PROCEEDINGS OF THE INTERNATIONAL CONFERENCE
NANOMATERIALS: APPLICATIONS AND PROPERTIES
Vol. **2** No 2, 02PCN23(2pp) (2013)

Influence of Ultrasound Treatment on the Properties of Synthetic Magnetite Nanoparticles

N.O. Dudchenko*, A.B. Brik, Yu.V. Kardanets, O.E. Grechanivskyy

M.P. Semenenko Institute of Geochemistry, Mineralogy and Ore Formation of NASU, 34, Palladina prosp, 03680, Kiev, Ukraine

(Received 07 June 2013; published online 01 September 2013)

The paper describes creation of magnetite nanoparticles under ultrasound treatment and investigation of their phase composition and magnetic properties. Magnetite nanoparticles were synthesized via co-precipitation of Fe^{+2} and Fe^{+3} with KOH in aqueous solution at 80°C. It was shown, that ultrasound treatment of solution during the synthesis of magnetite nanoparticles leads to the increasing of size and saturation magnetization obtained nanoparticles. The results of X-ray diffraction measurements show that the synthesized particles consist of magnetite. The size of synthesized magnetite nanoparticles according to X-ray diffraction measurements was approximately 10 nm. Saturation magnetization of synthesized magnetite nanoparticles is rather high (37 A*m²/kg). Synthesized magnetite nanoparticles are promising for different medical-biological applications.

Keywords: nanoparticles, magnetite, magnetic properties.

PACS numbers: 75.50._y, 75.75._a, 78.67.Bf, 81.07._b

1. INTRODUCTION

During last decade magnetite nanoparticles are widely used in different biological and medical applications such as magnetic resonance imaging contrast enhancement, tissue repair, immunoassay, detoxification of biological fluids, hyperthermia, drug delivery and cell separation, etc [1, 2]. So, many different methods for synthetic magnetic nanoparticles creation were developed. Among them: co-precipitation method, microemulsions, sol–gel syntheses, sonochemical reactions, hydrothermal reactions, hydrolysis and thermolysis of precursors, flow injection and electrospray syntheses and others [3]. Many factors could influence properties of created nanoparticles (pH, temperature, etc.).

We report here the method of magnetite nanoparticles creation under ultrasound treatment and investigation of the properties of created magnetite nanoparticles.

2. MATERIALS AND METHODS

2.1 Materials

All reagents used in the synthesis were commercial products and were used without further purification unless otherwise indicated. These were potassium hydroxide, hydrochloric acid, ferrous sulfate hexahydrate, ferric chloride heptahydrate, all from Sigma-Aldrich (St Louis, MO).

Magnetite nanoparticles were prepared by co-precipitation of ferrous sulfate hexahydrate and ferric chloride heptahydrate with potassium hydroxide in aqueous solution at 80°C during 1 hour. In order to verify whether ultrasound treatment affect the properties of synthetic nanoparticles, the same synthesis was carried-out by ultrasound treatment (P=16 W) of the reaction solution.

2.2 Methods

The main methods of the investigation were X-ray diffraction (XRD) and magnetometry method.

3. RESULTS AND DISCUSSION

Analysis of XRD data allow to identify the phase composition and particle size of synthesized nanoparticles. Six characteristic peaks for magnetite in XRD pattern (Fig. 1) were observed for magnetic nanoparticles. These peaks reveal that the resultant particles were magnetite.

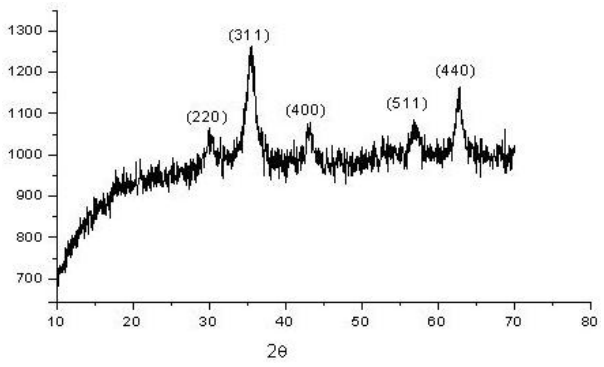

Fig. 1 – XRD pattern of the synthesized magnetite nanoparticles.

