



## Spectroscopic Characterization of Cobalt Selenide

Aripnammal S. and Velvizhi R.

Department of Physics, Gandhigram Rural Institute, Deemed University, Gandhigram, Dindigul District, Tamilnadu – 624302, INDIA

Available online at: [www.isca.in](http://www.isca.in), [www.isca.me](http://www.isca.me)

Received 11<sup>th</sup> October 2013, revised 28<sup>th</sup> December 2014, accepted 6<sup>th</sup> February 2014

### Abstract

*The study on cobalt selenide has been carried out by XRD, SEM, EDAX, FTIR and UV-VIS studies. The x-ray powder diffraction study has shown that the Cobalt selenide has been crystallized in orthorhombic structure. The scanning electron microscope reveals the morphology of the particles as square type particles embedded in gelly layer similar to seeds embedded in pomegranate. The particle size is determined as 99nm. The analysis of EDAX has shown the percentage of Cobalt and selenium. The FTIR study has shown the presence of O-H bond and metal complex. The UV-Vis spectrum has shown high absorption in the ultra-violet region at about 365.7nm which makes the material to be suitable for UV filters.*

**Keywords:** Cobalt selenide, gel growth, XRD, SEM, UV-VIS, FTIR.

### Introduction

Chalcogenides are the compounds whose main constituent elements include sulphur, selenium and tellurium of group VI<sup>1</sup>. The most outstanding characteristics of these chalcogens are their six electrons system of valence orbitals. They are having  $s^2p^4$  configuration. Each of these elements accept two electrons to assume the nearest rare gas configuration. The Se has  $(Ar)3d^{10}4s^24p^4$ . The chalcogens have each one pair of electron and two unpaired electrons in the outer p-subshell<sup>2</sup>. The atomic size increases from top to bottom of group VI elements (O, S, Se and Te). The chalcogen atoms combine with metals to form binary chalcogenide compounds<sup>1-3</sup>. They have shown very interesting properties such as semiconductor to metallic transition, valence transition and structural phase transition. They are having numerous applications in the field of modern technology such as switching devices, electrical and optical phase change data storage technologies, photo conductors, photo electro chemical energy conversion electrode, flexible radiometry and IR-imaging bundles for endoscopy and sensitive detector for high- field magnetic resonance imaging applications<sup>4-7</sup>. Cobalt is a d block transition metal element. The number of electrons in each of Cobalt's shells is 2, 8, 15, 2 and its electronic configuration is  $[Ar] 3d^74s^2$ . As an important transition metal chalcogenide cobalt selenide has attracted much attention due to its important applications in many areas. Cobalt Selenide is used in a number of industrial applications including infrared detection and imaging. American Elements when applicable, produces many standard grades, including military grade, Reagent and Technical Grade, Food, Agricultural and Pharmaceutical Grade; Optical Grade of US Pharmacopoeia, European Pharmacopoeia, British Pharmacopoeia and ASTM testing standards<sup>8-9</sup>. Motivated by these applications, cobalt selenide has been chosen for the present study and the results are presented in this paper.

### Material and Methods

The CoSe in powder form has been purchased from alfa aesar company as it is. It is dark black in colour. This CoSe powder was further characterized by XRD, SEM, EDAX, FTIR, UV-VIS and Photoluminescence spectrum. The powder XRD was performed by using Richseifert diffractometer. The SEM images were taken on a JEOL JSM-6390 model (made in Japan) scanning electron microscope. The EDAX spectrum was recorded by OXFORD INCAPENTAx3 model made in England. The FTIR spectrum was recorded using Perkin Elmer spectrum BX model spectrophotometer by KBr pellet technique in the range  $400-4000\text{cm}^{-1}$  at a resolution  $2\text{cm}^{-1}$ . The UV-Visible absorption spectrum was recorded using Perkin Elmer Lamda 35 spectrophotometer in the spectral range 200 to 1100nm.

### Results and Discussion

**XRD:** The recorded powder XRD pattern for the grown cobalt selenide is shown in figure-1. The peaks are indexed by analyzing the data using the method of least square fit. The compound is found to be crystallized in orthorhombic structure with  $a = 6.557 \pm 0.02 \text{ \AA}$ ,  $b = 3.588 \pm 0.02 \text{ \AA}$ ,  $c = 5.200 \pm 0.02 \text{ \AA}$  and Volume  $V = 122.34 \text{ \AA}^3$ .

