Electricity Generation By Magnetite Nanoparticles In Invented Hydroelectric Cell 2017 Conference Proceddings

Shipra Jain*, Jyoti Shah ,R K Kotnala
SpintronicMaterialandMagneticStandard,CSIR-NationalPhysicalLaboratory,New Delhi, 110012,India
*shiprajain121@gmail.com

Abstract :

Spontaneous water molecule dissociation by lithium substituted magnesium ferrite has been invented as electricity generation devicehydroelectric cell. It is a first kind of device in the world that generates current by few drops of water at room temperature. Electricity has been produced by Hydroelectric Cell (HEC) due to dissociation of water molecule at room temperature.Nanoparticles of magnetite has been synthesized forwater molecule dissociation used in hydroelectric cell.Chemidissociation and physisorption of water molecule by magnetitenanoparticlesproduceshydroniumandhydroxideions.Dissociatedionsarebeingcollectedby Znand Agelectrodesontheopposite faceofcellpellet.Anemfandcurrentisgeneratedbyoxidation/reductionreaction of the dissociated ionsat zinc anode to produce $Zn(OH)_2$and at silver cathode the liberation of $H_2(g)$.X-ray diffractionstudies confirmed the formation ofsingle phase of as synthesized spinelFe_3O_4nanoparticles. Effect of annealing in air on Fe_3O_4 showed phase change to y-Fe_2O_3 at 300°Cand to a-Fe_2O_3at 500°C.Annealing in air leads to grain growth with average size of 250 nm.Elemental analysis by electron diffraction (EDX)technique confirms the presence of Fe and O atoms in Fe_3O_4 sample. The cells when dipped in de-ionized water produce 60mA, 40mA and 4mA current and an emf of 0.9V. The maximum power output of cells showed 54mW, 36mW, 3.6mW respectively.As a result of current generation zinc hydroxide is formed on the zinc sheet which passivates hydroxide ion movement towards zincplate.

Keywords: magnetite nanoparticles, hydroelectric cell,coprecipitation, water molecule dissociation.

1. Introduction

Energy generation in the formofhy drogen gas using water molecules have been produced by various techniques like photo-catalyst, electrochemical process and algae photo synthesisetc. [1-3]. Direct electricity generation by watermolecule dissociation has been recently invented in the form of hydroelectric cell [4]. HEC do not emit harmful by products in the environment. Hydroelectric cell has come as a major breakthrough in electricitygeneration by using only few drops of water. It works on the principle of chemidissociation and physisorption of water molecule by nanoporous lithium magnesium ferrite to produce hydronium and hydroxide ions.Current is produced by collecting ions at Zn and Ag electrodes on the cell pellet. It shows an emf and current by oxidation/reduction reaction of the dissociated ions to produce $Zn(OH)_2$ and H_2 (g) at the respective electrodes.Nanoporous lithium magnesium ferrite used in HEC is highly resistive exhibit high ohmic losses. To improve the cell current, a lower resistive ferrite Fe_3O_4has been investigated for the invented HEC.

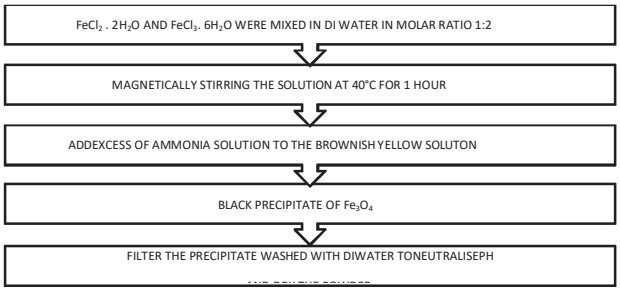
2. Experimental

2.1 Synthesis of Fe_3O_4Nanoparticles

High purity precursors $FeCl_2 .2H_2O$, $FeCl_3.6H_2O$ were taken in the molar ratio 1:2 and mixed in de-ionized water.Nanoparticles ofFe_3O_4were synthesized by coprecipitation techniqueat high pHusing aqueous ammonia solution in accordance withequation(1).

$2FeCl_3+FeCl_2+8NH_4OH‹Fe_3O_4(s)+4H_2O+8NH_4Cl$ (1)

The synthesis mechanism is described in the flow chartbelow. Black precipitate of magnetite is obtained by the conversion of metallic chlorides into metal hydroxides followed by the transformation of hydroxide into ferrite Fe_3O_4[5]. The formed precipitate is magnetically stirred for 1 hour. The pH neutralized powderis vacuumdried at 40ºC for 5 hours.



