International Journal of
Scientific Research in Science and Technology (IJSRST)
Print ISSN : 2395-6011, Online ISSN : 2395-602X
International Conference on Advanced Materials
Held on 14, 15 December 2017, Organized by Department of Physics,
St. Joseph's College, Trichy, Tamilnadu, India

Synthesis and characterization of MnO_2 Nanoparticles using Co-precipitation Technique

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Abstract

Manganese dioxide nanoparticles were synthesized using co-precipitation method for 0.1 mol and 0.2mol concentration, which is the simple way to prepare the aqueous solution. The dried samples were characterized using various techniques such as XRD, SEM, FTIR and UV-Visible spectroscopy. The average particle size of manganese oxide nanoparticles was calculated from the XRD study. The Morphology and size of the synthesized MnO_2 particles are studied by scanning electron microscopy (SEM). The band gap energy for MnO_2 is found using UV-Visible spectroscopy. The FT-IR spectra of MnO_2 shows the peaks corresponding to stretching and bending vibration. There are large number of potential applications of MnO_2 metal nanoparticles such as in the field of electrode materials in different rechargeable batteries, biosensors, coatings, nanofibres, nanowires and bioscience applications.

Keywords: MnO_2 nanoparcticles, Co-Precipitation technique (CPT), XRD, FTIR, UV-Vis, SEM.

Introduction

Nanotechnology is science, engineering, and technology conducted at the nanoscale, which is about 1 to 100 nanometres. It's hard to imagine just how small nanotechnology is. One nanometer is a billionth of a meter, or 10^{-9} of a meter. There are 25,400,000 nanometers in an inch. A sheet of newspaper is about 100,000 nanometers thick. Nano is derived from the Greek word meaning "dwarf". Nanoscience and nanotechnology are the study and application of extremely small things and can be used across all the other science fields, such as chemistry, biology, physics, materials science, and engineering.

1.1. Dimensional Classification

1.1.1. Zero Dimensional

These nanoparticles have nano-dimension in all three directions Metallic nanoparticles including gold and silver nanoparticles and semiconductors such as quantum dots are the perfect examples of this type. Most of these nanoparticles are spherical in size. The dimension of the particle will be between 1-50nm range.

1.1.2. One Dimensional

In these nanostructures, one dimension of Nano structure will be outside the range. These include nano wires nano rods and nanotubes. These material are long (several micro meter in length) but with diameter of only some nanometer. Examples: Nanowires and nanotubes of metals, oxides, nano rods, nano filaments, quantum wires.

1.1.3. Two Dimensional

In these nanomaterials, two dimensions are outside the nanometer range. These include different kind of Nano film such as coating and thin film-multilayer, Nano sheets or Nano walls. The area of the thin film can be large but the thickness is always

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in Nano scale range. Examples: Discs, Platelets, Ultrathin films, Super lattices, Quantum wells.

1.1.4. Three Dimensional

All dimensions are outside the nanometer range. This include bulk materials composed of individual blocks which are in nanometer range. (1-100nm)
Example: Fullerenes, Semiconductor Quantum dots, Quasi-crystal.

Co-precipitation (CPT) is the carrying down by a precipitate of substances normally soluble under the conditions employed. Analogously, in medicine, co-precipitation is specifically the precipitation of an unbound "antigen along with an antigen-antibody complex". The present work reports synthesis of MnO_2 nano particles and its characterization by Scanning Electron Microscopy (SEM), UV-Visible spectroscopy (UV), Fourier transform infrared spectroscopy (FTIR), X-Ray Diffraction (XRD) Technique.

2. Experimental Method

All chemical used in the experiment were of AR grade. The synthesis of manganese dioxide was performed using co-precipitation method by using two different salts should be of equal mol concentration mixed together with constant stirring at 40˚C. While stirring NaOH solution was added till the pH of the solution reaches 12. The stirring process was continued for one hour at constant temperature 40˚C. The precipitate was separated using the centrifuge (4000rpm). The sample was collected and heated for 24 hours in hot air oven at 100˚C.

