Synthesis of Fe_3O_4-SiO_2-Polyaniline Conducting NanoComposites

[1]Shivdeep Sharda, [2]Deepak Saini, [3]Anupreet Kaur
[1]Department of Electronics & Communications, Punjabi University, Patiala
[2] Department of Basics and Applied Sciences, Punjabi University Patiala
[1]shivdeepsharda@gmail.com

Abstract:

Conducting Polymers and their nanocomposites have been known for a while and are used in diverse range of applications. This study involves the synthesis of nanocomposites of Iron oxides particles coated with silica and in-situ polymerization of polyaniline. These nanocomposites are examined by Scanning Electron Microscopy, Fourier transform infrared spectroscopy for their structural morphology and bonding information.

Keywords: Polyaniline (PANI), Conducting Polymers (CPs), Silica nanocomposites, Iron oxide nanoparticles (IONPs).

Introduction

Conducting polymers are the synthetic materials which have been a big part of the research that is going on in nanotechnology and applications of these materials are extended in different fields. Polymers possess an advantage over metals that they can be easily processed than metals. Advantages of physical properties of these materials lead to the studies which explored the potential of the conducting polymers in applications of electronics devices, solar cells and energy storage devices [1-3].

Polyaniline (PANI) is a unique conducting polymer because of the conductivity that can be achieved through doping that is either protonation or anion uptake in it [5]. This unique conductivity sets PANI apart from other conducting polymers. In addition, the thermal stability and ease of synthesis [6] make PANI one of the most studied conductive polymer systems. Synthesis methods used for preparing polyaniline are chemical and electrochemical polymerization [7].

Many other conducting polymers are fabricated and studied for their properties, some examples of which are Polypyrrole (PPY), poly (3, 4 ethylenedioxythiophene) (PEDOT), polythiophene

(PTP). Chemical structure of these conducting polymers is shown in figure given below. These all CPs are also found to be beneficial in many applications for example Photovoltic cells, Elecrochromic devices, data storage, supercapacitors [8-10].

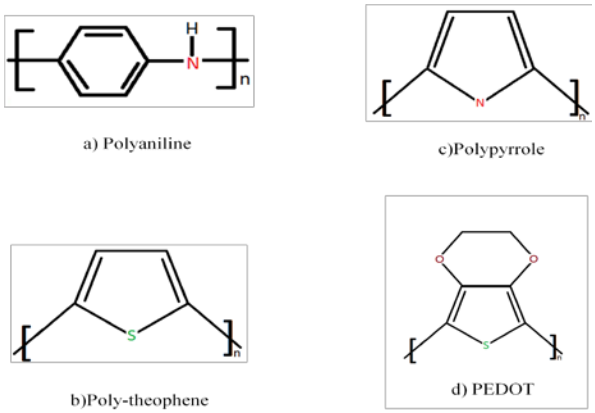

Figure 1:Chemical structure of Conducting Polymers a)Polyaniline b)Polythiophene, c)Polypyrrole d)Poly(3,4 ethylenedioxythiophene)

Experimental Procedure

Synthesis of nanocomposites of Iron oxides and Conducting Polymers

Iron oxides under this work are prepared using the co-precipitation method [11]. Mixture of $FeCl_3.6H_2O$ and FeCl2.4H2O is used aqueous solution of ammonia to synthesize black colored nanoparticles.

IONPs obtained by co-precipitation method are coated with silica. Usual process for coating silica onto Iron oxide nanoparticles is Stober's process [12]. Silica surface is used because it is can be used to attach polymers or ligands on to the iron oxide surface. Solution of iron oxide particles in propyl alcohol is prepared. Solution of ammonium hydroxide and then TEOS is added and this solution is stirred for 24 hrs to coat the particles. Product of this process is removed using magnets and then filtered out properly.

Synthesis of Polyaniline composite with silica coated iron oxide is done by in-situ oxidation polymerization of aniline [13]. Cupric sulfate is used as surfactant. Aniline solution in methanol

is used for polymerization and iron oxide particles are added in to it while adding cupric sulfate. This is followed by magnetic stirring.

Results and Discussion

Synthesized particles are studied by performing characterization procedures on to the sample. Scanning Electron Microscopy (SEM), Fourier Transform infrared spectroscopy (FTIR) characterizations are performed. SEM is used to know the morphology and size of nanoparticles. FTIR is the characterization used to understand bond structure of formed nanocomposites.

Scanning Electron Microscopy

Scanning Electron Microscopy analysis of powdered Fe_3O_4-SiO_2-Polyaniline is obtained. SEM analysis clearly shows the structure of particles to be nearly spherical and size is about 1000nm. Size of Iron oxide nanoparticles is believed to be increased with Polyaniline covering.

