COMPARISON OF OPTICAL CHARACTERISTICS OF ZINC OXIDE - NICKEL OXIDE AND ZINC OXIDE PREPARED USING NOVEL WET CHEMICAL SYNTHESIS

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Abstract

Aim: The main aim of this project is to relate optical properties such as absorbance and band gap analysis of Zinc Oxide- Nickel Oxide and pure Zinc Oxide which were prepared by using a novel wet chemical synthesis method.

Materials and methods: The optical properties of pure Zinc Oxide and Zinc Oxide- Nickel Oxide were compared and the analysis is done using UV spectrophotometer. The mean of absorbance and transmittance can be obtained using SPSS software. The sample size of pure Zinc Oxide and Zinc Oxide- Nickel Oxide is 234 which in turn gives a total sample size of 468 which was calculated using clincalc which had a pretest power of 80% and error correction of 0.05.
Results and discussion: It can be observed that transmittance of Zinc Oxide- Nickel Oxide is higher than the transmittance of pure Zinc Oxide. The mean of pure Zinc Oxide and Zinc Oxide- Nickel Oxide are 1.8257973 and .4588671 respectively. The attained significance of the optical characteristics is $P < 0.001$.
Conclusion: The optical band gap of pure Zinc oxide is 6.97 eV and Zinc oxide-Nickel oxide is 1.5 eV From the results of optical characteristics, it can be seen that the mean of pure Zinc oxide and Zinc oxide Nickel oxide are 0.458867 and 1.8257973 respectively. The absorbance of pure Zinc Oxide is higher than that of Zinc Oxide-Nickel Oxide and the optical band gap of Zinc Oxide- Nickel Oxide is higher than the pure Zinc Oxide which is also evident in SPSS result.

Keywords: Pure Zinc Oxide, Zinc Oxide- Nickel Oxide, Optical Properties, Absorbance, Band Gap, Novel Wet Chemical Synthesis.

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1. Introduction

Nanotechnology is one of the most rapidly developing disciplines of science and technology Researchers are interested in Zinc oxide nano composite due to its low toxic nature and different semiconductor properties like wide direct band gap energy, n-type conductivity, high exciton binding energy, large electron concentration, high thermal and mechanical stability and high optical transparency. Nanocomposites based on ZnO as a host semiconductor material have been provoked pronounced interest in several catalytic and photocatalytic applications, owing to their proficient electrochemical stability and better electrocatalytic behavior and Nickel oxide is aso been researched due to its better magnetic and electrical properties as a resultant that can be used for gas sensors, electrochemical capacitors, lithium ion batteries and so on, the Zinc oxide has its best optical,structural analysis and conductivity. Zinc oxide synthesis of nanocomposites might improve not only the resultant nanocomposites properties, namely thermal, mechanical and barrier properties and also facilitates additional functions and applications as antibacterial agents in food packaging industries.

The study conducted by Jlassi (Jlassi et al. 2014) said that due to its high electrical and mechanical properties Zinc Oxide- Nickel Oxide includes the construction of triglyceride biosensors (Narang, Chauhan, and Pundir 2013). Nickel Oxide can also be used in the catalysis process(Bhosale and Bhanage 2015). It enhances the bactericidal performance (Thambidurai et al. 2020).

In the last five years, several research papers of optical properties of Zinc Oxide- Nickel Oxide have been published. 16800 papers were published in google scholar. 19 publications were made in IEEE Xplore. The papers that were cited the most are "Structural and optical properties of nickel oxide nanoparticles: Investigation of antimicrobial applications, (Anand et al. 2020)" which was cited by 37. The other articles are "Structural, optical and electrochemical studies of organo-templated wet synthesis of cubic shaped nickel oxide nanoparticles, (Zahra and Ahmad 2020)", which has 20 citations.Our team has extensive knowledge and research experience that has translate into high quality publications(Bhavikatti et al. 2021; Karobari et al. 2021; Shanmugam et al. 2021; Sawant et al. 2021; Muthukrishnan 2021; Preethi et al. 2021; Karthigadevi et al. 2021; Bhanu Teja et al. 2021; Veerasimman et al. 2021; Baskar et al. 2021)