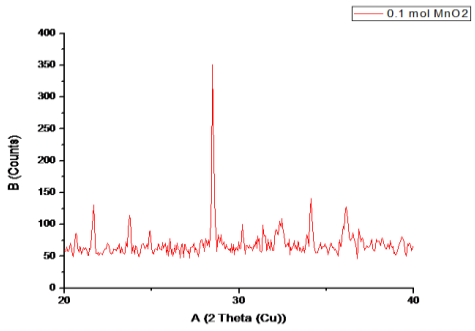
2.1. Characterization technique

The properties of formed MnO_2 nanoparticles were determined by X-ray diffraction (XRD) (2 Theta: 0.001; Minimum step size Omega:0.001). UV-Visible spectroscopy in the wavelength range 200-1000cm^{-1}, Fourier transorm Infra-Red Spectroscopy (FTIR) in the wavelength range 400-4000 cm^{-1}.

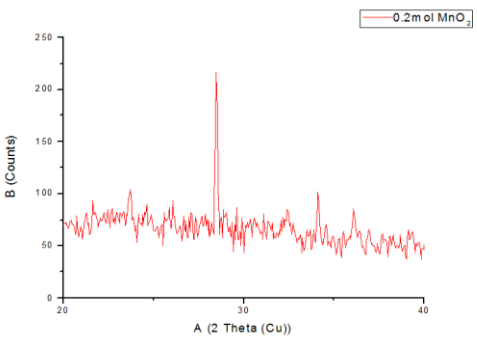
3. Results and Discussion

3.1 X-Ray Diffraction

Figure 1 shows that X-ray diffraction study of manganese dioxide metal nanoparticles synthesized by co-precipitation method. From the XRD pattern it is clear that manganese dioxide metal nanoparticle synthesized were purely crystalline in nature. The average particle size of manganese dioxide nanoparticle was calculated from the Debye-Scherrer equation for the preferential peaks at 2θ for all the peaks present in fig (a) 0.1 mol concentration and is found to be 52.6 nm and for Figure(b) 0.2 mol concentration is found to be 32nm.



(a)



(b)

Figure 1. X-ray diffraction pattern of manganese dioxide metal nanoparticles synthesized by co-precipitation method

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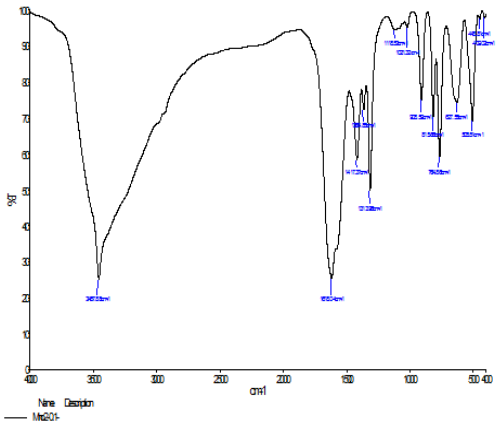
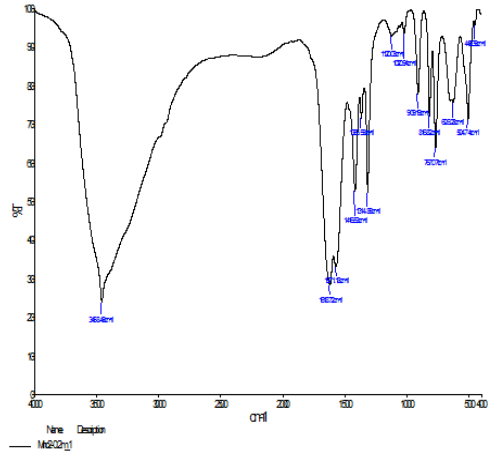
3.2. FT-IR Analysis



(a)



(b)

