DEVELOPMENT OF MAGNETO-NANOSENSORS BY USING NEEM LEAVES EXTRACT FOR BIOMEDICAL APPLICATIONS

Nurul Izza Taib[1], Famiza Abdul Latif[2], Zakiah Mohamed[2], Nur Diyana Syazwani Zambri[2]

[1]*Faculty of Applied Sciences, Universiti Teknologi MARA, Perak Branch, Tapah Campus, 35400 Tapah Road, Perak, MALAYSIA*

E-mail: izza257@uitm.edu.my

[2]*Faculty of Applied Sciences, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, MALAYSIA*

ABSTRACT

An economic, safe and eco-friendly co-precipitation method for the synthesis of iron oxide nanoparticles (Fe_3O_4-NPs) was performed using non-toxic neem leaves extract as a reducing and stabilizing agent. The successful synthesis was confirmed by infrared spectra analysis with strong peak observed between 400–600 cm^{-1} that corresponds to magnetite nanoparticles characteristics. X-Ray Diffraction (XRD) analysis showed that the nanoparticles are high purity with crystalline cubic structure phase in nature. Transmission Electron Microscopy (TEM) image displayed the synthesized Fe_3O_4-NPs were mostly spherical and oval shape with diameter was in the range from 9-14 nm which agrees with calculated Scherrer equation with average diameter of around 11 nm. The hysteresis loops of the nanoparticles were measured using Vibrating Sample Magnetometer (VSM) and the results showed a superparamagnetic behavior at room temperature, suggesting the potential applications for magnetic targeting drug delivery system.

Keywords: magnetite, iron oxide nanoparticles, *azadirachta indica*, superparamagnetic

1. INTRODUCTION

The exploration of iron oxide nanoparticles (Fe_3O_4-NPs) has earned numerous attentions as consequence of their biocompatibility, superparamagnetism, high saturation magnetization, low toxicity and various potential applications in biomedicine field [1-2]. There are numerous methods were investigated for synthesis of Fe_3O_4-NPs such as sol gel process, hydrothermal techniques, thermal decomposition, and microemulsion route [3]. However, the drawbacks of these methods include low production rates, high energy consumption and the usage of precursors and surfactants in organic solvent that are toxic enough to pollute the environment [4-6]. Thus, there is a growing need to develop environmentally benign nanoparticle synthesis that do not require harmful chemicals in the synthesis protocol. Green synthesis is not only able to reduce environmental impact but it is attractive enough if they are intended for invasive applications in medicine. In this study, we report on the synthesis of Fe_3O_4-NPs by one-pot reaction by the reduction of aqueous Fe^{3+} and Fe^{2+} ions with the neem leaf extract in an alkaline medium. The water soluble Fe_3O_4-NPs have been characterized by Fourier Transform Infrared (FTIR), X-Ray Diffraction (XRD), Transmission Electron Microscopy (TEM) and Vibrating Scanning Magnetometer (VSM).

2. MATERIAL AND METHOD

2.1. Preparation of Neem Leaf Extract

The collected leaves were thoroughly washed with distilled water to remove dirt followed by air dried in order to remove the remaining moisture. Then, the dried leaves were cut into small pieces and grind into fine powder. 5 g of neem leaf powder was added into 100 mL distilled water and the mixture was heated at 80 °C. The mixture was left to cool at room temperature before vacuum-filtered to obtain extract. The extract was stored at 4 °C for further characterization.

2.2. Synthesis of Fe_3O_4-NPs

0.40 g of iron (II) chloride tetrahydrate and 1.10 g of iron (III) chloride hexahydrate were dissolved in 100 mL of sterile deionized water under nitrogen blanket. The resulting mixture was heated up to 80 °C under mild stirring for 10 minutes. 5 mL of aqueous neem leaf extract was added slowly into the resulting mixture and subsequently 20 mL of 25% ammonium hydroxide (NH_4OH) was added into the reaction mixture drop by drop under vigorous stirring for 30 minutes. The instantaneous black color appearance indicated the formation of Fe_3O_4-NPs. After 30 minutes, the solution was poured into a beaker and magnetic decantation was carried out in order to remove the supernatant. The intense black precipitate Fe_3O_4-NPs was then washed with 15 mL deionized water and centrifuged at 5000 rpm for 10 minutes. The precipitate was resuspended in 10 mL of deionized water and centrifuged again under identical conditions. The precipitate was transferred to a vial and 10 mL deionized water was added. The obtained black powder was proceeds to freeze drying overnight and was subjected for further characterization.