Our institution is keen on working on latest research trends and has extensive knowledge and research experience which resulted in quality publications (Rinesh et al. 2022; Sundararaman et al. 2022; Mohanavel et al. 2022; Ram et al. 2022; Dinesh Kumar et al. 2022; Vijayalakshmi et al. 2022; Sudhan et al. 2022; Kumar et al. 2022; Sathish et al. 2022; Mahesh et al. 2022; Yaashikaa et al. 2022). Chemical vapor deposition method, thermal decomposition, hydrothermal synthesis, solvothermal method, pulsed laser ablation, templating method, combustion method, microwave synthesis, gas phase method, mentioned works include highly sophisticated equipment with high cost. The quantity of the output produced in the above works is low. Thus, the novel wet chemical synthesis method was used to reduce those issues. It includes low cost and the output produced is high. The main aim of this work is to compare the optical characteristics of pure Zinc Oxide and Zinc Oxide- nickel Oxide and determine which nanocomposite among the two has higher optical characteristics.

2. Materials and Methods

This synthesis and the studies of the different nanoparticles were carried out in the Nanomaterials and crystal growth laboratory at Saveetha School of Engineering, Chennai. The work starts with synthesis of Nickel Oxide-Zinc oxide nanocomposite and the nickel oxide nanoparticles .UV analysis was carried out by UV spectrophotometer including the transmittance and absorbance of pure Zinc Oxide and Zinc Oxide-Nickel Oxide. The work was divided into 2 groups by using a novel wet chemical synthesis method. The sample size of each group is 234, which thus gives the overall sample size of 468. Sample Tests were computed using Clincalc with a pretest power of 80 % and the error correction of 0.05.

The fabrication was done using novel wet chemical synthesis and the annealing process. Residues were formed using Zinc Acetate and Nickel Sulphate. Zinc Oxide and Zinc Oxide- Nickel Oxide were prepared using wet chemical synthesis.

Preparation of Undoped Zinc Oxide

The pure Zinc Oxide is synthesized using the novel wet chemical synthesis. The molar concentration of Zinc Oxide is around 0.1 M and molecular weight is around 183.50 gm/mol. The calculated weight of the Zinc Oxide is 1.835 gms.

A beaker is washed with soap solution and ethanol. Then the beaker is filled with 100 ml distilled water. This beaker is placed on a magnetic stirrer and the contents are mixed well. Zinc acetate (1.835 gms) has to be added into the beaker containing distilled water. In a beaker containing 100 ml of distilled water, 4g of NaOH is added. 100 ml of NaOH solution should be taken through

the pipette and should be added drop by drop into a zinc acetate solution which is placed on the magnetic stirrer as seen in fig. 1. (a). Then, by the use of pipette, 10 ml of ammonia solution is taken. This ammonia solution should be added into the zinc acetate solution drop by drop. This solution turns into a milky white colour. After the stirring process the zinc acetate is heated up to 80º C for 1 hour. The obtained dry residue should be collected into a ceramic and is placed into the muffle furnace at a temperature of 300º C and then is cooled down to room temperature. The dry residue is taken out from the furnace which is the pure Zinc oxide which can be seen in fig. 1. (b). To obtain the transmittance and absorbance, the obtained pure Zinc Oxide was then subjected to UV spectroscopy.

