

## Synthesis and Characterization of Composite Nanoparticles for Imaging†

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Dual functions of magnetic and fluorescent properties were created in composite particles that incorporated magnetite ( $\text{Fe}_3\text{O}_4$ ) nanoparticles (MNPs) as particle cores and fluorescent pyrene in particle shells of poly lactate-co-glycolide (PLGA). The  $\text{Fe}_3\text{O}_4$  nanoparticles were prepared by co-precipitation method and surface modified with oleic acid. MNPs were prepared by co-precipitating iron(II) and iron(III) in alkaline solution and then treating under hydrothermal conditions. Surface modification of magnetic nanoparticles by organic surfactants is known to provide them with solubility in organic solvents. The structural, magnetic and adsorption properties of iron oxide nanoparticles are derived in the presence of oleic acid as the capping agents. The surfactants provide them with excellent stability and solubility in organic solvents like toluene or chloroform. The presence of capping agents or high reaction temperatures favours the formation of smaller nanoparticles. The adsorption of the surfactants (chemisorption) was identified with FT-IR spectroscopy. Then, the magnetite particles were coated with the pyrene/PLGA by emulsion-diffusion method. The composite particles prepared had both magnetic and fluorescent properties. The present work proposes a method for synthesizing the dually functional particles, which have a core-shell structure. The particles in this work consist of an inner core of  $\text{Fe}_3\text{O}_4$  nanoparticles and a hybrid shell of polymer and organic dye. A basic technique of this work is polymer coating on  $\text{Fe}_3\text{O}_4$  nanoparticles. The prepared nanoparticles were characterized by scanning electron microscopy, particle size analyzer, X-ray diffraction, Gauss meter, Fourier transform infrared spectroscopy and fluorescence spectroscopy. The nanoparticles could generate singlet oxygen to cause remarkable photodynamic antitumor effects. These suggest that composite nanoparticles have great potential in diagnostic magnetic resonance imaging.

**Key Words:** Magnetic nanoparticles, Magnetic and fluorescent property, Core-shell structure.

### INTRODUCTION

Nanoparticles are mesostructures with some unique properties compared to bulk materials on one hand and atomic or molecular structures on the other. Compared to the bulk materials with constant physical and chemical properties regardless of their sizes, the nanoparticles have size-dependent properties for example, super paramagnetism in magnetic nanoparticles.

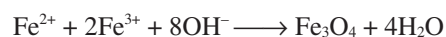
Composite microspheres with dual functions of magnetic and fluorescent properties have recently received much attention in various fields such as cell labeling, biosensing and in the drug delivery system<sup>1-6</sup>.

Magnetite ( $\text{Fe}_3\text{O}_4$ ) is a common ferrite that has a cubic inverse spinel structure and exhibits unique electric and magnetic properties based on the transfer of electrons between  $\text{Fe}^{2+}$  and  $\text{Fe}^{3+}$  in the octahedral sites. When the diameter of  $\text{Fe}_3\text{O}_4$  particles is in nano scale,  $\text{Fe}_3\text{O}_4$  regarded as single magnetic domain has the superparamagnetic property<sup>7,8</sup>.

### EXPERIMENTAL

All materials were purchased from Merck except PLGA which was purchased from Lakeshore. Pluronic F-127 was purchased from Sigma Aldrich. All the materials were used without further purification.

**Synthesis of superparamagnetic iron oxide nanoparticles (SPION):** Chemical reaction of  $\text{Fe}_3\text{O}_4$  precipitation is given by



According to the results of thermodynamic modeling of this system, a complete precipitation of  $\text{Fe}_3\text{O}_4$  is expected in pH value of 7.5-14 while maintaining a molar ratio of  $\text{Fe}^{2+}/\text{Fe}^{3+} = 1:2$  under a non-oxidizing environment.

**Coating SPIONS with oleic acid:** After the precipitation of SPIONS, oleic acid (40 %, w/w of formed magnetite) was added dropwise during 10 min and the flask was heated for 0.5 h. After drying, a black powder was obtained.

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**FTIR spectrum of uncoated SPIONs:** The presence of peak at 1589 is attributed to the carboxylate unit vibration modes, shows that oleic acid is bound through the carboxylate anions (Fig. 5).