1.2 Formation of Hydroelectriccell

Dried nanopowder was separated ito three parts S1, S2 and S3.In S1, as synthesized magnetite powder was pressedintoa1×1inch pelletbya hydraulic press with a pressure of 10 ton. Silver comb pattern was screen printed on one face and Zn sheet was pasted on opposite face of the square pelletto form the HEC. Electrical contacts were made from the silver and zinc electrodesrepectively to test the cell. Sample S2 and S3 were prepared by annealingt hepellet sat 300°C and 500°C in air for 2 hours respectively. The cell of pellet S2, S3 were formedusing same conditions asS1.

2.2 Characterizations of the Magnetite nano particles

In order to verify the phase composition of the samples, X-ray diffraction (Bruker AXS D8 advance XRD, Cu-Ka radiation (Z= 1.542 Å)) technique was used to record the data in 2© range20°–80° to analyze the sample phase and the crystal litesize. Micrographs were obtained by Scanning Electron Microscope (EVO MA10) operated at 10 kV to determine the surface morphology of the samplesand an estimated particle size of the as prepared samples .Elemental analysis of the samples was carried out by EDAX(OxfordISIS300EDS) as an attachment to SEM.

3. Results andDiscussion

3.1 X-raydiffraction

The X-ray diffraction pattern of the sample S1, S2 and S3 is shown in figure 1. X-ray diffraction peaks were matched with the standard JCPDS data. Figure 1a showed diffraction peaks at 2©=30.4°,35.42°,43.05°,53.41°,56.94°,62.522° which can be indexed to (220), (311), (400), (422), (333), (440) planes of Fe_3O_4 JCPDS Card No. (77-1545) Magnetite.The Cubic single phased spinel Fe_3O_4 showed broad peak indicating nanoparticle formation.On varying the sintering atmosphere,Fe_3O_4 started converting to Fe_2O_3 as observed by S2 and S3 XRD peaks as shown in figure 1 b. Diffraction peaks at 2©= 24.33°, 33.45°,41.18°, 49.86°, 54.55°, 62.94°, 64.48° can beind exed to (012), (104), (113), (024), (116), (214), (300) planes of Fe_2O_3 JCPDS Card No. 84-0311.Complete conversion to Fe_2O_3 was seen in S3 (figure1c).

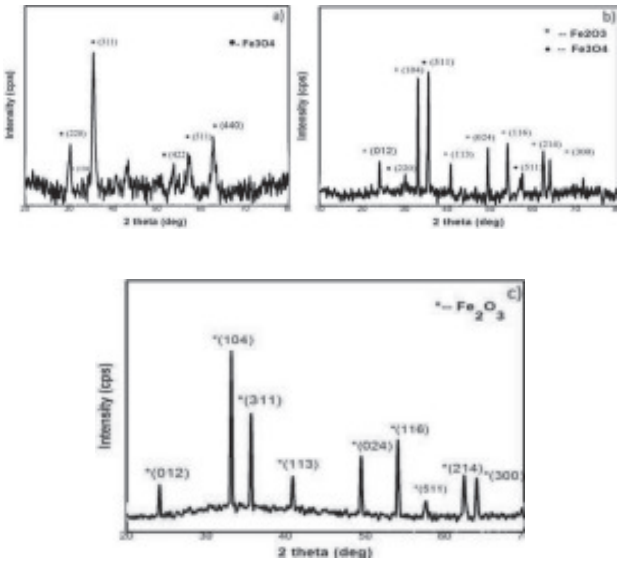
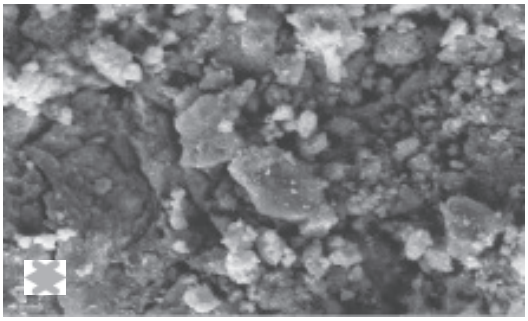


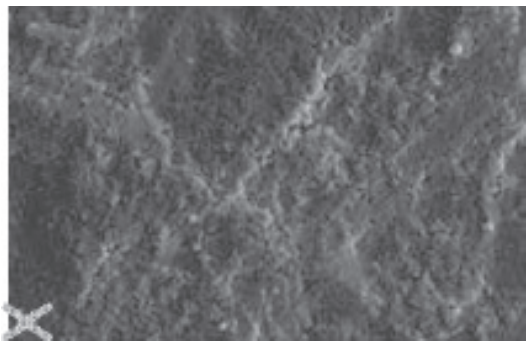
Figure 1:X-ray Diffraction pattern of sample : a) S1 b) S2 c) S3.

