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FABRICATION AND CHARACTERIZATION OF BIOMAGNETIC COMPOSITE MATERIAL

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Abstract

In this study, the synthesis and characterization of a biomagnetic composite material was achieved by a simple and cost effective method. Tomato processing waste was successfully converted into a magnetic material via embedding Fe_3O_4 nanoparticles to its structure. Due to its low cost and ease of application, co-precipitation method was used for loading the magnetite nanoparticles. Characterization studies were carried out with Fourier transform infrared spectroscopy, scanning electron microscopy and vibrating sample magnetometer spectroscopy and the outcomes of the analyses of non-magnetic and magnetic material were compared.

Key words: tomato processing waste, magnetic composite, magnetite nanoparticles, characterization

1. Introduction

Interest in nanotechnologies and nanoscale materials, particularly magnetic nanoparticles (MNPs), has grown recently and their applications have attracted the attention of both the research and industrial communities in the chemical, environmental and medical sectors. Their effective application in membrane separation water treatment and purification processes has been demonstrated [1]. Although there are many pure phases of iron oxide in nature, the most popular MNPs are the nanoscale zero-valent iron (nZVI), Fe_3O_4 and γ-Fe_2O_3. They possess different physicochemical properties originating from the difference in their iron oxidation states and their capability for contaminant removal. Among them, magnetite (Fe_3O_4), which is a ferromagnetic black color iron oxide of both Fe(II) and Fe(III), has been the most extensively studied. Magnetite is the preferred type because of the presence of the Fe^{2+} state with the potential of acting as an electron donor. Fabrication and synthesis techniques of magnetic nanoparticles have been reviewed by many authors such as co-precipitation method [2], aerosol route [3], hydrothermal reaction [4], oxidative precipitation [5], organic precursor method [6], sonochemical decomposition [7], and sol–gel synthesis technique [8]. In this study, co-precipitation method was used to convert tomato processing waste a magnetic composite material. The synthesized material was characterized and the properties of the composite were compared with non-magnetic material.

2. Materials and Method

2.1. Preparation of the biosorbent

Tomato processing waste was supplied from a fruit-vegetable processing mill at Adana, Turkey.

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Tomato processing waste was washed with hot distilled for several times and then dried in sunlight. The dried tomato processing wastewas sized to 14 mesh particle size and then washed with ultra-pure water again. It was dried at 70 ^{0}C in an oven for 24 h.

2.2. Preparation of the biomagnetic composite

In order to synthesize biomagnetic composite adsorbent, co-precipitation method was used as follows: The stoichiometric amounts of $FeCl_3$ and $FeCl_2$ were dissolved in distilled water. A certain amount of tomato processing waste was added to the mixture under vigorous stirring. Then NaOH solution was used to adjust the pH of the solution to the range of 10-11. After pH adjustment, the solution was kept at 100 ^{0}C for 4h. Then, the solution was filtrated, washed with distilled water several times and dried at 105 ^{0}C for 24 h. The synthesized adsorbent was labelled as magnetic tomato processing waste and stored in glass bottles.

2.3. Characterization studies

The surface chemical functionalities of samples was qualitatively determined by Attenuated total reflection Fourier transform infrared (ATR-FTIR) spectroscopy with a Perkin Elmer spectrum 100 spectrometer between 4000-400 cm^{-1}.
The surface morphology was identified by the scanning electron microscopy (SEM) instrument (Carl Zeiss Ultra Plus, UK). Micrographs of samples were observed by the assistance of coated with platinum, operating at 10 kV.
Vibrating sample magnetometer (VSM 7404, Lake Shore Cryotronics, USA) was utilized to magnetic features of the synthesized material.

3. Results and Discussion

3.1. FTIR analysis

The spectra of raw tomato waste and magnetic tomato waste were compared in Fig.1. The peak at 3286 cm^{-1} is due to O-H vibration. The absorption bands located around 2923 and 2855 cm^{-1} can be assigned to the aliphatic C-H vibrations. Two peaks at 1740 and 1632 cm^{-1} assigned to the C=O group and indicates the existence of aldehyde groups. The signals at 1443 and 1157 cm^{-1} are due to the C-C bindings. The peak at 1029 cm-1 indicates the stretching vibration of C-O bond. When the spectra of tomato processing waste and magnetic tomato processing waste were compared, it can be observed from the figure that, the peak intensities have changed after magnetite nanoparticles loading. In the spectra of magnetic composite, a new peak was occurred at 556 cm^{-1} that confirms the successful loading of the magnetite nanoparticles to the structure of tomato waste.

