CHAPTER I
INTRODUCTION

Magnetic nanoparticles can exhibit many unique properties such as chemical, electrical, and magnetic properties which are advantageous for using in a variety of the applications. There are many types of magnetic particles, and one of the most important groups is iron oxides generally existed in forms of hematite (α-Fe_2O_3), magnetite (Fe_3O_4) and maghemite (γ-Fe_2O_3), which are utilized for the different specific applications (Teja and Koh 2009). Hematite (α-Fe_2O_3), which is the most stable iron oxide under the ambient conditions, has an increasing interest in the fields of nanoscience and nanotechnology because of its potential applications in inorganic pigments (Cornell and Schwertmann 1996), catalysts (Brown *et al.* 1998), gas and humidity sensors (Chauhan *et al.* 1999; Huo *et al.* 2000), photoanode for photoelectrochemical cells (Watanabe and Kozuka, 2003), photoelectrolysis reactors (Kay *et al.* 2006), water treatment (Cao and Zhu 2008), and lithium ion batteries (Wu *et al.* 2008).

The preparation method is a key factor in determining the particle size, the morphology, the particle size distribution, the surface chemistry and therefore the properties of the final products. Up to now, a variety of methods have been reported in the literatures on the preparation of hematite nanoparticles, such as the hydrolysis method (Raming *et al.* 2002; Music *et al.* 2003), the hydrothermal treatment (Lian *et al.* 2004; Zhang *et al.* 2008; Sun *et al.* 2010), the chemical precipitation method (Liu *et al.* 2005, 2007), the solvothermal process (Lu *et al.* 2006), the facile solution route (Min *et al.* 2007), the microemulsion method (Bumajdad *et al.* 2007; Han *et al.* 2011), and etc. In comparison of all methods, the chemical precipitation method is probably the simplest and the most effective as well as of a relatively low cost without requirement of the special equipment or any additives. Recently, a simple chemical precipitation system via the catalytic phase transformation process has been successfully employed to synthesize hematite (α-Fe_2O_3) nanoparticles (Liu *et al.* 2007). The experimental results have revealed that this method has several advantages, such as can use a high reactant concentration, require a very short reaction time as well as a low reaction temperature, and get a high purity products of hematite nanoparticles.

Controlling of the particle size and morphology is considerably important in the preparation of hematite nanoparticles, because properties and applications of the ultrafine particles depend drastically on the particle size, morphology and monodispersibility of the products (Diamandescu *et al.* 1999). Until now, several researches have been focused on the study of the factors affecting the particle size and shape of the synthesized hematite nanoparticles. Those parameters have been reported in the literatures, such as the reactant concentration, the solution pH, the reaction time and temperature, the ionic strength, the anions, the surfactant, and the nature of iron salts (Cornell and Giovanoli 1985; Schwertmann *et al.* 1999; Lu *et al.* 2006; Liu *et al.* 2007; Min *et al.* 2007; Zhang *et al.* 2008; Kandori *et al.* 2008; Sun *et al.* 2010). However, in some cases such as using the surfactants or anions, the additional steps of removal the excess amount of chemicals used are required and the products obtained may have the lower properties compared to using the simple method.

In this work, a simple chemical precipitation method has been employed to directly synthesize hematite (α-Fe_2O_3) nanoparticles, with trace amounts of Fe(II) as a catalyst, under nitrogen atmosphere. The influences of the synthesis conditions, consisting of the precursor concentration (C), the solution pH, the amount of catalyst ($n_{Fe(II)}/n_{Fe(III)}$), the ionic strength (I), the reaction temperature and the reaction time on particle size and morphology of the synthesized hematite have been systematically investigated. Moreover, the electrical conductivity and magnetic properties depending on the particle size and shape of the synthesized hematite are also reported here.