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# Structural and Optical Characterization of Lead Oxide Nanoparticles

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**ABSTRACT:** This study focuses on the structural and optical characterization of lead oxide nanoparticles (PbO NPs). The unique properties of PbO NPs in the Nano scale range make them attractive for various applications in different fields. The preparation of PbO NPs using the precipitation method is described, and their structural and optical properties were analyzed using scanning electron microscopy (SEM), X-ray diffraction (XRD), and UV- Vis spectroscopy. The results confirm the polycrystalline nature of PbO NPs and reveal a band gap energy in the Nano scale range, indicating their potential use in diverse applications.

**KEYWORDS:** Lead oxide, XRD, XRD, SEM, UV-Vis spectroscopy.

## 1. INTRODUCTION

Nano materials are kind of materials with the sizes range from 1-100nm. In this range, Nano materials behave at variance from the bulk properties both in term of atoms and molecules. According to Tamirakar (2012) and Bisen et al (2015), the nanomaterial sizes, shapes, and the entire physical, chemical, electrical, and optical properties show clear differences from the bulk properties. Lead element has differences forms of oxide to include PbO,Pb2O3,and $PbO_2$. It is crystal clear that the aggregation of nanoparticles lead to the changes in their sizes, shapes and at the same time alter their chemical, physical and biological properties. In the opinion of Xi et al (2004), the unique optical, mechanical and electronic properties of PbO got the attention of scientists as to how these materials can be exploited in industries and medical applications. Also, Meshram et al (2015) supported the assertions of Alagar et al (2013) that PbO unique properties make it useful for network-modifiers in luminescent glassy material, pigments, gas sensors, paints, storage batteries. The nanoparticles materials with the nonmetric range 1-100nm like PbO are very useful in different fields such as material science, biotechnology and genetics, electronic, magnetic, opto electronic, biomedical, pharmaceutical, cosmetic, energy, environmental, catalytic and materials application (Yang et al, 2009). Lead oxide characteristics were formed due to its simplicity in the design, safety and low cost of manufacturing and reliability. PbO nanoparticles got various uses due to their lengthy life cycles (Karami et al, 2011). PbO use as glass modifier improves the glass's thermal and optical properties as well as its chemical and mechanical stability(Almeida et al,2016). The chemical process of synthesising PbO nanoparticle that is good at tailoring the size and it's morphology. According to Arulmozhi and Mythili (2013), the specific surface area of PbO nanoparticles depend on the interrelationship of the particle morphology and size as very important characteristics of this nanoparticles that shows its ability for both mechanical and optical activities. The aim of this study is to determine the structure and optical properties of lead oxide nanoparticles.

## 2. EXPERIMENTATION

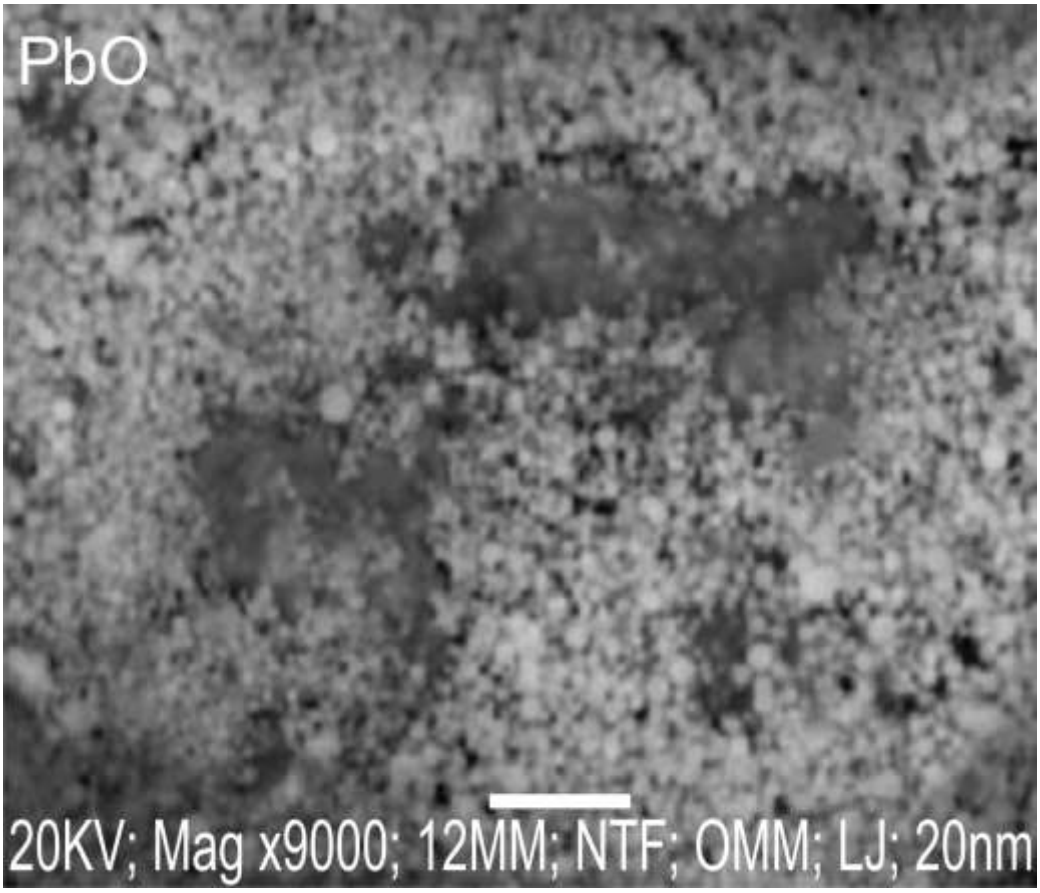
PbO powder was prepared by precipitation method resulted from the reaction of aqueous solution of lead nitrate mixed with that of sodium hydroxide in the following quantities (lead nitrate =0.06m, sodium hydroxide = 0.9m, purity 98%). The reaction solution was left for 24hrs, after, the PbO power is washed thoroughly for 6 times with distilled water, then the precipitates were filtered and dried in the sun. Then, the same was annealed in the oven at 300degreeC . The PbO powder appeared yellow. The end product was 98% and used for the analysis.