2.3. Characterization

The size and the morphology of the Fe_3O_4-NPs was observed by means of a transmission electron microscopy (TEM) using Technai G2 20S Twin TEM, Netherland working at 200 kV. For XRD analysis, the samples were placed on a flat plate while intensity data were collected as a function of the Bragg angle, θ, in the range $2\theta = 10°$ to 70° with a step size of 0.013° using a PANanalytical X'pert PRO diffractometer in Bragg-Brentono geometry using Cu K_a radiation wavelength $\lambda_{a1} = 1.5405$ Å, $\lambda_{a2} = 1.5443$ Å. Fourier transform infrared (FTIR) spectra were collected using a Perkin Elmer FTIR spectrophotometer using KBr pellet method with a range of 4000–400 cm^{-1}. The magnetic properties of the prepared Fe_3O_4 was revealed using a vibrating sample magnetometer (VSM, Lake Shore 7404) at room temperature 300 K.

3. RESULTS AND DISCUSSION

The strong absorption band around 3324 cm^{-1} in FTIR spectra are contributed to the N-H stretching and bending vibration of amine group NH_2 and OH the overlapping of the stretching vibration of attributed for water and *Azadirachta indica* leaf extract molecules. The adsorption peak at 1633 cm^{-1} (Fig. 1 (a)) corresponds to amide C=O stretching which suggest the presence of –COOH group in the *Azadirachta indica* leaf extract. The decreasing in intensity at 1633 cm^{-1} (Fig. 1 (b)) signify the involvement of amide C=O stretching in the reduction process. The adsorption peak at 2429 cm^{-1} (Fig. 1 (b)) corresponds to alkyne group present in phytoconstituents of extracts. Hence, the presence of these functional groups validates that flavanones or terpenoids molecules were chemically bonded to the surface of Fe_3O_4-NPs. It was also observed the occurrence of strong peaks at 541 cm^{-1}, 505 cm^{-1}, 490 cm^{-1} and 467 cm^{-1} that denotes to the Fe-O stretching band of iron oxide nanoparticles. XRD diffractogram (Figure 1 (c)) confirm the crystalline phase of Fe_3O_4 with no other characteristic peaks are detected, indicating that the purity of the synthesized sample. There are six series of characteristic peaks at $2\theta = 30°$, 36°, 43°,54°, 57° and 63° which corresponds

to (220), (311), (400), (422), (511) and (440) were observed. All the diffractions peaks were indexed as a cubic structure of Fe_3O_4 phase and the calculated lattice parameter of the sample was 8.38 Å. The calculated average particle size of Fe_3O_4 using Scherrer's formula was found to be 11 nm. TEM micrograph (Figure 1 (d)) of Fe_3O_4-NPs showed that the particle size of Fe_3O_4-NPs is found to be in the range of 9-14 nm. It reveals that the Fe_3O_4-NPs are well dispersed with predominantly spherical in shape, while some of the NPs were found to be having structures of irregular shape. Magnetic measurements of Fe_3O_4 (Figure 1 (e)) exhibit superparamagnetic behaviour without magnetic hysteresis or remanence at room temperature. The specific saturation (M_s) of Fe_3O_4 was determined to be 82 emu/g indicate the presence of non-magnetic surface layers resulting from the strong chemical attachment of the stabilizing agent of *Azadirachta indica* leaf extract to the Fe_3O_4's surface, also observed by FTIR spectroscopy.

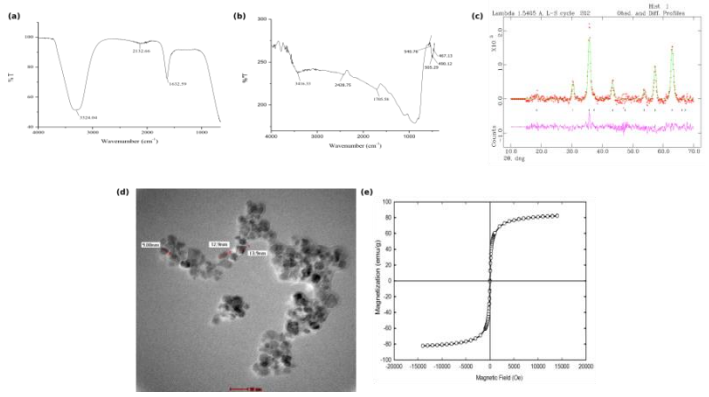

Figure 1. FTIR spectra of (a) aqueous leaf extract of neem and (b) synthesized Fe_3O_4-NPs, (c) Rietveld refinements of Fe_3O_4 against XRD data. Observed, calculated and the difference profiles are represented by red crosses, green lines and pink lines, respectively (d) TEM of synthesized Fe_3O_4-NPs and (e) Magnetization (emu/g) versus applied magnetic field (Oe) for Fe_3O_4-NPs

