Synthesis and Characterization of Silver Nanoparticles and Cerium (IV) Oxide Nanoparticles

Phyu Thwe Soe[1], Yi Yi Myint[2]

Abstract

In this research work, silver nanoparticles were prepared by a simple chemical reduction method and cerium oxide was prepared by co-precipitation method. In the synthesis of silver nanoparticles, silver nitrate, trisodium citrate, and glucose were used as starting materials. In the synthesis of cerium oxide nanoparticles, cerium (III) nitrate and potassium carbonate were used. The synthesized nanoparticles were characterized by X-ray diffraction analysis (XRD) and scanning electron microscopy (SEM). It was found that the size of the Ag NPs was in the range of 35 nm to 50 nm as well as CeO_2 NPs was from 22 nm to 29 nm.

Keywords: nanoparticles, Silver, Cerium (IV) oxide, simple chemical reduction, co-precipitation, surface morphology

Introduction

Nanotechnology is the science that deals with design and manipulation of materials in the atomic and molecular state to produce Nano-sized materials which can be measured in nanometers. Nanotechnology has gained immense interest due to the unique optical, electrical and magnetic properties of Nano--sized materials. Examples of nanostructures include carbon nanotubes, nanowires, fullerenes, quantum dots and nanoparticles.

Nanoparticles are small particles or particulate matters less than 100 nm in diameter that can be classified as liposomes, metallic nanoparticles, polymeric nanoparticles and albumin bound nanoparticles. Metallic nanoparticles exhibit unique thermal, optical, magnetic, physiochemical and antimicrobial activity. They are widely used in different field and have gained research attention due to their application potential in various fields. Examples of these metal nanoparticles include; silver, gold, platinum, iron, zinc and cobalt etc.

Nanoparticles can be synthesized using various approaches including chemical, physical, and biological. Although chemical method of synthesis requires short period of time for synthesis of large quantity of nanoparticles, this method requires capping agents for size stabilization of the nanoparticles. Chemicals used for nanoparticles synthesis and stabilization are toxic and lead to non-ecofriendly byproducts. The need for environmental non-toxic synthetic protocols for nanoparticles synthesis leads to the developing interest in biological approaches which are free from the use of toxic chemicals as by products.

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The term "nanoparticles" is used to describe a particle with size in the range of 1nm-100nm, at least in one of the three possible dimensions. In this size range, the physical, chemical and biological properties of the nanoparticles' changes in fundamental ways from the properties of both individual atoms/molecules and of the corresponding bulk materials. Nanoparticles can be made of materials of diverse chemical nature, the most common being metals, metal oxides, silicates, non-oxide ceramics, polymers, organics, carbon and biomolecules. Nanoparticles exist in several different morphologies such as spheres, cylinders, platelets, tubes etc.

Materials and Methods

Materials

In this study, silver nitrate, trisodium citrate, glucose, cerium (III) nitrate, potassium carbonate and distilled water were used.

Preparation of Silver nanoparticles by using simple chemical reduction method

40 ml of 0.01 M $AgNO_3$ and 40 ml of 0.01 M glucose were dissolved in 100 ml of distilled water. Then the mixed solution was placed in a beaker for 2 min at 60 ºC by using magnetic stirrer. Then after 5 min, 20 ml of 0.01 M $C_6H_5O_7Na$ was added and stirred -in 5 min, it's changed milky solution and then stirred again, brown solution occurred. And then, stirred in 2 min, gray solution was observed. After that, stirred for 16 hrs, the solution with silver mirror was observed. And then, the whole mixture was washed with distilled water to obtain neutral pH. and centrifuged , to get neutral solution. After that, washed with acetone and centrifuged at 6000 rpm in 15 min, gray precipitate was observed and dried in petri dish, dry powder of $AgNO_3$ was obtained, solution was measured, and the value of pH was 11.5. The whole mixture was washed with distilled water to obtain neutral pH. And then, the mixture was washed with ethanol and centrifuged at 6000 rpm for 10 min. The precipitate was dried and ground. Then, the powder was weighed.

Preparation of Cerium (IV) oxide nanoparticles by co-precipitation method

250ml of 0.02 M $CeNO_3$ and 100 ml of 0.03 M K_2CO_3 were added drop by drop -to 100 ml of –well stirred distilled water to precipitate a white precursor, namely cerium (III) carbonate–. The constant pH= 6 was maintained during the precipitation method. Resulting CeO_2 was dried at 65^{o}C for 2 hours, cooled to room temperature. Then the –product was aged at 220^{o}C for 2:30 hours without any washing and purification, and finally calcined at 600^o ~~o~~C for 3 hours.