**SEM:** The SEM images (figure-2) of cobalt selenide (CoSe) has shown considerable uniform distribution of nearly square type particles with particle size of 99nm. The scanning electron microscope reveals the morphology of the particles as square type particles embedded in gelly layer similar to seeds embedded in pomegranate. The expanded SEM image of magnification  $\times 30,000$  shown in figure 3 has shown clearly the appearance of the embedded particles in gelly layer like structure.

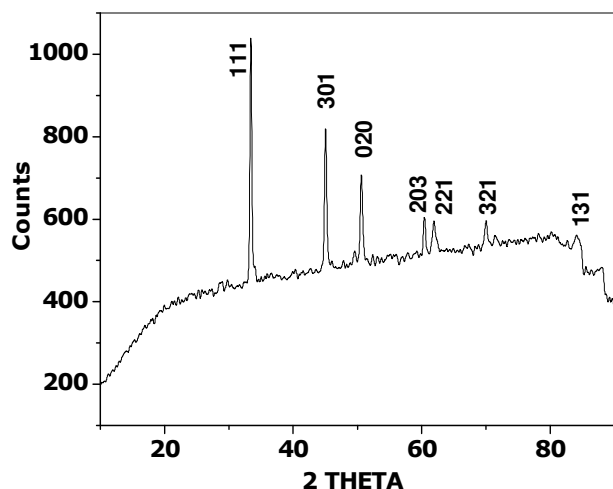


Figure-1

The X-ray powder diffraction pattern of Cobalt selenide

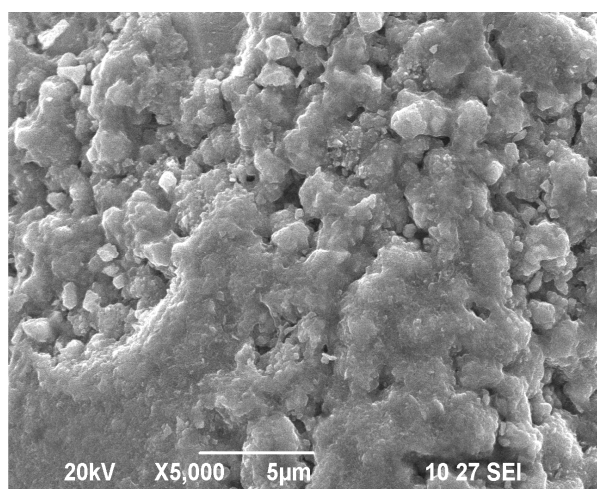
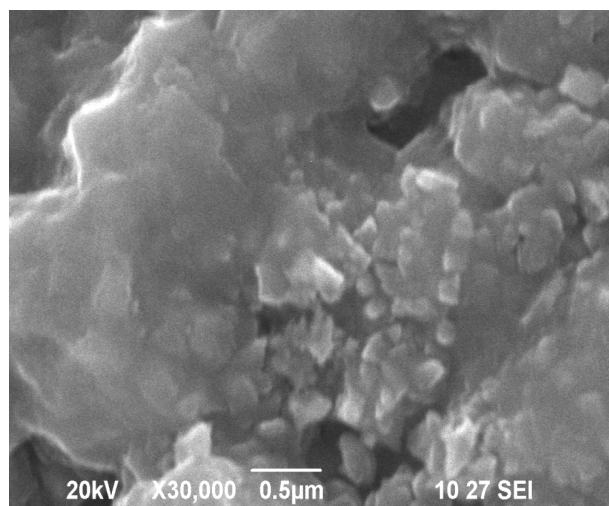


Figure-2

The SEM images of Cobalt selenide with two different magnification

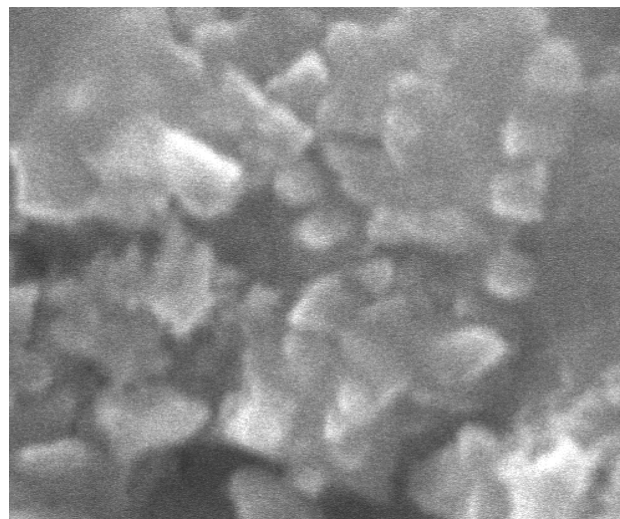


Figure-3

The Expanded SEM image of Cobalt selenide with  $\times 30,000$  magnification

**EDAX:** The energy dispersive x-ray spectrum of the cobalt selenide (figure 4) has shown that the Co and Se are present in weight percentage of 41.38 and 55.97 and the atomic percentage of 44.53 and 44.95 respectively. The expected weight percentage of Co and Se are 42.74 and 57.26 and they are found to be in agreement with the observed values.

