CHAPTER 1

Introduction

1.1 General

Researchers in materials science are always on a quest to further improve the properties of materials available in our world today. A better understanding of these new materials is sought, so that its characteristics may be tailored to the demands of consumers and the high levels of technology that exist today. One of the most enabling technologies of the 21st century is nanotechnology [1]. It is expected to revolutionize the world we live in by bringing innovations in fields as diverse as aerospace, information management, communications, electronics, materials sciences and medicine.

Magnetic nanoparticles, of which one example was produced in this work, exhibit remarkable and distinctly different properties to its bulk counterpart. Below a certain critical size, magnetic particles behave approximately as a single domain. Under such circumstances, a phenomenon known as superparamagnetism may be observed. Superparamagnetic materials contain uncompensated spins and may be ferro-, ferri-, or antiferromagnetic, which are useful properties. Although the spins may be coupled, thermal energy causes the spins to flip between energy minima, leading to the materials behaving as paramagnets. This means that upon removal of an applied field, no magnetization is retained. These materials are important in specific applications such as magnetic bioseparation and ferrofluids. More detailed information on methods used to produce nanometer-scale magnetic particles and composites as well as their properties are discussed in Chapter 2.

1.2 Objectives

The objectives of this work are as follows:

- To produce magnetic nanostructured iron oxide particles by precipitation from within the confines of a zeolite matrix, and
- To investigate the properties of the prepared samples, specifically its elemental and phase composition, crystal structure, particle morphology, response to an applied magnetic field, and to analyze its pore size and surface area.

1.3 Experimental Approach

A novel technique was used to prepare nanostructured iron oxide particles by using zeolites as the matrix of synthesis. Zeolites are aluminosilicate framework structures containing guest cations to balance the molecule. In this work, a particular type of zeolite, the type Y zeolite which contains Na cations (zeolite Na-Y), was used.

By replacing the sodium cations with ferrous ions through an ion exchange procedure, a zeolite paste containing ferrous ions (z-Fe) was obtained. This was followed by a precipitation process utilizing a combination of heat and the action of NaOH and H_2O_2, to produce iron oxide within the zeolite confines, which was termed as the ZIO (zeolite-iron oxide) system. A flow-chart of the study is presented in Fig. 1.2 while the experimental method used is explained in Chapter 3.

The methods that were used to characterize the product are expounded in Chapter 4. The characterization techniques include X-ray diffractometry (XRD), scanning electron microscopy (SEM), transmission electron microscopy (TEM), alternating gradient magnetometry (AGM), energy dispersive x-ray spectrometry (EDS) and gas adsorption desorption.

The results that were obtained from those characterization methods were then analyzed and discussed in Chapter 5. Several interesting conclusions were then summed up and presented in Chapter 6.

1.4 Conclusion

The potential value of the work presented here could be very useful in the fields of medicine and engineering. It also provides material for further studies into a fascinating field of science which deals with structures too small to be seen with the naked eye and phenomena which are still being explored and have not been fully understood by materials scientists.

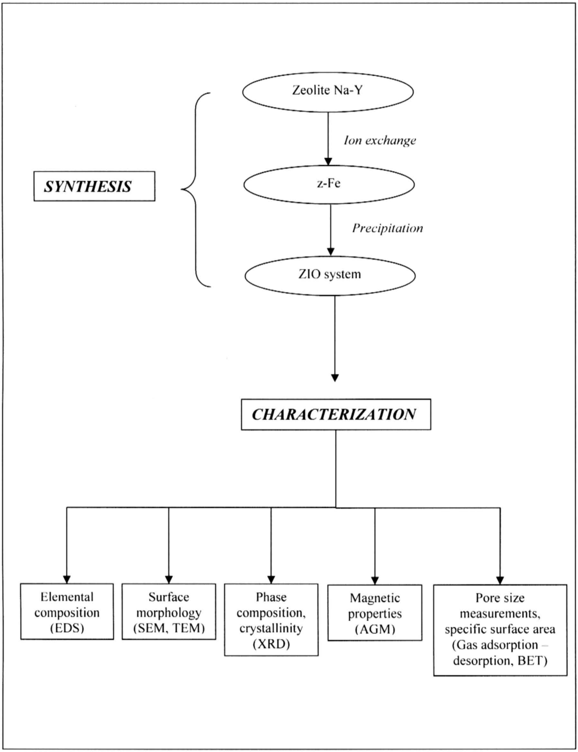

Fig. 1.1: The flow-chart of the study