Preparation of Zinc Oxide- Nickel Oxide

Sample preparation of group 2 i.e Zinc Oxide-Nickel Oxide was carried out, which is similar to that of the sample preparation of group 1. Zinc Oxide- Nickel Oxide consists of both Zinc Oxide and Nickel Oxide molar and molecular weights. Zinc Oxide has molar concentration of around 0.1 M and Molar concentration of Nickel Oxide is 0.1 M. Similarly, Molecular weight of Zinc Oxide is 183.50 gms and Nickel Oxide is 154.75 gms. Zinc acetate solution should be mixed with Nickel sulphate as seen in fig. 2. (a). The ammonia solution should be added into zinc acetate and Nickel sulphate solution drop by drop. This solution turns into a dark blue colour. Now the Nickel sulphate had to be heated upto 80º C for 1 hour. The obtained residue should then be placed in a muffle furnace over 300º C the annealed powder can be seen in fig. 2. (b). Thus Zinc Oxide- Nickel Oxide can be obtained.

Statistical Analysis

Analysis of components of optical data in which the independent variable was wavelength and dependent variables were intensity transmittance and absorbance was done using SPSS software. One way anova and descriptive statistics was done for obtaining mean, standard deviation and significance (Galt 2008).

3. Result

Optical properties of pure Zinc Oxide and Zinc Oxide- Nickel Oxide were compared in this work. Fabrication of the process was done using novel wet chemical synthesis and annealing techniques. The images of the solution and the nanocomposite powder after annealing are shown in fig. 1. (a) and 1. (b) respectively and fig. 2. (a) Formation of Zinc Oxide- Nickel Oxide solution and 2(b) obtained powder after annealing process. Fig. 3. Represents the absorbance of pure Zinc Oxide with the change in wavelength. Fig. 4. represents the absorbance of Zinc Oxide- Nickel Oxide with the change in wavelength. Fig. 5 represents the comparison of absorbance of pure Zinc Oxide and Zinc Oxide-Nickel Oxide. X axis denotes the wavelength and the Y axis represents the absorbance. Fig. 6 represents the bar graph in comparison to the absorbance of pure Zinc Oxide and Zinc Oxide-Nickel Oxide which was obtained using SPSS software.

Descriptive statistics comparison of pure Zinc Oxide and Zinc Oxide- Nickel Oxide was performed in Table 1. The respective mean are 1.8257973 and .4588671. Table 2 shows the results of an independent sample test of pure Zinc Oxide and Zinc Oxide-Nickel Oxide. Significance of 0.001, 0.001 was obtained respectively and had the standard error of 14.18920 & .19580238.

4. Discussion

The figure shows the prepared component of zinc oxide and zinc oxide nickel oxide and from table 1 it can be understood that the mean absorbance of zinc oxide is comparatively more compared to zinc oxide nickel oxide.

The absorbance study of pure Zinc Oxide is higher in study of (Manzoor et al. 2020) and it is similar to this research in which the absorbance of Zinc Oxide-Nickel Oxide is lower than the pure Zinc Oxide. In the work done by (Elilarassi and Chandrasekaran 2010), the absorbance of pure Zinc Oxide and Zinc Oxide- Nickel Oxide were compared and the results shows that pure Zinc Oxide has higher absorbance compared to Zinc Oxide- Nickel Oxide. It is similar to this proposed findings that pure Zinc Oxide has higher absorbance compared to Zinc Oxide- Nickel Oxide.

Coprecipitation method was adapted for formation of Zinc Oxide- Nickel Oxide nanoparticles with different concentrations of nickel at 550°C in the work of (. and Mayekar . 2015). But in this research the temperature used for the preparation was 500℃ by the novel wet chemical synthesis method. In the work done by (Saravade et al. 2020) Zinc Oxide-Nickel Oxide was grown on sapphire by metal organic chemical vapor deposition (MOCVD) with varying Ni content under two growth conditions of 400°C/100 Torr and 450°C/30 Torr. But in this research the temperature used for the preparation was 500℃ by the novel wet chemical synthesis method.

The main limitation of this work is that the observations done by us are not highly accurate when compared to the observations made using

sophisticated equipment. The future scope is to improve accuracy using this method.