The relative crystalline size of synthesized magnetite nanoparticles was determined from the width of the (311) XRD peak at half height using the Scherrer equation (3.1):

$$D = K\lambda / b\cos\theta$$

where λ the X-ray wavelength (1,54051Å), b the width of the XRD peak at half height (radian), K a shape factor (about 0.9 for magnetite), and θ the angle of the reference peak [4]. The determined crystalline size was 6,3±0,1 nm for the magnetite nanoparticles, obtained without ultrasound treatment and 10,5±0,1 nm for the magnetite nanoparticles, obtained in the presence of

*ndudchenko@igmof.gov.ua

ultrasound treatment.

Also, the lattice constant was calculated for the synthesized nanoparticles, using the ratios for cubic crystals [5]:

$$\frac{1}{d_{hkl}^2} = \frac{h^2 + k^2 + l^2}{a^2}$$

where a the lattice constant of cubic crystal, d the interplanar distance. It was shown, that the calculated parameter for the sample, obtained in the presence of ultrasound treatment (a = 8,392) was close to that of magnetite (a = 8,397).

The magnetic properties of the magnetic particles were verified by magnetization curve measurements (Fig. 2).

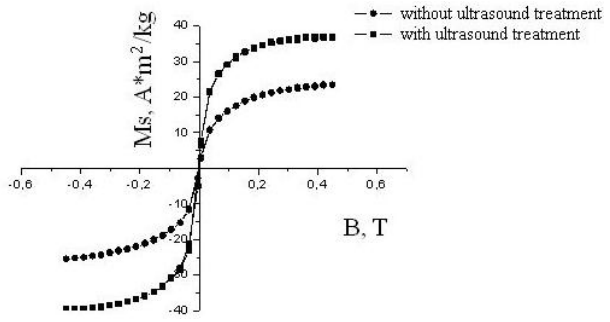

Fig. 2 – Magnetization curves of magnetite nanoparticles, synthesized with and without ultrasound treatment.

It was shown, that saturation magnetization of nanoparticles synthesized in the presence of ultrasound treatment was higher (37 A*m²/kg) then the saturation magnetization of nanoparticles synthesized without ultrasound treatment (24 A*m²/kg). This saturation magnetization of magnetic particles makes them rather susceptible to magnetic field. The shape of magnetization curve is extremely narrow, that indicates superparamagnetic state of obtained magnetite nanoparticles.

So, one could conclude that ultrasound treatment during the synthesis of magnetite nanoparticles affect the properties of obtained nanoparticles.

4. CONCLUSIONS

1. The phase composition of the nanoparticles, synthesized in the presence of ultrasound treatment and without ultrasound treatment is the same (magnetite).

2. Saturation magnetization of nanoparticles synthesized in the presence of ultrasound treatment was higher (37 A*m²/kg) then the same of nanoparticles synthesized without ultrasound treatment (24 A*m²/kg). The saturation magnetization of obtained nanoparticles is rather high and makes them susceptible to magnetic field.

3. Synthesized magnetite nanoparticles are promising for different medical-biological applications.

REFERENCES

1. P. Gould, *Nanotoday* **1**, 34 (2006).
2. A.K. Gupta, M. Gupta, *Biomaterials* **26**, 3995 (2005).
3. N. O. Dudchenko, *Nanosystems, Nanomaterials, Nanotechnologies* **7**, 1027, (2009).
4. Y. Sun, M. Ma, Y. Zhang, N. Gu, *Colloids Surf. A* **245** 15, (2004).
5. Cornell R.M., Schwertmann U. *The Iron Oxides. Structure, properties, reactions, occurences and uses* (Wiley: 2003).