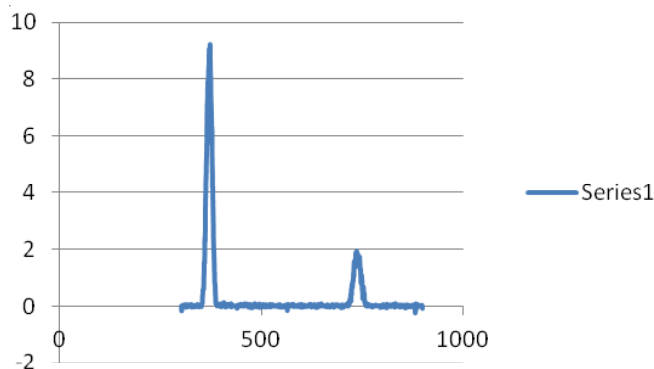


Fig. 4. Fluorescent spectra for pyrene embedded SPIONS

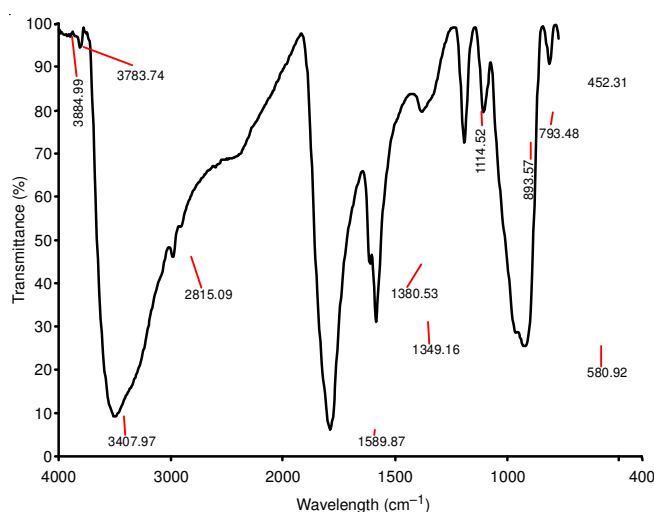


Fig.5 FTIR of oleic acid coated SPIONS

**UV-Visible absorbance analysis:** UV-VIS absorbance of SPIONS using Na (Fig. 6).

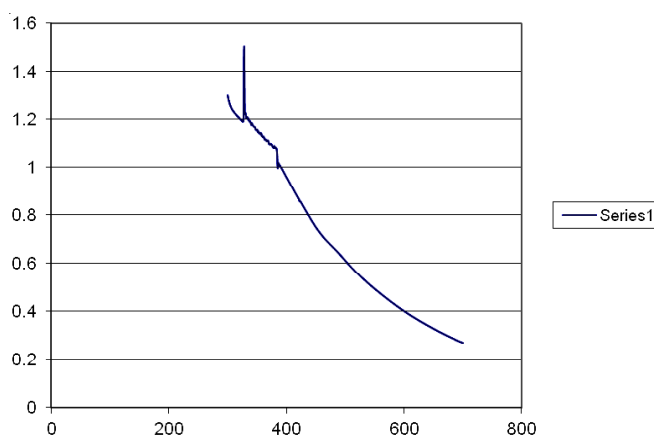


Fig. 6. UV-Visible spectrum of SPIONS

Superparamagnetic iron oxide nanoparticles were prepared by the co-precipitation method from ferrous and ferric ion solutions with a molecular ratio of 1:2. The uncoated SPION prepared by the controlled chemical co precipitation process can be expected as magnetite. Based on the results from XRD, it can be clearly seen that the particles do not show sharp diffraction peaks corresponding to extended crystalline structure. Instead, a broad band appears in each spectrum.

### Conclusion

In summary, innovations in nanoparticle technology over the last several years have provided many benefits to imaging. Composite particles with a magnetic core and fluorescent polymer shell was prepared by emulsion-diffusion polymerization in the presence of pyrene. The fluorescent spectra showed there is no interference between the magnetic component in the core and the fluorescent particle in the shell. The amount of pyrene added to the system was 10 mg. Thus, these magnetic nanoparticles can be very interesting for magnetic resonance imaging to control the drug delivery localization after a local administration in tumors yielding a better treatment efficacy and lesser treatment induced side effects.

### REFERENCES

1. K.T. Thurn, E.M.B. Brown, A. Wu, S. Vogt, B. Lai, J. Maser, T. Paunesku and G.E. Woloschak, *Nanoscale Res. Lett.*, **2**, 430 (2007).
2. S. Liang, Y.X. Wang, J.F. Yu, C.F. Zhang, J.Y. Xia and D.Z. Yin, *J. Mater. Sci: Mater. Med.*, **18**, 2297 (2007).
3. Y.Q. Ge, Y. Zhang, S.Y. He, F. Nie, G.J. Teng and N. Gu, *Nanoscale Res. Lett.*, **4**, 287 (2009).
4. G.X. Zhang, Y.B. Liu, C.F. Zhang, W.Q. Hu, W.B. Xu, Z. Li, Zheng, S. Liang, J.Q. Cao and Y.X. Wang, *J. Nanopart. Res.*, **11**, 441 (2009).
5. D. Nagao, M. Yokoyama, N. Yamauchi, H. Matsumoto, Y. Kobayashi and M. Konno, *Colloid Polym. Sci.*, **286**, 959 (2008).
6. Z.-L. Chen, Y. Sun, P. Huang, X.-X. Yang and X.-P. Zhou, *J. Nanopart. Res.*, **4**, 400 (2009).
7. Y.-Y. Liang, L.M. Zhang, W. Li and R.-F. Chen, Ru-Fu, *Colloid Polym. Sci.*, **285**, 1193 (2007).
8. P. Dallas, A. Bourlino, D. Niarchos and D. Petridis, *J. Mater. Sci.*, **42**, 4996 (2007).