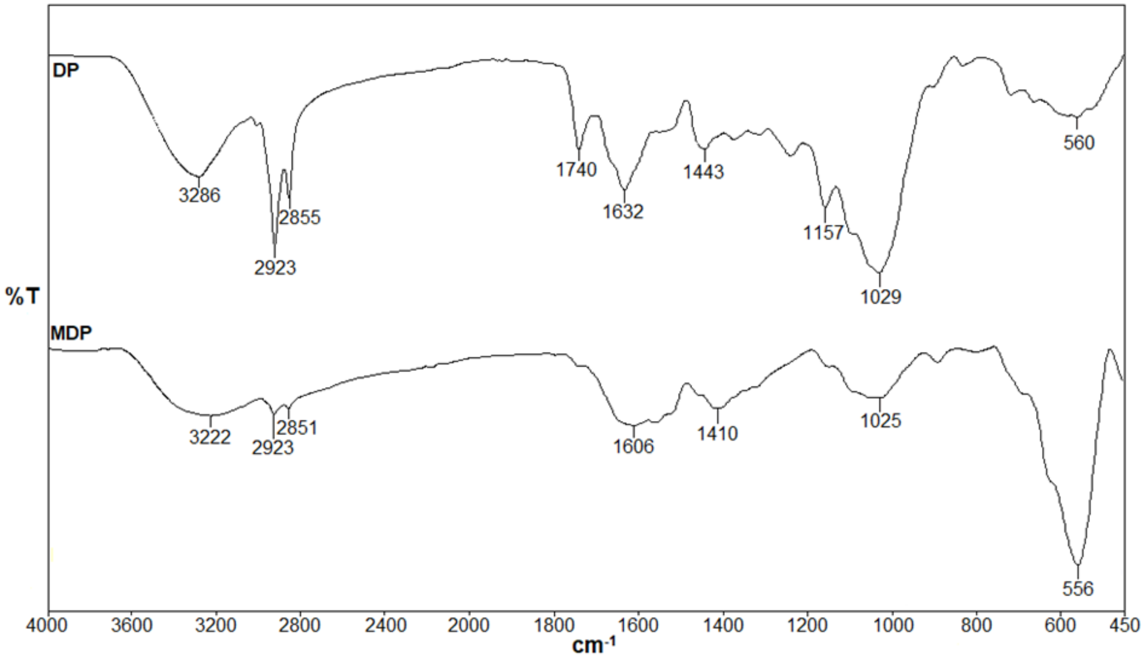

Figure 1. FTIR spectrum of tomato processing waste and its magnetic composite.

3.2. SEM analysis

SEM micrographs of tomato processing waste and magnetic tomato processing waste are shown in Fig.2. It can be seen from the figure that, the surface of tomato processing waste and magnetic tomato processing waste are different from each other. The surface of magnetic tomato processing waste is has an unregular structure and has some cavities and cracks.

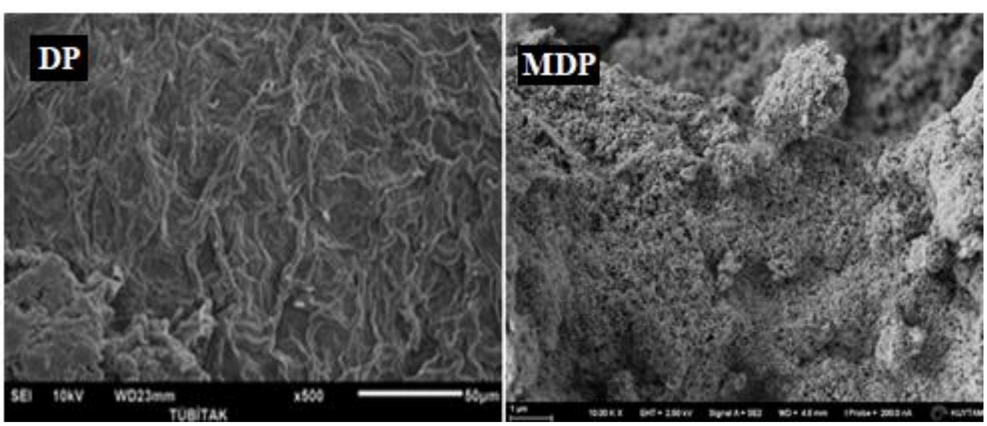

Figure 2. SEM images of tomato processing waste and its magnetic composite.

3.3. VSM analysis

VSM curves of the magnetic tomato processing waste is seen in Figure 3 and indicates the magnetic property of the synthesized material. Also the inset figure shows that the synthesized composite material is magnetically separable.

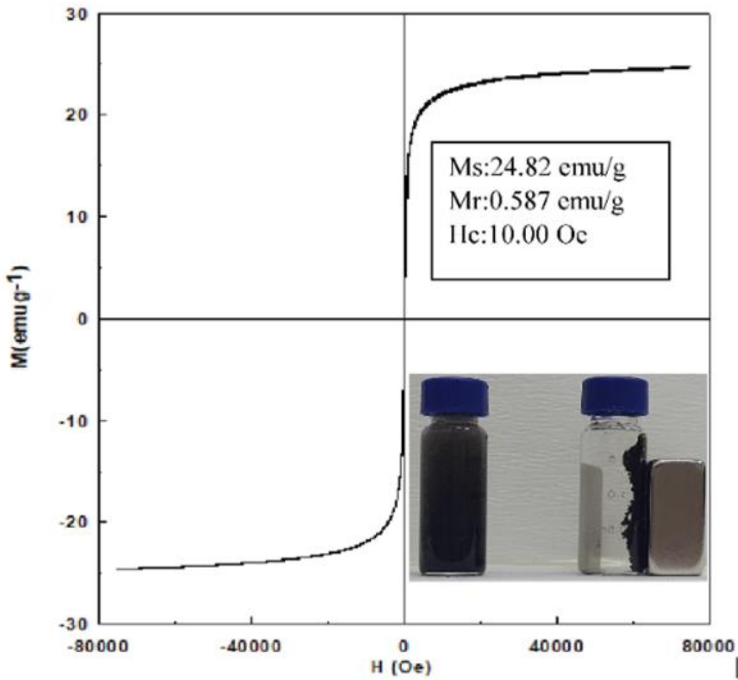

Figure 3. VSM curves of MTPW composite.

Conclusions

A novel magnetically separable composite material was synthesized from a global waste. The fabricated material was characterized in terms of surface structure and magnetic features and also compared with its non-magnetic form. This study indicated that, tomato waste could be used as a promising feedstock for production of magnetic materials due to its abundantly avalability and low cost.

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