5. Conclusion

From this project, optical properties of pure Zinc Oxide and Zinc Oxide- Nickel Oxide were obtained. The optical band gap of pure Zinc oxide is 6.97 eV and Zinc oxide-Nickel oxide is 1.5 eV. Nickel doped Zinc oxide produce consistent results and pure zinc oxide produce variable results.

Declaration

Conflict Of Interest

There is no conflict of interest in this work.

Authors Contribution

Author NTK was involved in data collection and data analysis. Author SRM was involved in conceptualization, data validation and critical review of manuscript.

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Tables and Figures

Table 1. Comparison of transmittance and absorbance of pure Zinc Oxide and Zinc Oxide- Nickel Oxide. The mean of pure Zinc Oxide and Zinc Oxide- Nickel Oxide are 500 and 500 respectively. The standard deviation is 174.07087.

Groups		**N**	**Minimum**	**Maximum**	**Mean**	**Std. Deviation**
Pure Zinc Oxide	**Absorbance**	234	-0.27300	9.999	1.8257973	3.10341281
	Groups	234	2.00	2.00	2.00	0.00

	Valid N(listwise)	234				
Zinc Oxide-Nickel Oxide	**Absorbance**	234	0.11700	9.999	0.4588671	1.38157120
	Groups	234	2.00	2.00	2.00	0.0000
	Valid N(listwise)	234				

Table 2. Comparison of independent sample test of pure Zinc Oxide and Zinc Oxide- Nickel Oxide. The significance of pure Zinc Oxide and Zinc Oxide- Nickel Oxide is 0.001. The standard error is 14.18920 and the mean difference is .00000.

		Levene's Test for Equality of Variances		**t-test for Equality of Means**						
		F	**Sig.**	**t**	**df**	**Sig. (2-tailed)**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
									Lower	**Upper**
1	**Equal variances assumed**	0.000	0.001	.000	600	1.00	.00000	14.18920	-27.86653	27.86653
	Equal variances not assumed			.000	600.000	1.000	.00000	14.18920	-27.86653	27.86653
2	**Equal variances assumed**			6.981	600	.000	1.36693023	.19580238	.98238892	1.75147154

3	**Equal variances not assumed**			6.981	414.416	.000	1.36693023	.19580238	.98204055	1.75181991

Fig. 1. (a) Pure Zinc Oxide preparation using novel wet chemical synthesis method (b) Zinc Oxide nanocomposite after annealing.

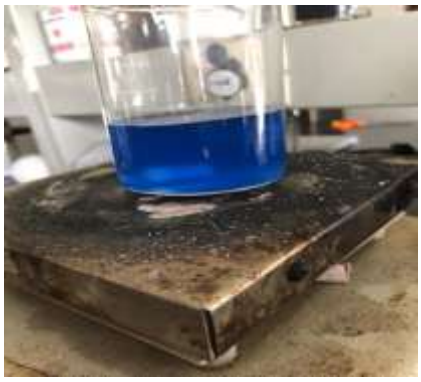

Fig. 2. (a) Preparation of Zinc Oxide- Nickel Oxide using Novel wet chemical synthesis. (b) Zinc Oxide- Nickel Oxide nanocomposite Formation after annealing.

