Study of Surface Morphological, Phytochemical and Structural Characteristics of Rhodium (III) Oxide (Rh_2O_3) Nanoparticles

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Abstract. In the current research, Rhodium (III) Oxide (Rh_2O_3) nanoparticles were produced in various sizes using ultrasonic waves and by adding various concentrations of linoleic acid as capping agent. Using X-Ray Diffraction (XRD) methods, phytochemical and structural characteristics of the produced samples were studied and the mean particle size was calculated by Debye – Scherer equation. The phytochemical characteristics of the produced nanoparticles were studied by Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR). The surface morphology of these structures shows that the Rhodium (III) Oxide (Rh_2O_3) nanoparticles are formed in a spherical shape.

1. INTRODUCTION

In recent years, magnetic nanomaterials have been considered due to their applications in magnetic recording technologies. Rhodium (III) Oxide (Rh_2O_3) nanoparticles is one of these materials. Rhodium (III) Oxide (Rh_2O_3) nanoparticles is used in rechargeable batteries, gas sensors, catalyzers and magnetics [1–8]. Rhodium (III) Oxide (Rh_2O_3) has two stable structural types (RhO_2 , Rh_2O_3). The energy gap of RhO_2 and Rh_2O_3 are between 1.9–2.3 eV and 2.7–3.1 eV, respectively [9, 10].

Characteristics of Rhodium (III) Oxide (Rh_2O_3) nanoparticles are dependent to their size. Many phytochemical and structural characteristics of materials are varied by variation in their size. When colloid solutions remain for some time, smaller particles eliminate and remained particles enlarge. To control particle size, it is possible to make steric repulsion between nanoparticles using chemicals such as surfactants, organic compounds and polymers and hence, avoid agglomeration of nanoparticles [11–14].

In the current research, X-Ray Diffraction (XRD), Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) and Scanning Electron Microscope (SEM) were used to study these compounds from morphological, structural and phytochemical points of view.

2. TEST METHOD

In the current study, Rhodium (II) acetate ($\text{Rh}_2(\text{AcO})_4$) with 99% purity, Sodium hydroxide (NaOH) with 99% purity, ethanol and linoleic acid were used. To produce Rhodium hydroxide, 1.5 gr Rhodium (II) acetate ($\text{Rh}_2(\text{AcO})_4$) and 0.5 gr Sodium hydroxide were solved in 35 ml ethanol to produce 0.4 molar solution of each one. Then, Sodium hydroxide solution was added to Rhodium (II) acetate ($\text{Rh}_2(\text{AcO})_4$) solution. Linoleic acid was used as capping agent to change particle size. In each step of test, a special amount of linoleic acid by 0, 0.4 ml, 0.8 ml and 1.2 ml concentrations was added. The resulting solution was subjected to ultrasonic waves for 75 minutes. Then, the solution was centrifuged and washed by distilled water for seven times and finally, the resulted precipitate was dried in vacuum. To produce Rhodium (III) Oxide (Rh_2O_3), samples were placed in oven at 450° C for two hours.

3. RESULTS AND DISCUSSION

Figures 1 and 2 show X-Ray Diffraction (XRD) spectrum of Rhodium (III) Oxide (Rh_2O_3) nanoparticles with various concentrations of capping agent. As can be seen, the concentration of capping agent is effective in formation of Rhodium (III) Oxide (Rh_2O_3) nanoparticles as well as particle size. By adding linoleic acid, other phases of Rhodium (III) Oxide (Rh_2O_3) nanoparticles are formed and the width of peaks are increased. The mean crystallite size are calculated by Debye – Scherer equation.

Figure 1. X-Ray Diffraction (XRD) spectrum of Rhodium (III) Oxide (Rh_2O_3) nanoparticles without capping agent.

Figure 2. X-Ray Diffraction (XRD) spectrum of Rhodium (III) Oxide (Rh_2O_3) nanoparticles samples produced by various concentrations of linoleic acid.

By increasing linoleic acid concentration, the absorption edge is shifted toward shorter wavelengths and shortening of absorption edge wavelength indicates the increase in energy gap and in fact, reduce in particle size. Figure 3 shows the results obtained from Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR–FTIR).

Figure 3. Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR–FTIR) of Rhodium (III) Oxide (Rh_2O_3) nanoparticles samples produced by various concentrations of linoleic acid.

The morphology of the produced samples were studied by Scanning Electron Microscope (SEM). Based on the comparison between Scanning Electron Microscope (SEM) images, it can be observed that although there are particles in nanometer size, the formed nanostructures are adhered together and they form a bulk structure when capping agent is not presented. Figure (4a) and (4b) are for Rhodium (III) Oxide (Rh_2O_3) nanoparticles produced by increase in linoleic acid as capping agent. It is clear in the figures that by adding capping agent, nanoparticle size reduces. This is confirmed by X-Ray Diffraction (XRD) results. Furthermore, simulation of surface morphological characteristics of Rhodium (III) Oxide (Rh_2O_3) nanoparticles were presented in Figure 5.

Figure 4. (a) Sample without linoleic acid and (b) Sample produced by adding 0.8 ml linoleic acid.

Figure 5. Simulation of surface morphological characteristics of Rhodium (III) Oxide (Rh_2O_3) nanoparticles.

4. CONCLUSION

The Rhodium (III) Oxide (Rh_2O_3) nanoparticles were produced using ultrasonic waves and by adding linoleic acid. The X-Ray Diffraction (XRD) results confirmed the effect of capping agent on formation of Rhodium (III) Oxide (Rh_2O_3) nanoparticles and particle size. Attenuated Total Reflectance Fourier Transform Infrared Spectroscopy (ATR-FTIR) showed that energy gap of nanoparticles increased from 3.1eV to 5.3eV. The surface morphology, phytochemistry and structure of these nanoparticles showed that they are adhered together and their size decreased by adding linoleic acid.

5. REFERENCES

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