous sodium iodide (NaI) solution was mixed with 10 ml of basil leaf extract in a 9:1 (v/v) ratio. The pH of the resulting mixture was initially below 7. To adjust the pH to between 8 and 9, a 50 ml aqueous solution of 2 g NaOH was added drop-wise to the reaction mixture. The entire process was conducted at room temperature. The reaction solution was left undisturbed for 24 hours in a shaded environment. After this period, the solution colour changed from light reddish to dark reddish, indicating the formation of nanocomposites. The solution was then centrifuged at 10,000 rpm for 20 minutes. The precipitates were collected, washed four times with doubly distilled water, and dried at 60-70°C for 24 hours in a hot air oven. The resulting powder was then used for further characterization.

2.5 Characterization of Iodine doped Nano composites

The optical properties were assessed using a UV-visible spectrophotometer, covering a wavelength range from 200 to 800 nm. The crystal structure of the synthesized nanocomposites was analysed with an X-ray diffractometer (XRD) over a 2θ range of 10° to 80°, with a step size of 0.02°. The compositional analysis was performed using energy-dispersive X-ray (EDX) spectroscopy. The surface morphology of the samples was examined with a field emission scanning electron microscope (FESEM). Furthermore, the functional groups on the surface of the nanocomposites were characterized using Fourier-transform infrared (FTIR) spectroscopy.

3. RESULTS AND DISCUSSION

3.1 Structural properties (XRD):

Figure 1 illustrates the X-ray diffraction (XRD) pattern of the synthesized iodine-doped nanocomposites. The pattern shows twelve distinct peaks at 2θ values of 14.8°, 24.3°, 29.9°, 35.6°, 35.8°, 38.1°, 39.6°, 43.5°, 46.3°, 50.7°, 52.6°, and 60.6°, corresponding to crystal planes with (h k l) indices of (0 2 0), (1 1 1), (1 1 2), (1 1 3), (0 0 4), (0 4 0), (1 3 2), (2 0 2), (1 3 3), (1 3 4), (2 2 3), and (1 1 6), respectively. This pattern closely matches the orthorhombic structure of the standard CIF file no. np-23153. The average crystalline size (D) of the nanocomposites was calculated using the Scherrer equation:

$$D = \frac{K\lambda}{\beta COS\theta}$$

where D represents the crystalline size (nm), K=0.9 is the shape factor, λ is the X-ray wavelength (0.15406 nm), β is the full width at half maximum (FWHM), and θ is the diffraction angle. The average crystalline size of the synthesized sample was determined to be 82.3 nm.

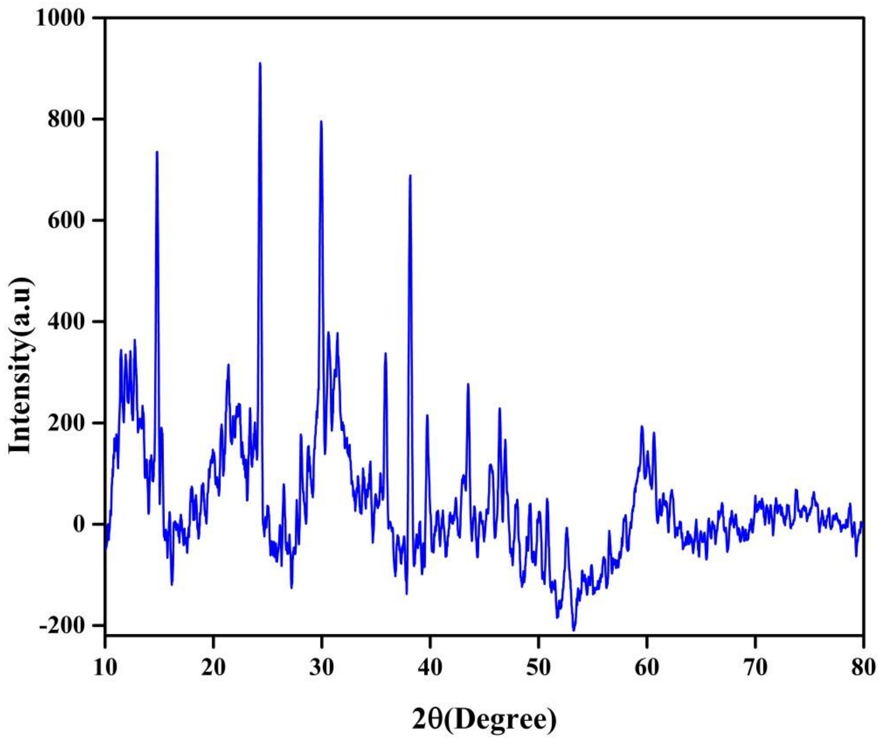

Fig-1 XRD pattern of Iodine doped Nano composites.