Characterization Methods

Crystal structure and crystallite size of Silver nanoparticles and Cerium Oxide nanoparticles were characterized by XRD method. The size distribution and morphology were determined by SEM technique.

XRD Analysis - Department of Chemistry,Yangon University of Research Centre
SEM Analysis - Department of Chemistry,Yangon University of Research Centre

Results and Discussion

The yield percent of Silver nanoparticles and Cerium Oxide nanoparticles were presented in table (1).

Table (1) Yield (%) of Silver and Cerium Oxide Nanoparticles

No	Metal and Metal Oxide	Method	Calcined Temperature (°C)	Yield%
1.	Silver	Chemical reduction	500	13.5666
2.	Cerium oxide	Co-precipitation	600	19.2811

Characterization of prepared Ag NPs by XRD

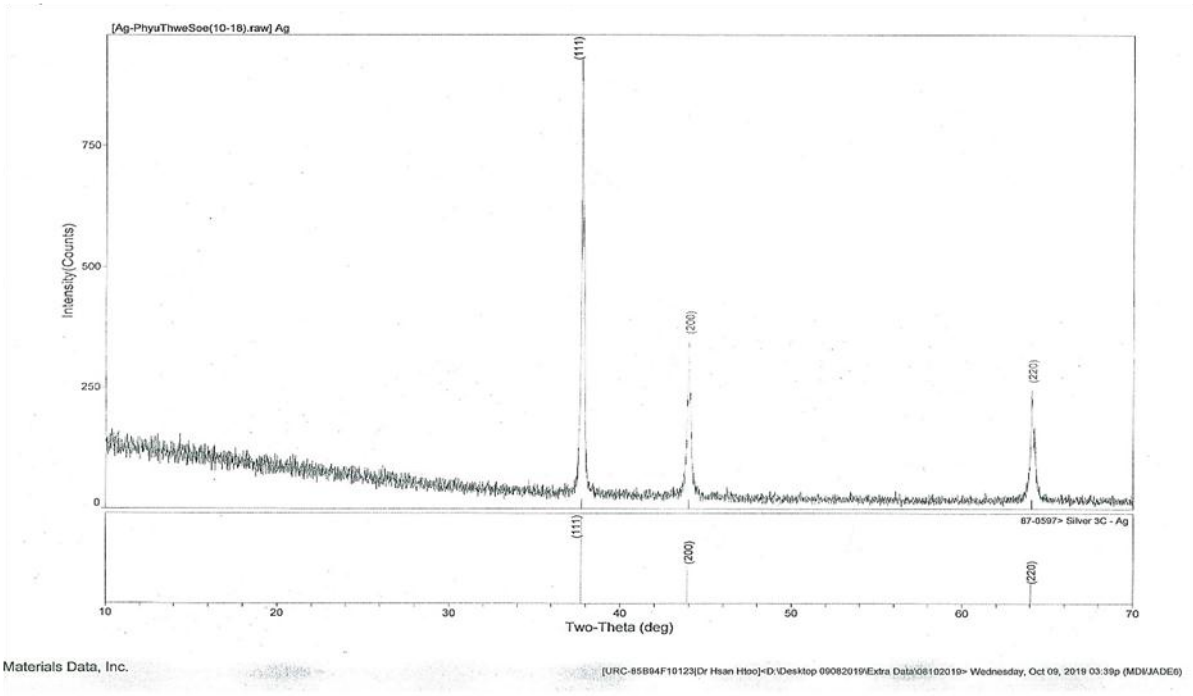

Figure 1. XRD Spectrum of Silver nanoparticles

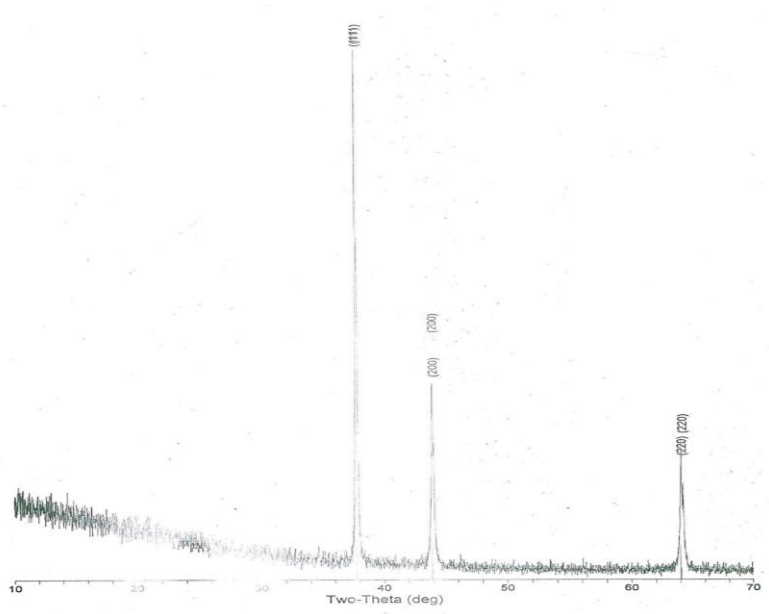

Figure 2. Lattice constants from peaks location and Miller indices of Silver nanoparticles