## 3. CHARACTERIZATION of lead oxide

### (a) Structure characterization

(i) Scanning Electron Microscope (SEM) was used for PbO nanoparticle surface morphology and particle size analyses as shown in fig 1 a and b.

(a)




(b)

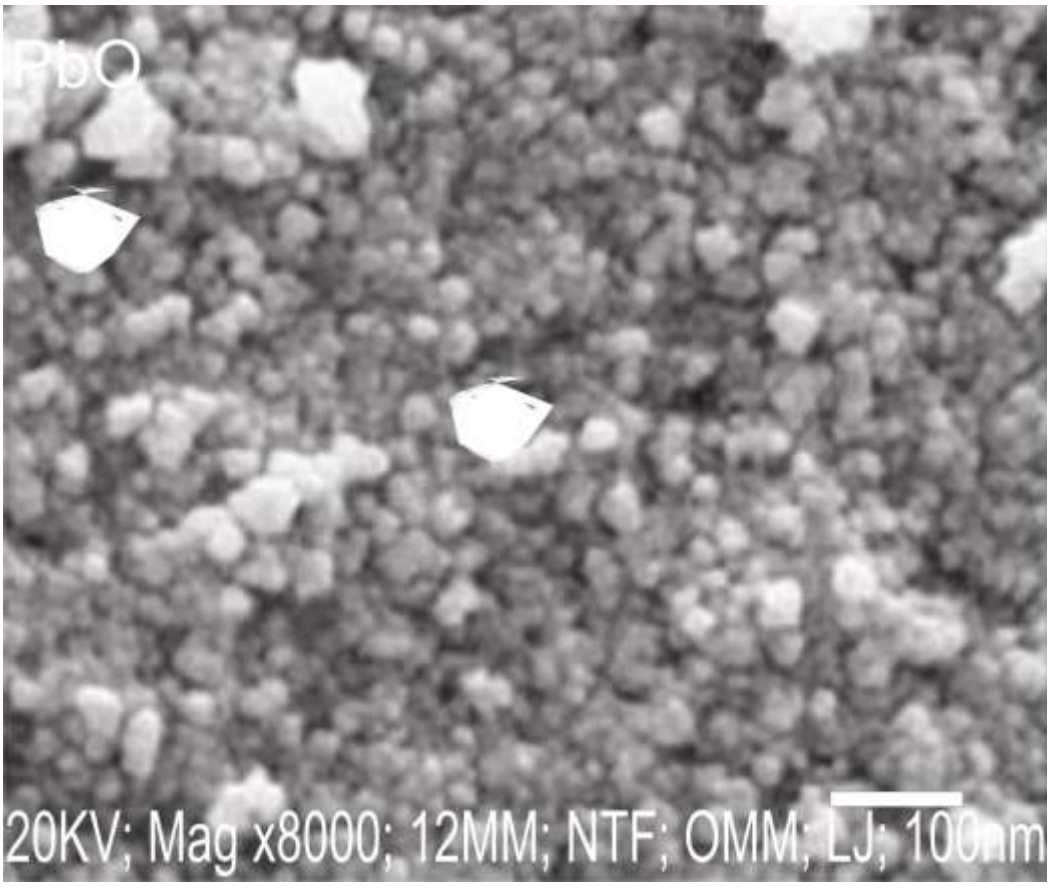



**Fig 1a&b: Scanning Electron Microscope SEM of PbO nanoparticles.**

The prepared sample of PbO nanoparticle show shapes of isometric and rod -like with the distribution range of 20-100nm. The crystallinity index of the sample PbO nanoparticle was calculated using the relation : $I_{cry} = D_P/D$ ,(Arulmozhi and Mythili,2013), where Icry= Crystallinity index and D= particle size calculated using Debye scherrer formula. The calculated crystallinity index of this sample is approximately 1.7 and show that the particles are polycrystalline. The SEM analysis show that the prepared PbO sample have good morphology and connectivity. SEM observations revealed the agglomeration of lead oxide particles with a fine face and rod-like particle shapes, indicating a low impurity content.

