

# Preparation and characterization of $Fe_2O_3$ nanoparticles

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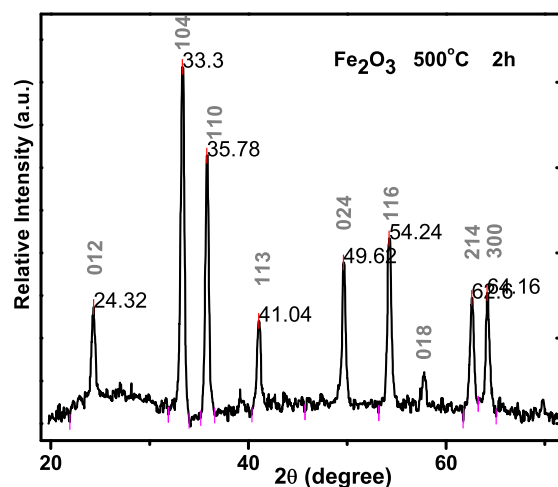
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**Abstract.** Nano particles hematite ( $Fe_2O_3$ ) with good crystallinity were prepared by Pechini method. Hematite ( $Fe_2O_3$ ) has emerged as a promising photo-electrode material due to its significant light absorption, chemical stability in aqueous environments, and ample abundance. Photoelectrochemical cells offer the ability to convert electromagnetic energy from our largest renewable source, the Sun, to stored chemical energy through the splitting of water into molecular oxygen and hydrogen. The structure and the size of the  $Fe_2O_3$  nanoparticles were analyzed by SEM and XRD. The UV-Vis optical absorption of the samples was also investigated. These methods help to define the obstacles that remain to be surmounted in order to fully exploit the potential of this promising material for solar energy conversion.

## 1. Introduction

Many industrial dyes are toxic and carcinogenic. The organic dyes present in industrial wastewater often pose significant threats against human health and environmental pollution control. Therefore, it is important to remove organic dyes from wastewater. However, wastewater exhibits stable behavior under harsh conditions and resists biodegradation, making it difficult to remove organic dyes easily [1, 2, 3, 4, 5, 6, 7, 8]. Many wastewater treatment methods have been explored for example the adsorption technique, but this method is now becoming unpopular because it is expensive, and the adsorbent has low recyclability. Photocatalysis is an environment friendly process that utilizes irradiation energy for catalytic reactions. Hence, photocatalytic technology has been widely investigated for applications to the decomposition of pollutants. Researchers are especially interested in developing photocatalysts that can extend the absorption wavelength into the visible-light region [1, 2, 9, 10]. Hematites ( $Fe_2O_3$ ) are minerals belonging to the group of iron-oxide minerals; they have a hexagonal structure and exhibit paramagnetic behavior. Moreover, they show strong catalytic activity, widely and easily available, and are extremely environment friendly. In particular, hematite may be a promising candidate for visible-light photocatalysis it can absorb visible light, collect up to 45% of solar-spectrum energy, and is one of the cheapest semiconductor materials available [2, 9, 10, 13]. In this study, hematite nanoparticles are employed for the removal of Rhodamine B (RhB) dye by photocatalytic decomposition. RhB is nonbiodegradable and extensively used in the industry; therefore, it is selected as the model contaminant.





**Figure 1.** X-ray powder diffraction patterns of  $Fe_2O_3$  prepared by the polymeric precursor method at 500 C.

## 2. Experimental

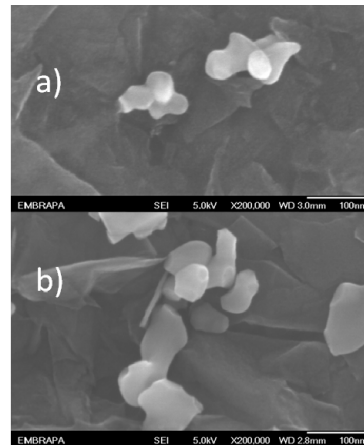
The polymeric precursor method (pechini) is based on the polymerization of metallic citrate by ethylene glycol[11, 12]. A hydrocarboxylic acid such as citric acid is normally used to chelate cations in an aqueous solution. The method is based on an intensive blending of positive ions in a solution, controlled transformation of the solution into a polymer gel, removal of the polymer matrix and development of an oxide precursor with a high degree of homogeneity. During the synthetic process, metal salts or alkoxides are introduced into a citric acid solution with ethylene glycol. The formation of citric complexes is believed to balance the difference in individual behavior of ions in solution, which results in a better distribution of ions and prevents the separation of components at later process stages.

