論文 / 著書情報
Article / Book Information

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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	ライフエンジニアリング　系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of (Engineering)
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要旨（和文 2000 字程度）
Thesis Summary（approx.800 English Words ）

This is a brief summary of the thesis entitled "Study on magnetic gels based on iron oxide nanoparticles embedded in chemically responsive chitosan hydrogel". The purpose of this study is to demonstrate magnetic chemical sensing using magnetic gels composed of iron oxide nanoparticles (FeOx NPs) embedded in chitosan hydrogel (CH). Magnetic detection of external chemical stimuli was successfully demonstrated by coupling the chemical responsiveness of CH to the FeOx NPs' magnetic property. Magnetic relaxation of the NPs in the magnetic gels were studied by measuring the AC magnetic susceptibility (ACMS) using a PPMS device and coil-FRA device built-in the laboratory. Chemical responsiveness of the magnetic gels were evaluated by measuring the swelling ratio (SR) and Feret diameters (D_F)at different pH and ionic concentrations. For the magnetic chemical detection, changes in the magnetic relaxation of the magnetic gels at different pH and ionic concentrations were demonstrated. Analytical calculations of the magnetic relaxation of the magnetic gels were also presented based on the experimental data. Good correlation between SR and χ'' peak frequencies for both pH and ionic magnetic sensing were also established. Moreover, the study also successfully synthesized different forms of FeOx-CH magnetic gels to cover different areas applications such as transdermal to injectable magnetic gel application. The synthesized samples were bulk FeOx-CH with ~20 mm size, FeOx-CH macrobeads with ~3 mm size, and M300-CH microbeads with ~ 100- 300 μm size. Synthesis optimization of each sample, and characterization were also shown. The thesis has five chapters and are outlined as follows:

In chapter 1, a general background about nanoparticles and their broad applications have been discussed. In particular, an introduction about the magnetic nanoparticles, which is a special type of nanoparticle, have also been discussed. Specifically, basic magnetism about magnetic nanoparticles, as well as the theoretical framework of the dynamics of magnetic nanoparticles in AC fields were discussed. Related concepts about the stimuli responsive polymers and their potential application to magnetic based sensing were also described. Previous studies on FeOx-CH composite magnetic gel were also discussed. Lastly, the objectives, motivation and significance of this study have also been discussed.

In chapter 2, the basic experimental methods used in the study was discussed. These include the synthesis of the three magnetic gels via in-situ coprecipitation and blending method. The working principles of the main characterization tools used to characterize the samples were also included in this chapter.

In chapter 3, a study on the effect of the different pH and ionic strength conditions on bulk FeOx-CH bulk was discussed. Bulk FeOx-CH was successfully synthesized using in-situ coprecipitation method, and was characterized. SR of the bulk FeOx-CH increases as the pH values decreases due to the protonation of the CH amine groups at low pH values, Also, SR results of the bulk FeOx-CH was shown to decrease as the ionic concentration increase, and this was explained by considering the amount of water flow into the gel due to the difference in the osmotic pressure inside and outside the CH. The χ'' frequency peak of the ACMS results of the bulk FeOx-CH was determined to shift to higher frequency as the pH decreases. Furthermore, ACMS results was shown to shift to higher frequency when the ionic concentration decreases. This expected shift to higher frequency of the χ'' peak is originated in the swelling of the bulk FeOx-CH that enhances the Brownian relaxation. Good correlation between SR and χ'' peak frequencies for both pH and ionic magnetic sensing were also established. The change of effective viscosity due to the change in pH and change in the ionic concentration were both determined to be of values 8.6% and 6.13 %, respectively.

In chapter 4, a study on the syntheses of the other two magnetic bead gels (FeOx-CH macrobeads and M300-CH microbeads) were discussed. Also included in this chapter is the ACMS result of the FeOx-CH macrobeads, which was shown to have two peaks located at low frequency and high frequency. The core and hydrodynamic sizes of the NPs inside the beads were estimated using the magnetic relaxation equations. Bimodal distributions of the hydrodynamic size were observed due to the bound and clustered, or the unbound NPs inside the M300-CH microbeads. Measured D_F of the M300-CH microbeads was shown to increase as the pH value decreases. Magnetic pH detection using the M300-CH microbeads was also shown, and a shift to lower frequencies were measured as the pH values decreases. This result again successfully demonstrates the coupling of the chemical sensitivity of the chitosan hydrogel to the magnetic property of the FeOx NPs

In chapter 5, a general conclusion from all the studies was presented. Future prospects and potential outlooks were also added.