Synthesis of SiO_2-Coated magnetic nanoparticles as a new Adsorbent for the Removal of Nickel Ion from Aqueous Solution

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Abstract
Magnetic Fe_3O_4@SiO_2 nanoparticles were prepared via two steps -- hydrothermal method for the synthesis of Fe_3O_4 core followed by carbonation decomposition of Na_2SiO_3 depositing SiO_2 on the surface of magnetic core. The composite particles with core-shell structure were characterized by XRD, SEM, TG and FTIR. Factors affecting adsorption, such as, initial ion concentration, pH and contact time were investigated. Langmuir and the Freundlich adsorption isotherms were selected to explicate the interaction of the nickel ion and magnetic adsorbant. The characteristic parameters for each isotherm have been determined. Adsorption kinetic followed pseudo-second-order reaction kinetics.

Keywords
Adsorption; Freundlich adsorption model; kinetics; SiO_2-Coated magnetic nanoparticles; nickel ion

INTRODUCTION

Many natural waters are polluted by metal ions as a result of their release by industrial plants or mining activities. Metal ions do not easily get converted into harmless end products and so exposure to heavy metals, even at trace level, is believed to be a risk for human beings [Peng et al., 2004]. Thus, how to effectively and deeply remove them from water system is still a very important but still challenging task. People are increasingly interested in studying different approaches to removal them from waste water.

In this study, a novel magnetic nano adsorbent of Fe_3O_4@SiO_2 were synthesized and characterized. The adsorption properties of the as-obtained composite were investigated using nickel ion as an adsorbate.

EXPERIMENTAL

Preparation of Fe_3O_4@SiO_2 nanoparticles

Magnetic Fe_3O_4 core was synthesized following the literature [Liu et al. 2014]. The as-synthesized Fe_3O_4 particles were dispersed to a certain concentration of Na_2SiO_3 solution. CO_2 was blown into the mixture solution until the pH value reached 9. Stirring was kept during the whole procedure of carbonation decomposition. The products were washed by deionized water and ethanol twice.

Characterization of the synthesized materials

X-ray diffraction(XRD) patterns were recorded on Rigaku D/MAX 2500 diffractometer. Scanning electron microscopy (SEM) was performed on Zeiss Ultra Plus model. Magnetization measurement(VSM) was using Lakeshore Model 7407 Vibrating Sample Magnetometer at room temperature. Thermogravimetric analysis (TG) was performed on TA Instruments SDT Q600. The infrared spectroscopy measurements (FT-IR) were performed on Perkin–Elmer Spectrum 100.

Adsorption experiments

For equilibrium experiment, 100 mg of Fe_3O_4@SiO_2 nanoparticles was added into 30 mL of Ni^{2+} solution at a series of known initial concentrations (C_0). After stirring the samples for 24 h with a agitator, the magnetic particles were separated using a magnet from the solution.

The amount of the adsorbed pollutants to the magnetic adsorbents was calculated with Eq. (1)

$$q_e = \frac{(C_0 - C_e)}{m} \times V \quad (1)$$

For kinetic experiments, Zero time was taken when 200 mg of Fe_3O_4@SiO_2 nanoparticles was

added into 200 mL of Ni^{2+} solution with different initial concentrations. The solution was stirred and taken at appropriate time intervals.

RESULTS AND DISCUSSION

Characterization of adsorbent

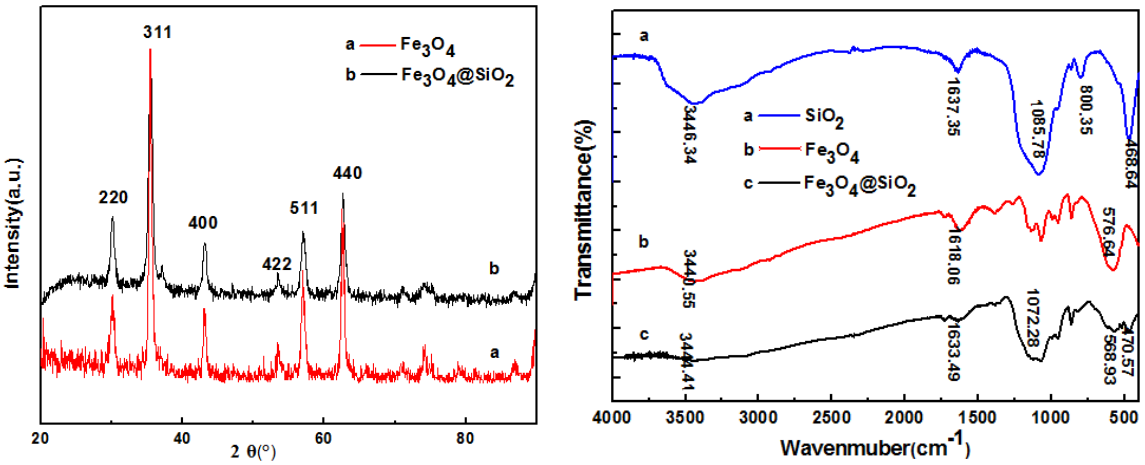

Figure 1. Fig.1 The XRD and FT-IR contrast figure of Fe_3O_4 and $Fe_3O_4@SiO_2$

XRD and IR spectra curve were exhibited in Figure 1. In IR spectra, the characteristic functional groups of Si-O-SiO can be found in $Fe_3O_4@SiO_2$ particles. In xrd curves, the magnetic core had the structure of Fe_3O_4 was proved.

Adsorption of Ni^{2+}

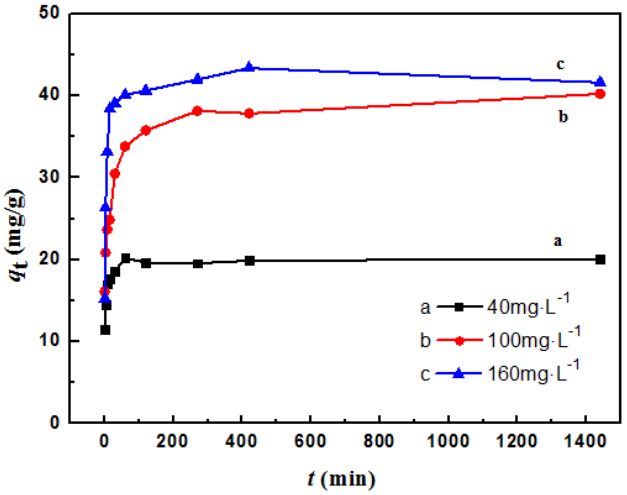

Figure 2. Ni^{2+} adsorption kinetics on nanomagnetic $Fe_3O_4@SiO_2$ paritcles; initial Ni^{2+} concentrations: (a) 40 mg/l, (b) 100 mg/l, (c) 160 mg/l

Adsorption dynamics of Ni^{2+} by nanomagnetic particles of $Fe_3O_4@SiO_2$ were investigated at different initial concentrations of Ni^{2+} and the results are shown in Fig.2.

CONCLUSION

$Fe_3O_4@SiO_2$ Nanoparticles can be synthesized. The particle has the ability of adsorption to metal ion.

REFERENCES

Peng, S.H., Wang, W.X., Li, X.D., Yen, Y.F.(2004) Metal partitioning in river sediments measured by sequential extraction and biomimetic approaches. Chemosphere, 57, 839–851.

Liu, Y., Chi, Y., Shan, S., Yin, J., Luo, J. & Zhong, C. (2014) Characterization of magnetic NiFe nanoparticles with controlled bimetallic composition. Journal of Alloys and Compounds, 587, 260–266.