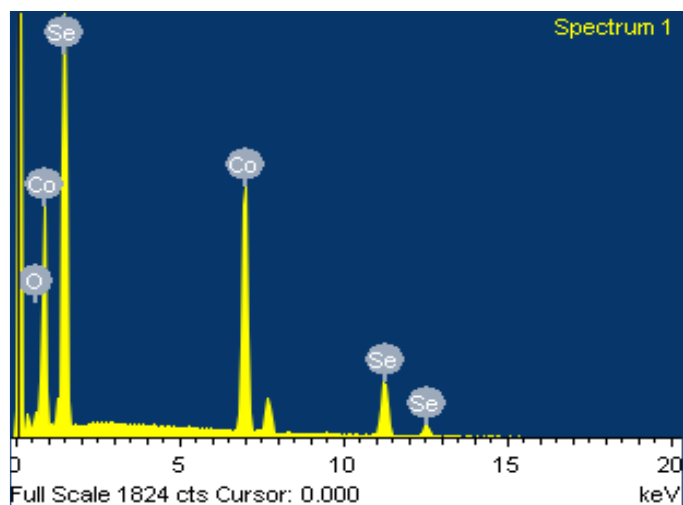


Figure-4

The EDAX pattern of Cobalt selenide

**FTIR:** The figure 5 shows the FTIR spectrum of the Cobalt selenide and table 1 presents the observed absorption frequencies and their assignments in relation to their characteristic vibrational modes. The broad trough starting from  $2300$  to  $3840\text{cm}^{-1}$  enclosing,  $3834.49$ ,  $3587.6$ ,  $3441.01$ ,  $3404.36$ ,  $2929.87$  and  $2314.58$ , indicates the presence of O-H bonding<sup>10-11</sup>. All the other peaks at  $1641.42$ ,  $1363.67$ ,  $1028.06$  and  $462.92\text{cm}^{-1}$  corresponds to Cobalt complex confirming the bonding with  $\text{Se}^{13}$ .

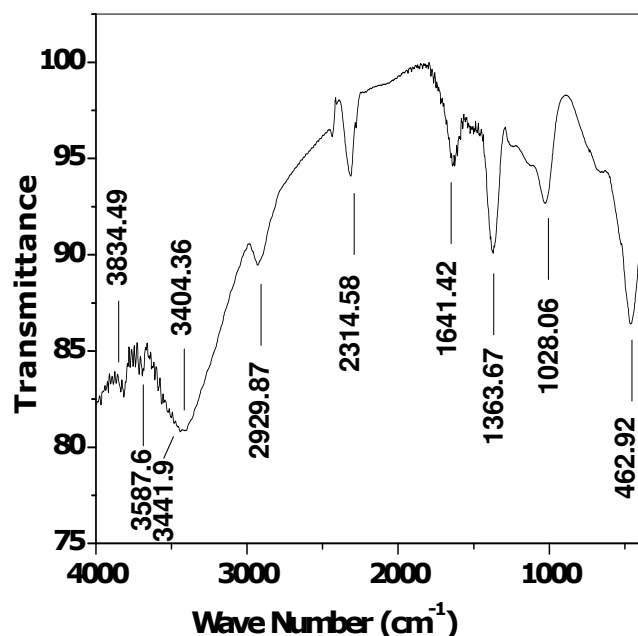


Figure-5  
The FTIR spectrum of Cobalt selenide

Table-1  
The assignment of FTIR bands of Cobalt selenide

Sl.NO.	Frequency of bands $\text{cm}^{-1}$	Assignment
1.	3834.49	O-H stretching
2.	3587.6	O-H stretching
3.	3441.01	O-H stretching
4.	3404.36	O-H stretching
5.	2929.87	OH in plane bending
6.	2314.58	O-H stretching
7.	1641.42	Metal-oxygen bonding
8.	1363.67	Cobalt complex, O-H in plane bending
9.	1028.06	Cobalt complex, O-H stretching
10.	462.92	Co-Se bonding

**UV-Visible:** The absorption spectrum of Cobalt selenide recorded in the UV-Vis region is shown in figure 6. It shows high absorption in the ultra-violet region from 229.62 nm in UV region of the spectrum. This makes the material to be suitable for devices for good absorption of UV radiation that is, it can be used as a UV filters. The wide absorption has been observed in the UV region from 229.62nm and upto the entire visible region (225 to 1100 nm) which enables it to be a potential candidate for using it as filters. The sample is black in colour and it shows high absorption visible spectral range from 360 to 740 nm.