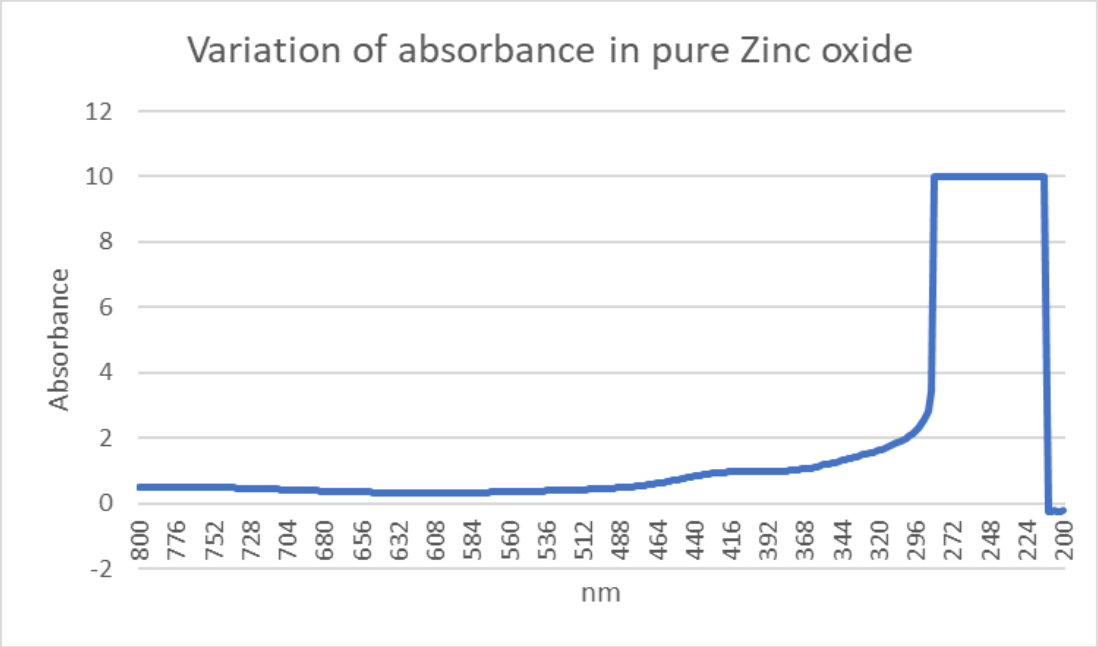

Fig. 3. Absorbance of pure Zinc Oxide with change in wavelength. Absorbance of pure Zinc Oxide is increased from 800 nm to 296 nm and then there is a constant absorbance from 296 nm to 224 nm. The absorbance was decreased from 224 nm to 200 nm.