4. CONCLUSION

The crystalline Fe_3O_4-NPs can be synthesized in a one-step reaction using a green facile approach by using *Azadirachta indica* leaf extract also has been proven to be effective and efficient according to FTIR analysis. XRD pattern showed that Fe_3O_4 to be crystalline in nature, and all the diffraction peaks can be indexed to the pure cubic phase. The TEM result confirmed the size of nanoparticles in the range of 9-14 nm. The Fe_3O_4-NPs are superparamagnetic with the saturation magnetization (M_s) of 82 emu/g. Fe_3O_4-NPs synthesized in this work could be useful for biomedical applications as magnetic targeting drug delivery system or contrasting agents due to their small particle size and superparamagnetic property.

REFERENCES

1. Laurent, S., Forge, D., Port, M., Roch, A., Robic, C., Elst, L. V., Muller, R. N., (2008). Magnetic Iron Oxide Nanoparticles: Synthesis, Stabilization, Vectorization, Physicochemical Characterizations, and Biological Applications, Chemical Reviews, 108, 6, 2064–2110
2. Xu, C., Sun, S., (2013). New Forms of Superparamagnetic Nanoparticles for Biomedical Applications, Advanced Drug Delivery Reviews, 65, 5, 732-743
3. Lu, A. H., Salabas, E. L., Schüth, F., (2007). Magnetic Nanoparticles: Synthesis, Protection, Functionalization, and Application, Angewandte. Chemie - International Edition, 46, 8, 1222–1244

4. Mittal, A. K., Chisti, Y., Banerjee, U. C., (2013). Synthesis of Metallic Nanoparticles using Plant Extracts, Biotechnology Advances, 31, 2, 346–356
5. Saif, S., Tahir, A., Chen, Y., (2016). Green Synthesis of Iron Nanoparticles and Their Environmental Applications and Implications, Nanomaterials, 6, 11, 209
6. Mohanpuria, P., Rana, N. K., Yadav, S. K., (2008). Biosynthesis of Nanoparticles: Technological Concepts and Future Applications," Journal of Nanoparticles Research, 10, 3, 507–517

Pejabat Perpustakaan
Librarian Office

Universiti Teknologi MARA
Cawangan Perak
Kampus Seri Iskandar
32610 Bandar Baru Seri Iskandar,
Perak Darul Ridzuan, MALAYSIA
Tel: (+605) 374 2093/2453 Faks: (+605) 374 2299

UNIVERSITI TEKNOLOGI MARA

Surat kami : 700-KPK (PRP.UP.1/20/1)
Tarikh : 30 Ogos 2022

YBhg. Profesor Ts Sr Dr Md Yusof Hamid, PMP, AMP
Rektor
Universiti Teknologi MARA
Cawangan Perak

YBhg. Profesor

PERMOHONAN KELULUSAN MEMUAT NAIK PENERBITAN UiTM CAWANGAN PERAK MELALUI REPOSITORI INSTITUSI UiTM (IR)

Perkara di atas adalah dirujuk.

2. Pihak Perpustakaan ingin memohon kelulusan YBhg. Profesor untuk membuat imbasan (*digitize*) dan memuat naik semua jenis penerbitan di bawah UiTM Cawangan Perak melalui Repositori Institusi UiTM, PTAR.

3. Tujuan permohonan ini adalah bagi membolehkan akses yang lebih meluas oleh pengguna Perpustakaan terhadap semua bahan penerbitan UiTM melalui laman Web PTAR UiTM Cawangan Perak.

Kelulusan daripada pihak YBhg. Profesor dalam perkara ini amat dihargai.

Sekian, terima kasih.

"WAWASAN KEMAKMURAN BERSAMA 2030"

"BERKHIDMAT UNTUK NEGARA"

Yang benar