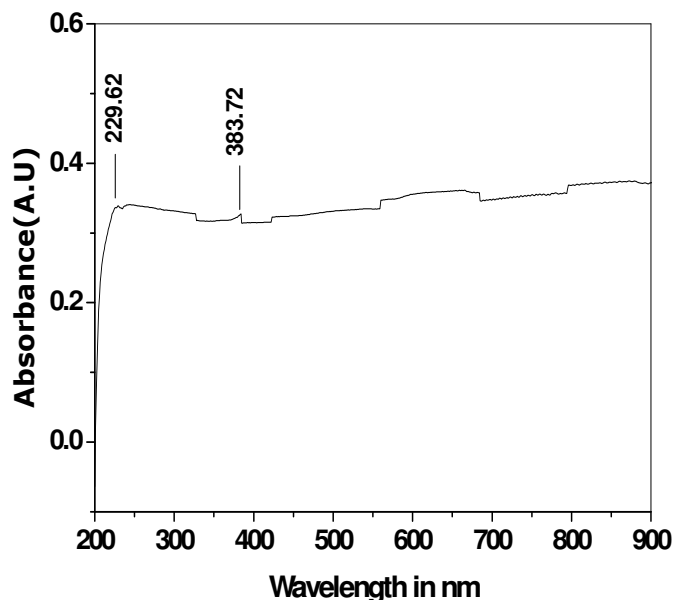


Figure-6  
The UV-VIS spectrum of Cobalt selenide

## Conclusion

Thus, the Spectroscopic XRD, SEM, EDAX, FTIR and UV-Vis studies have been made on Cobalt Selenide successfully. The XRD study confirms the orthorhombic structure of CoSe. The SEM reveals the morphology of the particles as square type particles embedded in gelly layer similar to seeds embedded in pomegranate with particle size of 99nm. The EDAX has shown the agreement of the weight percentage of Co and Se with the expected weight percentage. The frequency assignment has been made by FTIR and confirms the presence of cobalt bonding with selenium. The UV-VIS study has shown suitability of the compound as a potential candidate for using it as filters.

## References

1. Cotton F. and Wilkinson G., Advanced Inorganic Chemistry, A Comprehensive text, John Wiley and Sons, USA (1980)
2. Phillips J.C., Bonds and Bands in Semiconductors, Academic Press, New York and London (1973)
3. Albert Cotton F., Geoffrey Wilkinson and Paul L. Gaus, Basic Inorganic Chemistry, 3<sup>rd</sup> Edition, John Wiley and Sons, Singapore (1995)
4. Materials World, Published by IOM Communications Ltd., London, April (2005)
5. Peter Turmezei, Chalcogenide Materials for Solar Energy Conversion, Acta Polytechnica Hungarica, 1(2), 13 (2004)
6. Viacheslav Artyushenko Cezar Wojciechowski, Vitaly Kononenko, Jacek Ludczak, Andrzej Grzebieniak, Zdzislaw Wojciechowski., Specialty fibers for broad

- spectra of wavelength and power, Proceedings of SPIE **5951**, 595103 (2005)
7. Yeong-Ah Soh and Gabriel Aeppli, Making sense of magnetic fields, *Nature*, **417**, 392-393 (2002)
  8. <http://www.americanelements.com/cose.html> (2013)
  9. Zhan J.H., Yang X.G., Li S.D., Xzie Y., Yu W.C. and Qian Y., Synthesis of nanocrystalline cobalt selenide in nonaqueous solvent, *J. of Solid State Chemistry*, **152**, 537-539 (2000)
  10. Silverstein, Basster and Morrill, Spectrometric identification of organic compounds, John Wiley and Sons, USA, 87-106 (1991)
  11. Jag Mohan, Organic Spectroscopy, Narosa Publishing House, New Delhi, **36**, 81-85 (2000)
  12. Kazuo Nakamoto, Infrared and Raman Spectra of Inorganic and Coordination compounds, John-wiley and sons Inc., USA, 111,121,239,245,255 (1986)