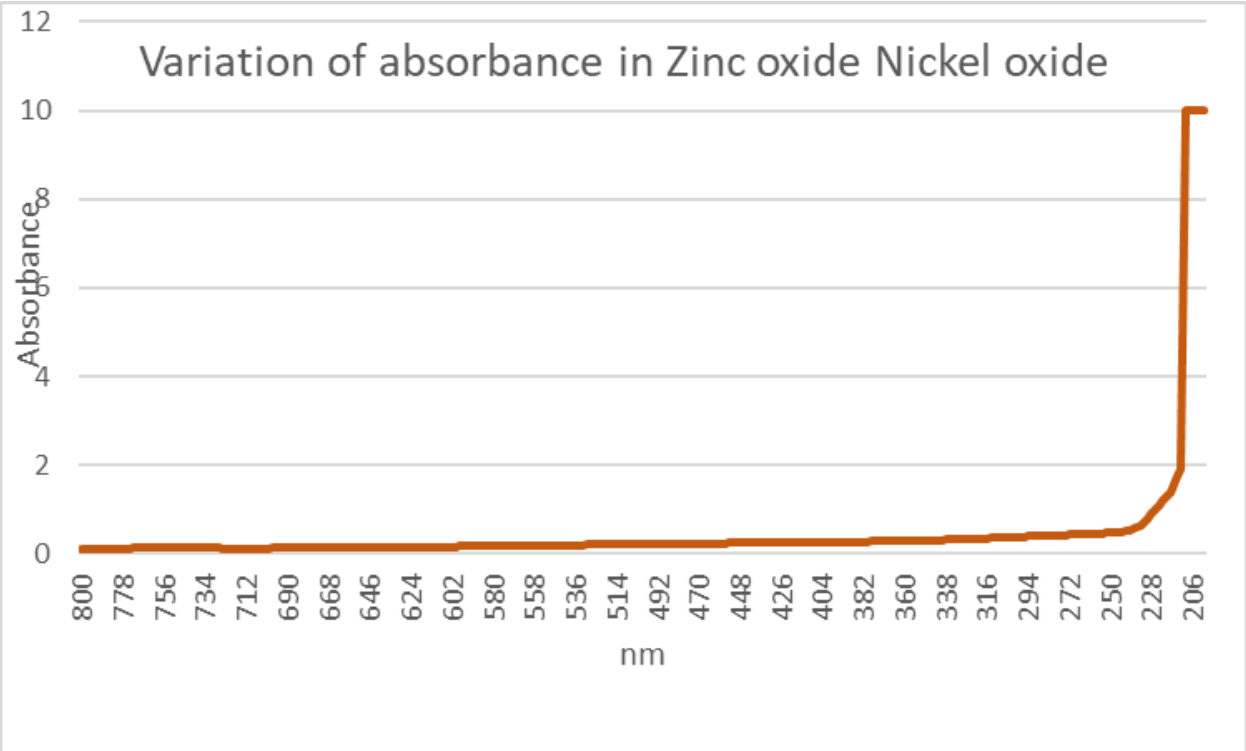

Fig. 4. Absorbance of Zinc Oxide- Nickel Oxide with change in wavelength. Absorbance of Zinc Oxide- Nickel Oxide was increased gradually from 800 nm to 228 nm and then there is a sudden rise in absorbance from 228 nm to 206 nm.