3.2 Optical properties (UV-Visible)

The optical properties were examined using UV-visible spectroscopy over a wavelength range of 200-800 nm. The band gap of the synthesized nanocomposites was calculated using the following formula:

$$\mathbf{E} = \frac{hc}{\lambda}\ \mathbf{eV}$$

Where h = Plack's constant λ = Wavelength of light and c = speed of light (m/s)

The absorption peaks of the Nano composites are observed at 229.5nm in the UV region (Figure-2). The estimated band gap of the prepared Nano composite is equal to 5.42eV.

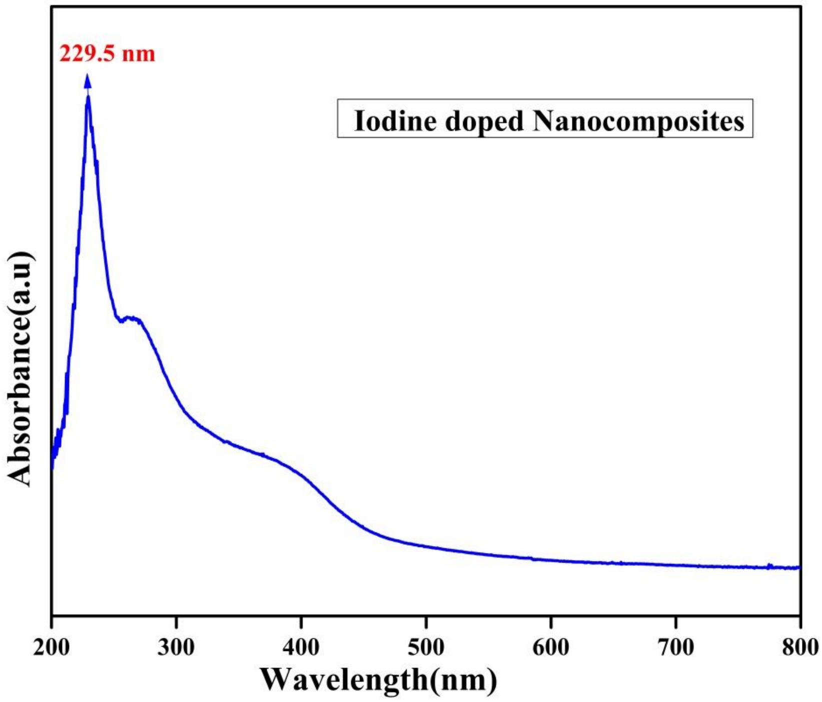

Fig-2 UV-Visible absorption spectra of Iodine doped Nano composites

3.3 Surface Morphology and Composition Analysis (FESEM & EDX)

Figure 3 shows the Field Emission Scanning Electron Microscope (FESEM) image of the green-synthesized iodine-doped nanocomposites. The particle sizes observed in the FESEM image are significantly larger compared to the grain sizes measured by XRD. Figure 4 presents the Energy Dispersive X-ray Spectroscopy (EDX) spectra of the synthesized nanocomposites. The EDX results confirm the presence of iodine (I), along with oxygen (O), carbon (C), magnesium (Mg), sodium (Na), calcium (Ca), and phosphorus (P) in the composites. The presence of oxygen and carbon is attributed to the functional groups in the basil leaf extract used during synthesis. Sodium is expected from the sodium iodide salt solution. Magnesium, calcium, and phosphorus are included because these are essential minerals commonly found in basil leaves.

