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# Synthesis of Iron Nanowires and its Magnetic Properties

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**Abstract:** This work reports a solvothermal synthesis of wire-like iron nanostructures. Iron nanowires synthesized in the presence of ethylenediamine. The phase structure and morphology of the as-synthesized sample was extensively characterized by X-ray diffraction, scanning electron microscopy. The results showed that the as-synthesized product was iron with well-crystallized body-centered cubic structure. FESEM result suggests that the prepared iron sample composed of wire-like structure with uniform size distribution. FTIR result indicates that the ethylenediamine molecules are on the surface of the Fe Nanowires. Saturation magnetization value of Fe wire-like nanostructures measured was 196.8 emu/g. Coercive force value of Fe nanowires was 361.6 Oe, relatively higher compared to bulk Fe.
**Keywords:** Synthesis of Iron Nanowires and its Magnetic Properties.

## 1. Introduction

Nanomaterials possess at least one dimension between 1 and 100 nm and large specific surface area (>60$m^2/cm^3$). Nanoparticles exhibit optical, electrical, and chemical characteristics that are not present in bulk materials[1, 2]. Metal nanoparticles are one of the most widely used nanoparticles due to their unique electronic, optical, mechanical, magnetic and chemical properties[3]. Recently, considerable attention has been devoted to the synthesis of magnetic nanomaterials due to their potential applications such as ferrofluids, advanced magnetic materials, catalysts, optical and mechanic devices, high density magnetic recording media and medical diagnostics[4-7]. In particular, Fe, Co and Ni nanostructured materials are receiving increasing attention for a large variety of applications in diverse areas, such as catalysis, high density magnetic recording media, ferrofluids, environmental remediation and medical diagnosis[8-10]. Among these materials, iron nanoparticles are particularly popular owing to their excellent magnetic, catalytic, electrical and mechanical properties, which show various applications including magnetic recording media, catalysis, bioseperation, biosensing, drug delivery, MRI contrast enhancement and environmental remediation[11,12]. Several methods are used for fabrication of Fe nanostructures. They include sonochemical synthesis, thermal decomposition process and reverse micelle[13-15]. In this paper, iron nanowires have been synthesized by solvothermal method in the presence of ethylenediamine (EDA). The as-prepared nanowires have been investigated by various characterization techniques.

## 2. Experimental

All agents were of analytical grade and used without further purification. Fe nanostructures were prepared by the following procedure: A 28 ml of ethanol solution of ferrous chloride tetrahydrate (0.01 M) was added into 2.0 ml of hydrated hydrazine (80%) by intensive stirring for 2 h. Then 12 ml of ethylenediamine was added to the above mixture under vigorous stirring for 2 h. The mixture was transferred into Teflon-lined stainless autoclave with a capacity of 42 ml sealed and maintained at 120 °C for 16 h. The autoclave was then allowed to cool from 120 °C to room temperature. The obtained product was washed with distilled water and ethanol by centrifugation for several times and dried in a vacuum at 60 °C for 4 h. The as-prepared product was examined by various characterization techniques.

The X-ray powder diffraction pattern of the sample was carried out with a PANalytical (X'pert PRO) X-ray diffractrometer using CuK$\alpha_1$ radiation ($\lambda$ = 1.5406 Å). FTIR spectrum was recorded from 450 $cm^{-1}$ to 4000 $cm^{-1}$ with a Perkin Elmer spectrometer. SEM image was recorded on FEI Quanta FEG 200 - High Resolution Scanning Electron Microscope.

## 3. Result and Discussion

### 3.1 XRD Analysis

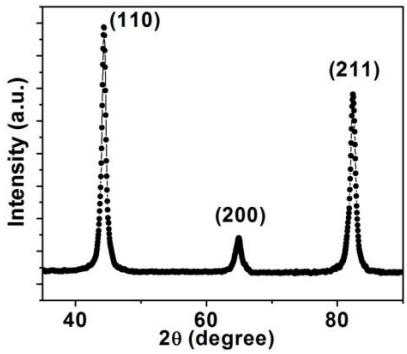


**Fig. 1. XRD pattern of Iron nanowires.**

The crystal structure of the as-prepared product was analyzed by X-ray diffraction. Fig. 1 shows the XRD patterns of the as-synthesized product. The diffraction peak of the sample match well with the Fe body-centered cubic structure (International Centre for Diffraction Data file no. 87-0721, space group *Im3m* (229)). The peaks at 2θ = 44.67°, 65.02° and 82.33° have been assigned to (110), (200) and (211) planes of Fe respectively. No characteristics peaks of impurities, such as FeO, $Fe_3O_4$ can be detected, suggesting that the pure metallic Fe product could be obtained under the current synthesis conditions and the Fe nanostructures were very stable in ambient atmosphere. The crystallite size are found to be 35 nm for wire-like Fe nanostructures respectively by Debye-Scherer equation ($D = 0.89\,\lambda/(\beta\,cos\theta)$).