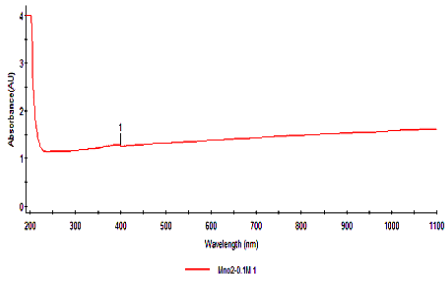
Figure 2. FT-IR spectra of manganese dioxide metal nanoparticles synthesized by co-precipitation method

Figure 2 shows that FT-IR spectra of MnO_2. The bands at 515 and 480cm^{-1} correspond to the Mn-O bond. The absorption peak for fig (a) 0.1 mol concentration at 1313.96cm^{-1} corresponds to O-C Bending. For1118.53cm^{-1} and 1021.32cm^{-1} corresponds to C-N stretching. The peaks at 908.59, 815.66 and 764.85cm^{-1} corresponds to O-H bending and 627.55cm^{-1} correspond to C-H Bending.

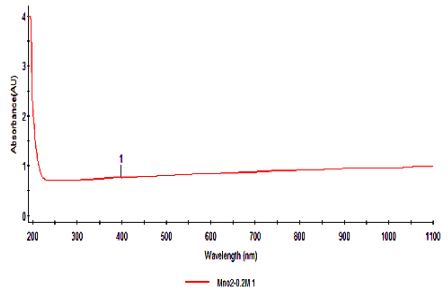
The absorption peaks for fib (b) 0.2 mol concentration at 901.19 cm^{-1} corresponding to =C-H and $=CH_2$ Bending and 816.8, 767.07cm^{-1} and 626.9 cm^{-1} corresponds to CH Bending.

3.3. UV-Visible Spectroscopy

Figure 3 shows that the UV-Visible spectra of manganese dioxide nanoparticles. The band gap for Figure(a) 0.1 mole concentration is found to be 5.17eV. The band gap for Figure(b) 0.2 mol concentration is found to be 5.22eV.



(a)



(b)

Figure 3. Uv-spectra

4. Scanning Electron Microscope (SEM)

The morphology and size of the synthesized MnO_2 particles are studied by SEM. The figures represents the SEM pictures of prepared MnO_2 nanoparticles at different magnification. These pictures confirm the formation of MnO_2 nanoparticles. SEM morphology of MnO_2 nano crystalline particles found to have an irregular spherical shape.

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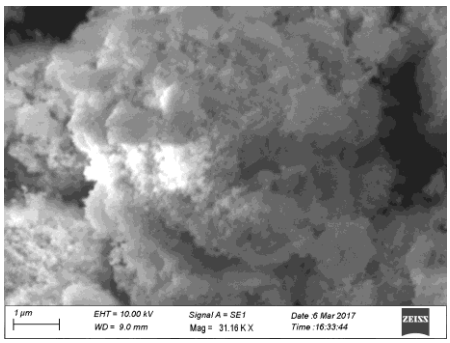
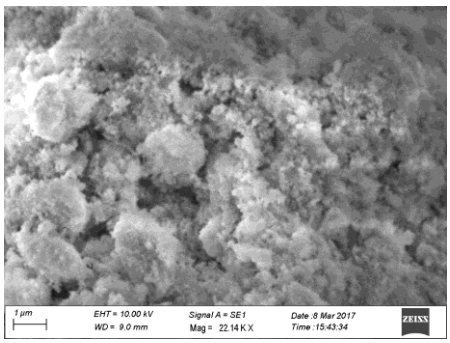


(a)



(b)

4. Conclusion

MnO_2 nanoparticles of simple cubic structure were synthesized by co-precipitation method. The FT-IR spectral analysis reveals the characteristic peaks of Mn-O stretching. The UV-Visible absorption shows sharp absorption at 240.3nm due to metal nanoparticles. XRD spectra predicts the average size for 0.1 mol of MnO_2 and is found to be 52.6nm and for 0.2 mol of MnO_2 found to be 32nm. SEM image reveals the particles is found to have an irregular spherical shape. There are large number of potential applications of MnO_2 metal nanoparticles such as in the field of electrode materials in different rechargeable batteries, biosensors, coating, nanofibres and bioscience applications.

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