Table (1) Calculation of Lattice Constants from Peak Locations and MillerIndices

No	2θ	hkl	a-Axis	b-Axis	C-Axis
1	37.752	(111)	4.1239	4.1239	4.1239
2	43.959	(200)	4.1161	4.1161	4.1161
3	64.070	(220)	4.1073	4.1037	4.1037

Average Lattice Constants = 4.1158 A^o

Crystal Nature = Cubic

Table (2) The size of silver nanoparticles

No	2θ	hkl	FWHM	Inter planer spacing, d (Å)	Particle size, D (nm)
1	37.752	(111)	0.167	2.3810	50.267
2	43.959	(200)	0.224	2.0581	38.239
3	64.070	(220)	0.263	1.4522	35.633

The average crystalline shape of Ag NPs are in the range of is 29.50 nm.

Characterization of prepared CeO_2 NPs by XRD

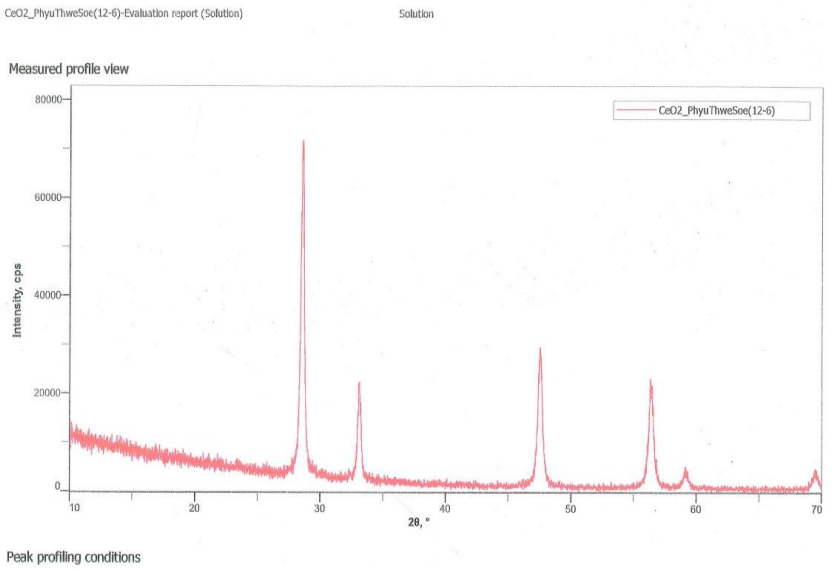

Figure 3. XRD spectrum of Cerium Oxide Nanoparticles

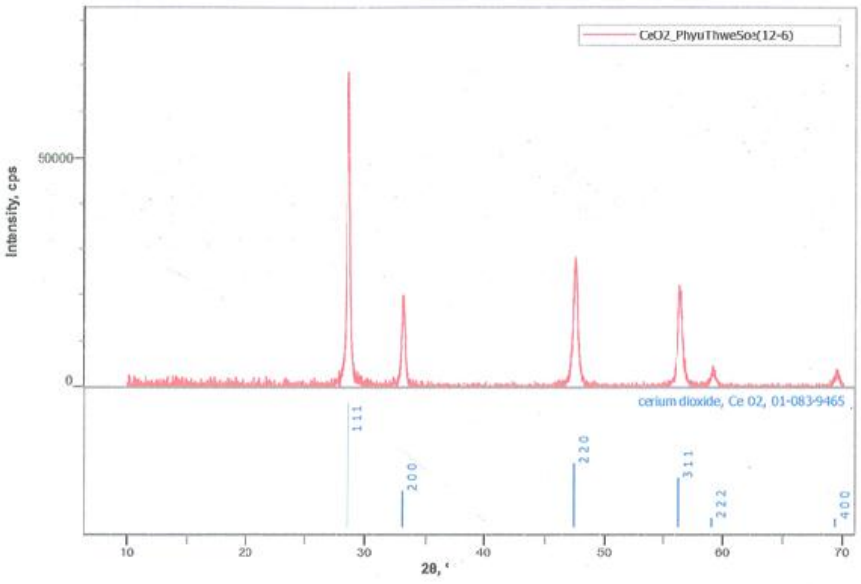

Figure 4. Lattice constants from peaks location and Miller indices of Cerium oxide nanoparticles