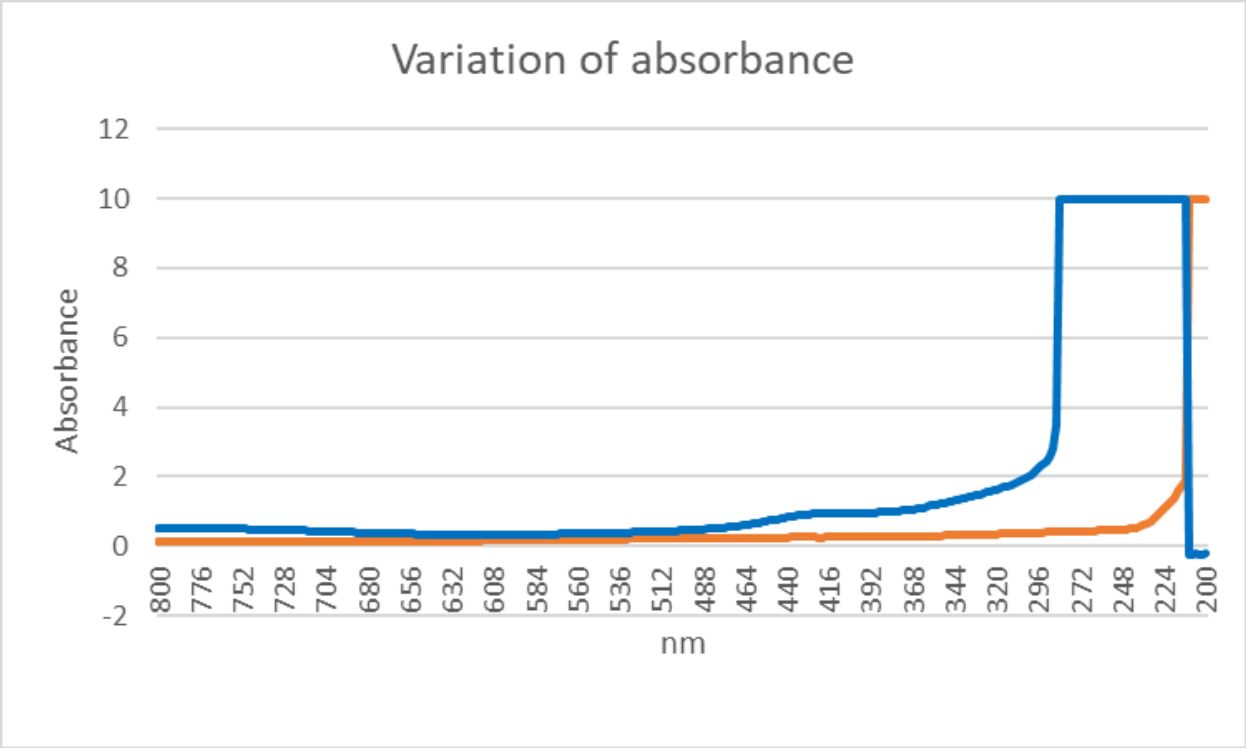

Fig. 5. Comparison of the absorbance of pure Zinc Oxide and Zinc Oxide- Nickel Oxide. X axis denotes wavelength and Y axis represents absorbance.

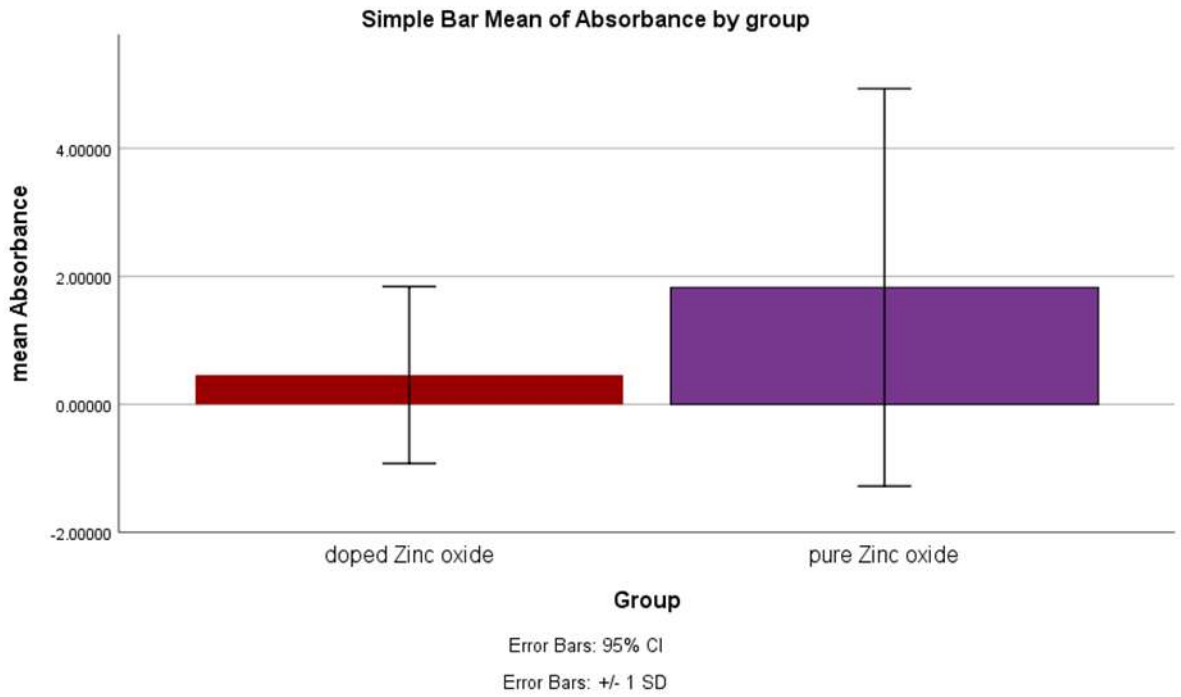

Fig. 6. Bar chart representing the comparison of absorbance of pure Zinc Oxide and Zinc Oxide- Nickel Oxide. This is obtained by using SPSS with +/-1 SD. Pure Zinc Oxide has higher absorbance than the Zinc Oxide-Nickel Oxide. Nickel doped Zinc oxide produces consistent results and pure zinc oxide produces variable results.