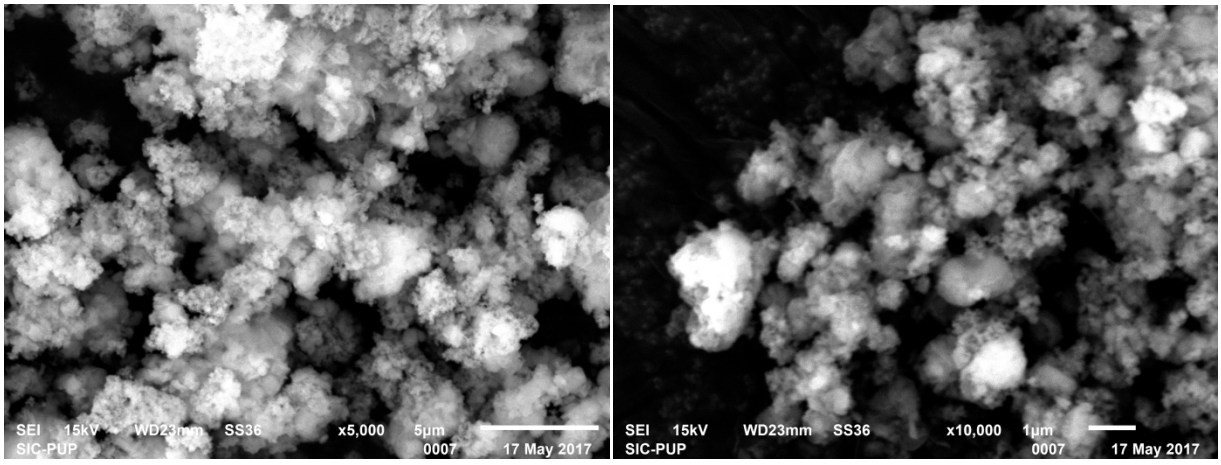

Figure 1: SEM Image of sample

FTIR-Attenuated Total Reflectance

FTIR – Attenuated total reflectance characterization reveals the bond stretching and bending of the synthesized samples which indicate the functional groups present in it. Sample is placed under a dense crystal with high reflective index and an infrared beam is directed into crystal. Sample is under close contact with crystal so that there is some interaction of light with sample before reflectance of light. These interactions of light with sample are observed to know wave number values at which there is absorption occurring in the sample. This information of absorption at specific wave numbers reveals the bending and stretching of chemical bonds in samples [13].

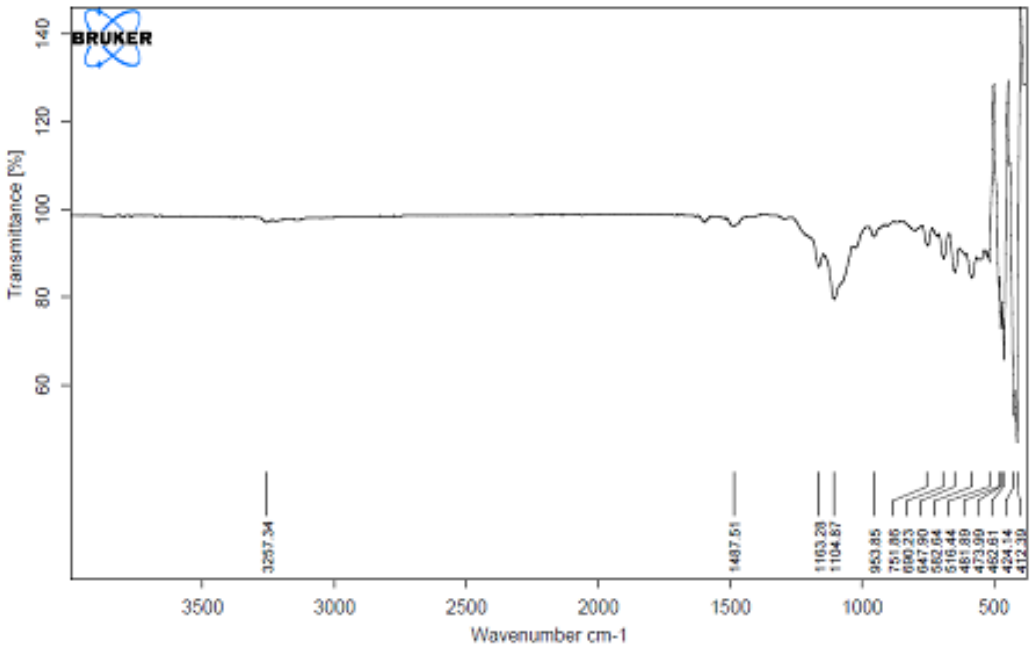

Figure 2: FTIR-ATR analysis of Sample

Frequencies at which sample shows the absorbtion can be looked from graph of FTIR and they are at 3257.34, 1487.51, 1163.28, 1104.67,1104.87,953.85,751.86,690.23,647.90, 582.64, 516.44, 481.89, 473.99, 462.61, 424.14, 412.39 cm^{-1}.

The peaks belonging to wavenumber 462, 582, 647 are for iron (Fe) and oxygen(O) bond streching. The peaks at 473, 481 cm^{-1} indicates the asymmetric strecthing vibrations of Silicon and oxygen bonds (Si-O-Si). Peak at 620.23 cm^{-1} tells the bond of (Fe-O-Fe) of iron oxide particles and 1163 cm^{-1} peaks shows bonding between iron oxide and Polyaniline.

CONCLUSION

The work comprised of synthesis of Polyaniline composites with Silica coated magnetite particles. SEM characterization reveals the size of particles to be under the 1000nm and forming an agglomerated structure. FTIR analysis confirms the bonding between particles. Silicon oxygen bonds and Iron oxygen bonds and polyaniline iron bonds are confirming the composite structure.

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