**(ii) X-Ray Diffraction (XRD).** The XRD pattern of the prepared sample is shown in fig 2.

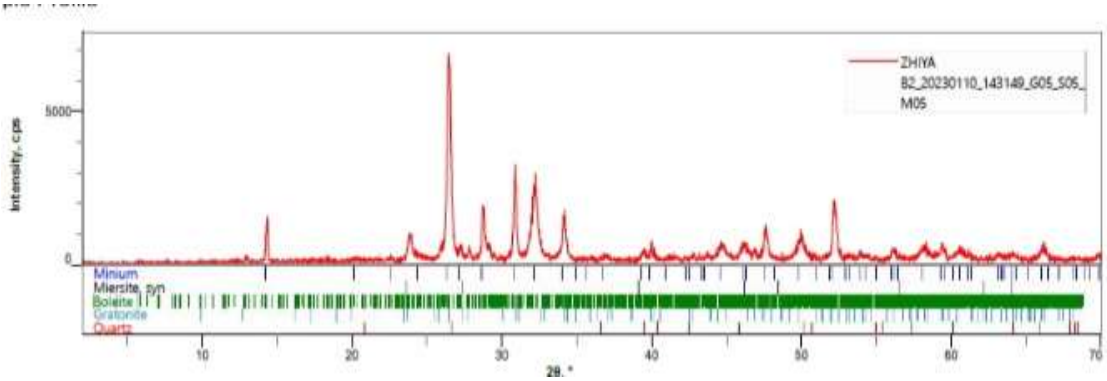
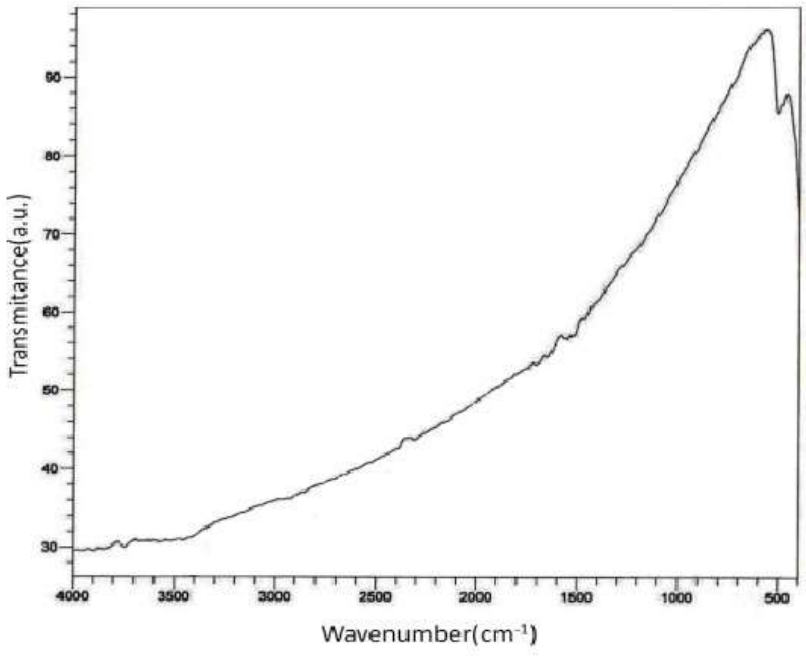



**Fig 2: XRD pattern of PbO nanoparticles.**

The grain size of PbO nanoparticle was calculated using Debye scherrer formula $D=0.9\lambda/\beta\cos\Theta$, where D = particle size,β = Full width half maximum (FWHM), λ= wavelength of x-ray source and Θ= Bragg's angle of diffraction. The particle grain size calculated is 58nm. The width of the peak increases as the size of the particle decreases. The diffraction peaks was indexed to PbO according to the peak position and no impurity peak was observed, this shows that the obtained product was pure PbO. It has very sharp and strong peaks, this indicates that the product has good crystallization.