## 3. Results and discussion

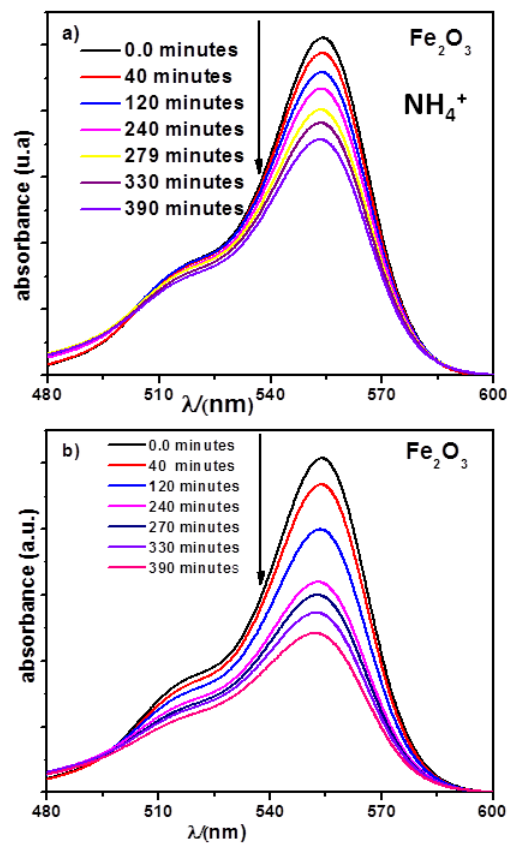
The XRD pattern ( 1 ) of the annealed sample shows the formation of phase pure hematite. shows the XRD pattern of the dark red-brown materials,  $Fe_2O_3$  obtained after 500C. The XRD spectrum of the nanoparticles shown in figure (1) contains nine peaks, which are clearly distinguishable [13]. All of them can be perfectly indexed to rhombohedral  $Fe_2O_3$  in peak position (JCPDS No. 24-0072), space group  $R\bar{3}(148)$ . The spectrum contains no impurity phase. Furthermore, the relative intensity of the (110) diffraction peak is greater than that of polycrystalline  $Fe_2O_3$  power. The fact indicates that the nanoparticles  $Fe_2O_3$  crystals may develop preferentially rather than randomly.

The nanoparticles size was roughly estimated to be about 60 – 70nm from the SEM data, as shown in figure 2 Such a type of unique morphology was observed for the first time for iron oxide with excellent magnetic properties. SEM images also clearly showed the nano-structural homogeneities and remarkably unique neck-structured morphology with average size of 50 – 60nm. Although the neck-structure shaping mechanism is unclear, low temperature during autoclave, long time oxidation and annealing may be responsible to the neck-structure formation. Further study is needed to clarify the mechanism. The figure 2a) shows the sample without addition of  $NH_4$  at a temperature of 500C this presents an irregular shape of the nanoparticles, while figure 2 b) is  $Fe_2O_3$  with addition of  $NH_4$  at a temperature of 500C, these nanoparticles have a more regular basis.

Figure 3 shows the absorption spectra of the RhB solution during different irradiation times.



**Figure 2.** Examples of hematite nanoparticle morphologies: SEM images of hematite prepared by the thermal oxidation method (top image  $Fe_2O_3$ , bottom image  $Fe_2O_3$  with  $NH_4$ ). Temperature 500C.



**Figure 3.** (Color online) Absorption spectra of rhodamine B aqueous solution in presence of nanoparticles of  $Fe_2O_3$ , using  $\lambda = 350nm$  for the illumination. a) with addition of  $NH_4$ , b) without added  $NH_4$ .

In this work, experiments were performed in three different conditions, namely: (1) without catalyst, (2) in the presence of  $Fe_2O_3$  with PH=7 as catalyst and (3) in the presence of

$Fe_2O_3$  nanoparticles as catalyst. UV irradiation of RhB in the absence of hematite catalyst showed almost a negligible variation in the absorbance maximum. However, when hematite nanostructures were used as photocatalyst, the absorption maximum (at  $\lambda = 550$  nm) steadily decreased upon irradiation with UV, without any obvious peak shift of the absorption maximum. This suggests that the complete degradation and decolourization of aqueous RhB was purely due to the catalyst under UV irradiation. This work reports a facile and simple method for the large scale synthesis of hematite nanostructures. The prepared hematite nanostructures showed excellent photocatalytic activity towards Rhodamine B, which was believed to be due to the high surface area. Among these two structures of the hematite, the  $Fe_2O_3$  without  $NH_4$  showed relatively faster photocatalytic activity towards RhB.

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