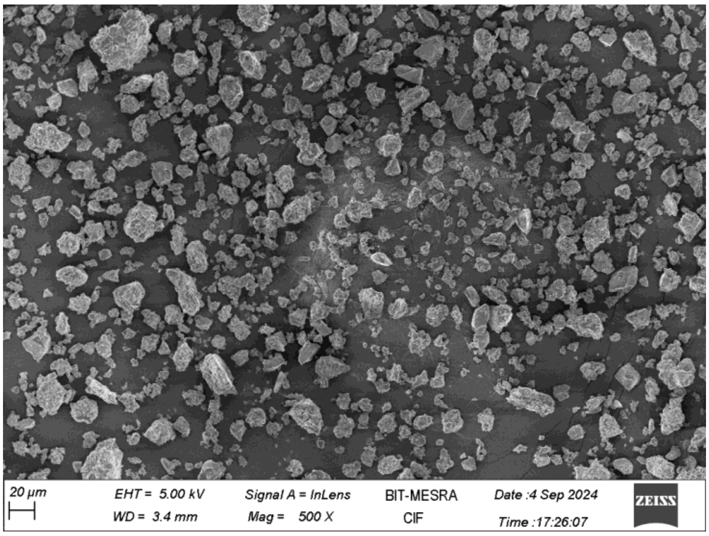

Fig-3 FESEM pattern of Iodine doped Nano composites

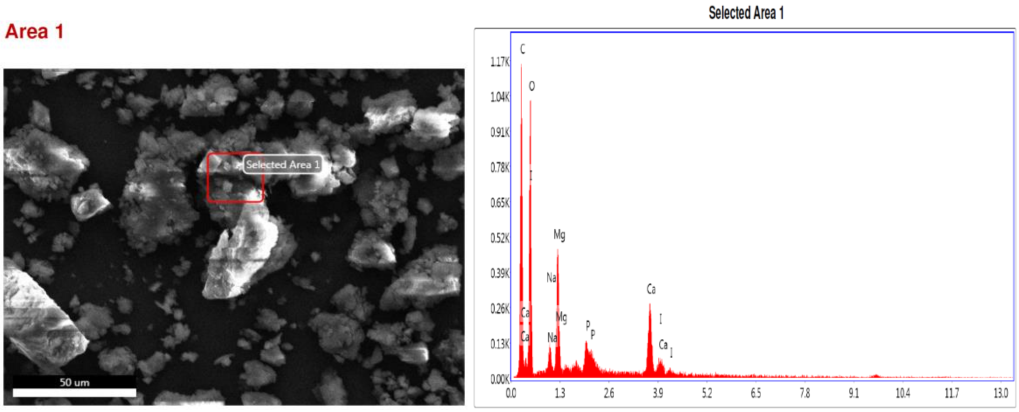

Fig-4 EDX pattern of Iodine doped Nano composites

3.4 FTIR Analysis

FTIR spectroscopy is used to identify the functional groups present in materials [24]. Figure 5 shows the FTIR spectra of the synthesized iodine-doped nanocomposites, measured in the range from 4000 to 400 cm^{-1}. Key absorption peaks are observed at 3356.7, 2922.9, 2868.7, 1624.7, 1409.0, and 562.3 cm^{-1}. The broad peak at 3356.7 cm^{-1} indicates the presence of O-H stretching vibrations from carboxylic and hydroxyl groups. Peaks at 2922.9 and 2868.7 cm^{-1} correspond to the aromatic C-H stretching vibrations. The peak at 1624.7 cm^{-1} is associated with the C=C stretching mode in amide and benzene groups, while the peak at 1409.0 cm^{-1} is related to C-N stretching vibrations of aromatic amines.

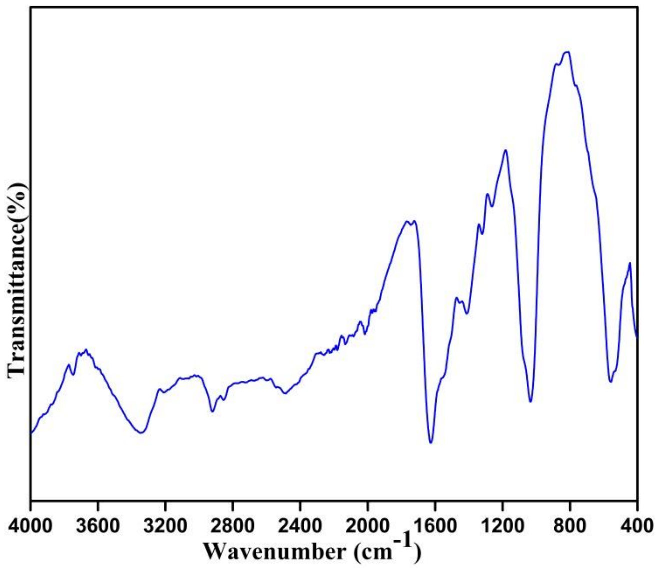

Fig-5 FTIR spectra of synthesised Iodine doped Nano composites

4. CONCLUSION

The green synthesis method offers a cost-effective and efficient approach for producing iodine-doped nanocomposites. This technique is both simple and effective. However, maintaining quality control presents a challenge, as the synthesized material includes not only iodine but also other elements from the basil leaves. As a result, the spectra obtained through various analytical techniques exhibit minor deviations from standard values. The calculated band gap of 5.42 eV suggests that the prepared nanocomposite is non-metallic in nature.

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