X-4

Preparation of Nanometric $Cu_xFe_{1-x}O{\cdot}Fe_2O_3$ magnetic particles for Treatment of Tumor

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I. Introduction

Recently, water-based ferrofluids established by Shimoizak were widely applied in biomedical application such as cells separation, drug delivery, cancer's diagnosis and treatment, etc. The copper[67] is effective in tumor therapy because it is a β-emitting radionuclide with the energy of 0.577 MeV and the half life of 61.83 h. Also, ^{67}Cu radiates the γ-line of 150 keV close to the energy of ^{99m}Tc which is often used in tumor diagnosis so that the radiation may be imaged easily with γ-camera [1]. Furthermore, the radii, electonegativity and valence of Cu^{2+} are quite similar to the Fe^{2+}, so the copper can substitute Fe^{2+} in the Fe_3O_4 crystal according to Hume-Rothery rule [2]. In this study, radioactive copper substitute Fe^{2+} in Fe_3O_4 crystal to produce radioactive magnetic fluids that offers a high potential for treatment of tumor.

II. Experimental

The magnetic fluid was prepared by precipitation method [3]. In the first step, the mixed solution of $CuCl_2{\cdot}2H_2O$, $FeCl_2{\cdot}4H_2O$, and $FeCl_3{\cdot}6H_2O$ was heated to 80℃ with continuous stirring, then alkali was excessively added. The coprecipitate was coated with decanoic acid. This step involves following reaction:

$$xCuCl_2+(1-x)FeCl_2+2FeCl_3+8OH^- \longrightarrow Cu_xFe_{1-x}O{\cdot}Fe_2O_3+8Cl^-+4H_2O$$

In the second step, the precipitates was washed with acetone and water, and then they were coated with nonanoic acid which was dissolved at 60℃ in 60 ml water.

III. Results and Discussion

3.1) Magnetization of magnetic particles

Figure 1 shows that magnetization of the particles decreases with increasing copper contents. The reason is that the diamagnetic copper element substitutes Fe^{2+} position in Fe_3O_4 crystal.

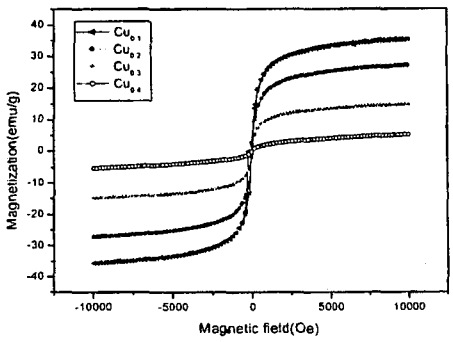

Fig. 1. Magnetization curves of particles

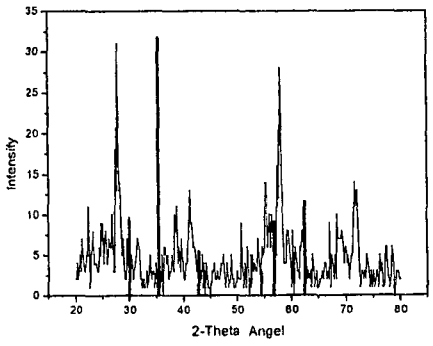

Fig. 2. X-ray diffraction pattern

3.2) XRD analysis of the magnetic particles

Figure 2 shows the XRD pattern of the magnetic particle samples, in which the red line is the standard diffraction pattern of magnetite. The molar concentration of copper is 10% in this sample. The analysis revealed that the crystal structure has changed after introducing the copper element into the magnetite.

3.3) Effect of precipitator on characteristics of magnetic fluid

Both ammonia water and sodium hydroxide have been used as precipitator to prepare the magnetic particles. Figure 3 shows the precipitator had little influence on the concentration of magnetic fluids but influenced markedly on the magnetization and the substitutional amount of copper element.

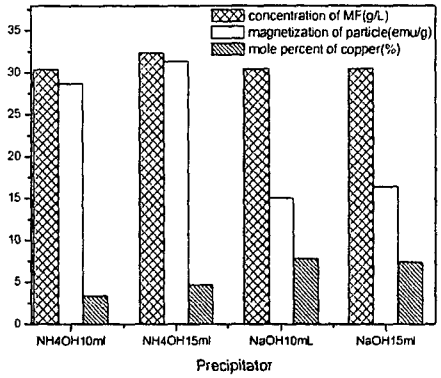

Fig. 3. Magnetization of particle and concentration of magnetic fluid prepared using different precipitators.

Fig. 4. TEM micrograph of $Cu_xFe_{1-x}O{\cdot}Fe_2O_3$ particles

3.4) Size of magnetic particle

As shown in Fig.4, the magnetic fluids consist almost of perfect single particles with 10 nm mean diameter, even though their morphology is somewhat irregularly shaped form oval to sphere. Such fine particles have active chemical and physical character different from the bulk, such as stronger absorbability and easier oxidation. Also, fine particles can be well dispersed in water.

IV. Conclusions

The copper was coprecipitated with the elements of Fe^{2+} and Fe^{3+}. The copper iron substituted partly Fe^{2+} in the Fe_3O_4 crystallite and the crystal structure was changed. The magnetic particles of $Fe_xCu_{1-x}O{\cdot}Fe_2O_3$ were prepared with mean diameter of about 10 nm by the chemical coprecipitation. The magnetization of the particles decreased with increasing substitution amounts of diamagnetic copper element.

V. References

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