Table (3) Calculation of Lattice Constants from Peak Locations and Miller Indices

Phase name	a, A^o	b, A^o	C, A^o	α , ^{o}	B, ^{o}	ϒ, ^{o}
Cerium oxide	5.41137	5.41137	5.41137	90.000	90.000	90.000

Crystal Nature = Cubic

Table (4) The size of cerium oxide nanoparticles

No	2θ	hkl	FWHM	Inter planer Spacing d (Å)	Particle Size, D (nm)
1	28.547	(111)	0.295	3.1243	27.785
2	33.067	(200)	0.285	2.7068	29.072
3	47.489	(220)	0.370	1.9130	24.255
4	56.340	(311)	0.382	1.6317	23.587
5	59.10	(222)	0.40	1.5619	22.826
6	69.46	(400)	0.42	1.3521	23.011

The average crystalline shape of CeO_2 NPs are in the range of is 25.089 nm.

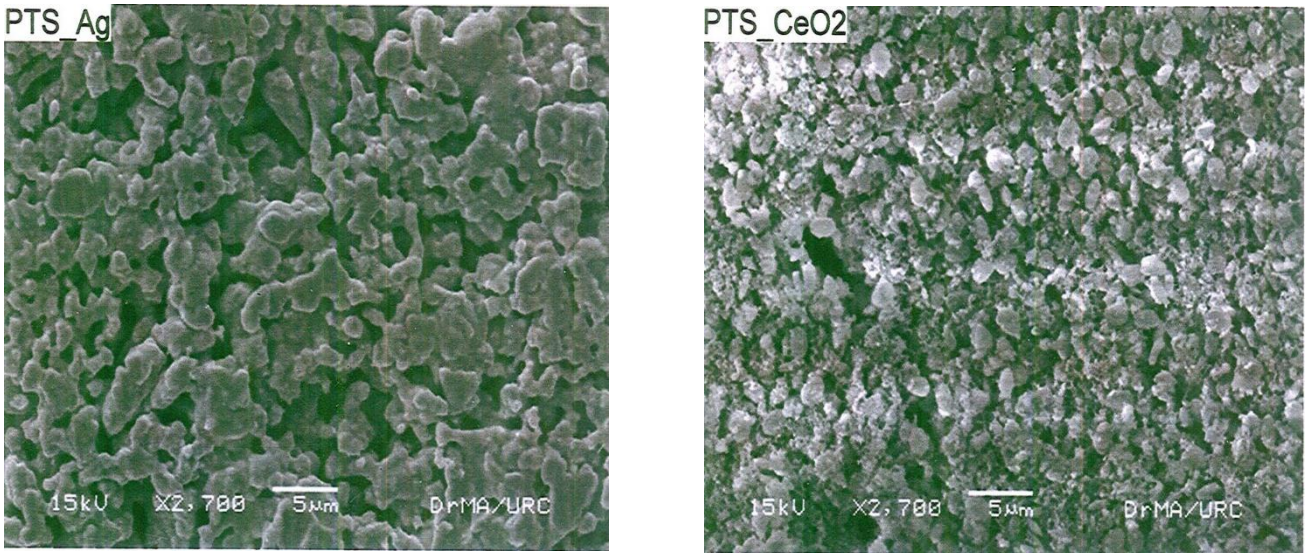

Figure 5. SEM image for Silver and Cerium oxide Nanoparticles

CONCLUSION

In this research, the synthesis of silver nanoparticles was carried out by using silver nitrate, trisodium citrate and glucose by simple reduction method. The synthesis of cerium oxide nanoparticles was prepared by co-precipitation method. The preparation of silver nanoparticles was prepared by silver nitrate, glucose and trisodium citrate 2:2:1–(w/w). The prepared silver nanoparticles were characterized by XRD, SEM techniques. The XRD results of prepared silver nanoparticles showed the characteristic peaks at 2θ values of 37.752º, 43.959º and 64.070º were corresponding to 50.265nm, 38.239nm and 35.633nm. The average crystalline size was 29.50nm.

The cerium oxide nanoparticles were prepared by cerium nitrate and potassium carbonate. The XRD results of cerium oxide nanoparticles showed the characteristic peaks at 2θ values of 28.547º, 33.067º, 47.489º, 56.340º, 59.10º and 69.46º were corresponding to 27.785nm, 29.072nm, 24.255nm, 23.587nm, 22.826nm and 23.011nm.

The average crystalline size was 25.089nm.The SEM image of AgNPs displayed the appearance of silver nanoparticles as well as the microgram of CeO_2 NPs appeared the aggregate structure of Cerium oxide nanoparticles.

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