### 3.2 SEM Image

The morphology of the as-synthesized product was examined by FESEM. Fig. 2 shows the SEM image of the Fe product synthesized at 120 °C for 16 h, it can be seen clearly that the sample consists of wire-like morphology with a diameter of 30 nm - 40 nm.

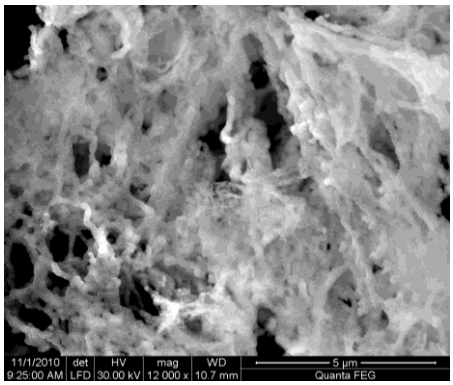


**Fig. 2. SEM image of Iron nanowires.**

### 3.3 FTIR Analysis

FTIR technique is applied to detect the surface state of the samples. Figure 3 shows the FTIR spectrum of the as-prepared Fe product. The peaks observed at 1460, 2846 and 2927 $cm^{-1}$ are assigned to asymmetric bending, symmetric stretching and asymmetric stretching vibrations of the $-CH_2$ respectively. The peak at 1341 $cm^{-1}$ can be assigned to $CH_3$ symmetric stretching and the peak at 1631 $cm^{-1}$ is assigned to N-H deformation vibration, indicating the presence of EDA molecules on the surface of the Fe product.

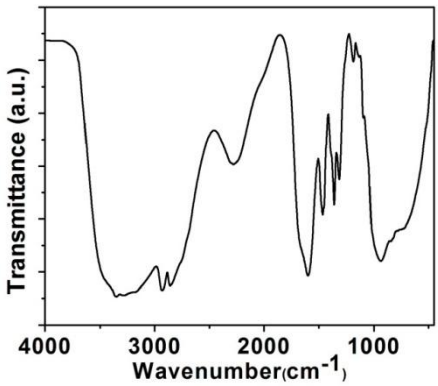


**Fig. 3. FTIR spectrum of Iron nanowires.**

### 3.4 magnetic Measurements

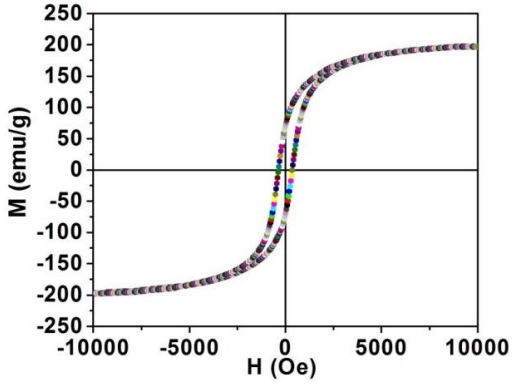


**Fig. 4. Hysteresis loop of Iron nanowires.**

The magnetic property of the as-prepared nanowires was measured by recording the hysteresis, which is shown in Figure 4. The value of saturation magnetization for nanowires is 196.8 emu/g and the value of coercive force is 361.6 Oe. The saturation magnetization value of the synthesized nanowires was found to be lower than that of bulk Fe ($M_s$ = 218 emu/g). However, compared with the corresponding bulk Fe (0.9 Oe), the

$H_c$ of Fe nanowires clearly show significant enhancement. This enhancement can likely be attributed to their shape anisotropy [16].

## 4. Conclusion

Wire-like iron nanostructures have been prepared through solvothermal synthesis in the presence of ethylenediamine. X-ray diffraction result revealed that the as-synthesized product was well-crystallized iron with body-centered cubic structure. FESEM image showed that the prepared iron sample consisted of wire-like structure with homogeneous size distribution. The magnetic measurements revealed that the synthesized iron nanowire has ferromagnetic character with saturation magnetization and coercive force of iron nanowires is 196.8 emu/g and 361.6 Oe.

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