The interplanar spacing and lattice parameter for S1 calculated is 2.5345Å and 8.406Å which is close to the reported value[6-8].The crystallite size was calculated using scherrer formula[9].The crystallite size showed the usual increase (~32 nm to 67 nm) for Fe_3O_4 and (~76nmto83nm) for Fe_2O_3 as aneffect of the rmalinduced grain growth kinetics.

3.2 Scanning electron Microscopy(SEM)



2µm **a)**



2µm **b)**

2µm

Figure2: Scanning electron microscopy images for samplesa)S1b)S2c)S3,d) EDX spectra of S1

Figure2 depicts the surface morphology of sample S1,S2 and S3, S1 and S2 reveals the aggregation of nanoparticles with size 200-400nm. Aggregation of nanoparticles leads to wide pores.Well resolved nanoparticles are estimated in S3.Sintering in air leads to grain growth and bigger particles with average size of 250 nm. Meso pores (2-50 nm) and macro-pores(>50 nm)can be seen over the entire surface. Figure 2d shows the EDX spectra of S1, with only Fe and O peaks of atomic% 36.38 an 63.62 and weight % 66.62 and 33.38.

2.3 Hydroelectric CellOutput

Current –Voltage output of HEC S1,S2 and S3 are shown in table 1. S1 produced highest current while in S2 and S3, the current decreased with formation of Fe_2O_3.The formation of white $Zn(OH)_2$ confirms the reaction mechanism(Figure 3).S1 prduces 60 mA current,conversion of $Fe_3O_4$to Fe_2O_3leads to decrease in current as seen in S2 and S3.Dissociation of water molecule occurs on octahedrally coordinated unsaturated suface cations (Fe^{2+}-Fe^{3+}) and oxygen vacancies created in defective spinel ferrite. The dissociation of H_2O into $H_3O^+$and OH^- ions occur via chemidissociation and physisorption of water molecule. Using Zinc sheet and silver on the opposite surface of the pellet, Zinc sheet acts as ananode and oxidises to form $Zn(OH)_2$ with an oxidation potential of 0.76V and H_2gas is liberated at the silver cathode with a reduction potential of 0.22 V.Fe_2O_3shows poor sensitivity toward water molecule dissociation. It may be due to sintering in air that converted all Fe^{2+} to Fe^{3+} in Fe_2O_3. Thus less vacancies and dangling bonds are available at the surface to dissociated water molecules.The maximum power output of cell is 54mW, 36mW, 3.6mW respectively.

TABLE 1

Sample	Short circuit current (mA)	EMF(V)
S1	60	0.9
S2	40	0.9
S3	4	1

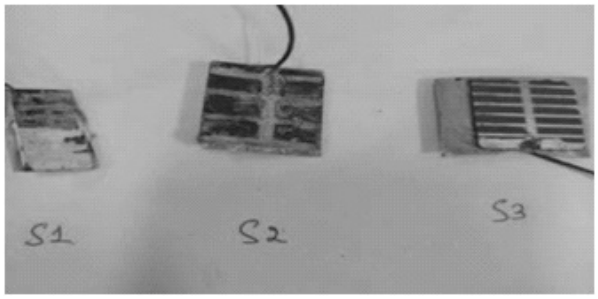


Figure 3: HEC pellet S1,S2 and S3

4. Conclusions

Magnetite nanoparticles have been prepared by chemical co-precipitation technique. Different annealing temperature effect on magnetite are analyzed by XRD and SEM. Presence of unsaturated surface cations and oxygen vacancies lead to the

dissociation of water molecule on the surface of lesser resistive and nanoporous magnetite to produce highelectric current in HEC .The effect of conversion of Fe_3O_4 to Fe_2O_3 has effected the current output of the cell. Conversion of Fe_3O_4 to Fe_2O_3 in air has been observed by grain growth which decreasing the effective surface area and surface defects thus reducing the dissociation of water molecule by Fe_2O_3.

5. Acknowledgement

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