(**iii) Optical characterization**. The Ultraviolet-visible (UV -Vis) spectroscopy was used to analyze the optical properties of PbO nanoparticles. The UV-Vis spectrum depends on size of the nanoparticles and the particle size (Yi et al, 2005). The UV-Vis absorption and the band gap spectra of PbO nanoparticles are shown in Fig 4 and 5 while fig 3 show the transmittance versus wavenumber. This figure shows the transmittance of PbO nanostructure after calcination at 300 degree C for 60 minutes. The figure reveals that the pure PbO sample consists of large aggregates which was transformed to fine aggregates. The transmittance also supports SEM investigations of the samples which reveal the crystalline nature of PbO nature of nanoparticles



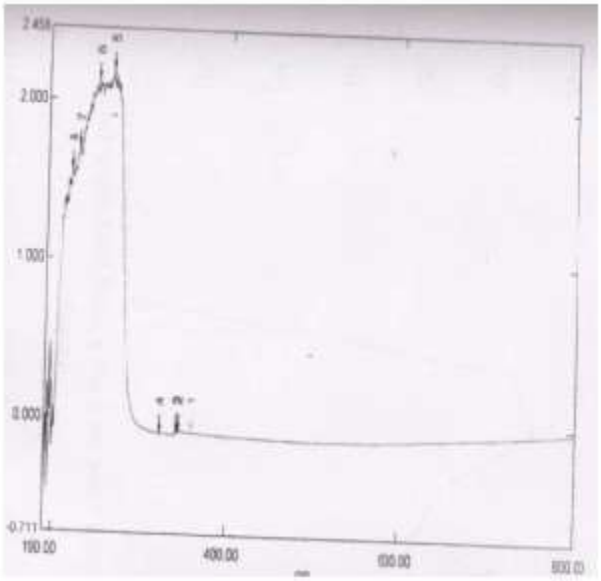


Figure 4. UV-Visible Spectrum of PbO

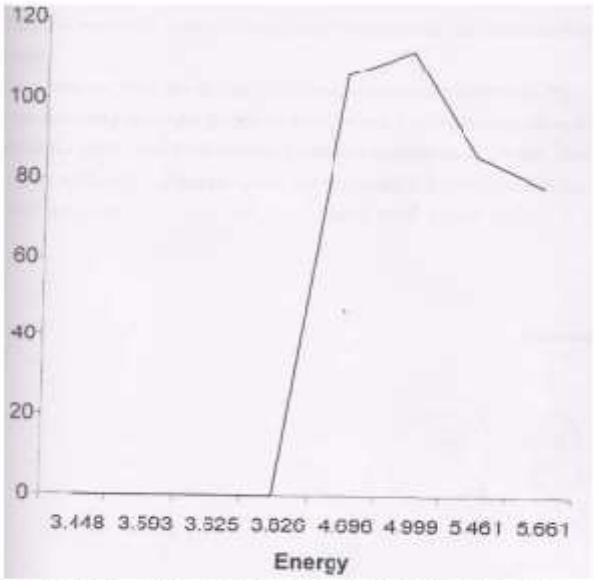



Figure 5. Energy Band gap Spectrum of PbO nanoparticles.

The absorption peaks of 260, 240, and 210nm are correlated to pure PbO nanoparticles, this shows that the prefect shift in optical absorption spectrum is as a result of quantum size effects. The calculated band gap energy value using the wave energy formula Eg=hc/λ eV, where h=Plancks constant, C= velocity of light, λ= wavelength of the sample are 3.25, 3.30, 3.35, and 3.40eV for the sample PbO nanoparticles. These values are higher than the values of bulk PbO band gap, which shows that the pure PbO are in nano range scale. This is in agreement with the opinion of several researchers that the band gap increases when the particle size decreases. It shows the shift in band gap as a result of quantum confinement which has the quantitave form (Manichathai et al, 2008) The variation in shape, size and mass explain well the optical properties of nanoparticles. As particle size increases, so does the maximum wavelength of the absorption.

## CONCLUSION

**T**his comprehensive study provides valuable insights into the elemental, structural, morphological and optical properties of lead oxide.

PbO was prepared by precipitation method using lead nitrate and sodium hydroxide. The particle size of PbO is in nano range scale. As a result of the performance of XRD measurement, the formation of PbO, structure and the particle size were confirmed. The position and intensity of lines in the diffraction pattern also confirm the orthorhombic structure of PbO nanoparticles. The microstructure and the grain size of PbO are examined using SEM as 58nm. The calculated crystallinity index of PbO is 1.7 which indicates that the prepared PbO nanoparticle is polycrystalline. The band gap energy of PbO nanoparticle was determined by UV-Vis spectroscopy and found to be 3.25, 3.30, 3.30, 3.35 and 3.40eV. The optical properties characteristics showed that the absorbance increases when the particle size decreases. PbO nanoparticles possess anti-bacteria properties due to its smaller particle size that has larger ability to kill bacteria. Also has good adhesive property which is good for the fabrication of bio-sensors and other applications. Overall, this research contributes essential knowledge to enhance the efficient utilization of lead oxide across various industrial processes.

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