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## SYNTHESIS AND STUDY OF NOVEL MATERIAL USING ZINC OXIDE AND PVA

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### ABSTRACT

Developing novel composite polymeric materials with characteristics is vital for crucial research and electrical applications in numerous fields. Using the solution casting method, the blend of the hydrophilic (polyvinyl alcohol (PVA) as host carriers for important metal oxide particles of ZnO. The precursors are zinc dust, Polyvinylacetate, sodium hydroxide, acetic acid, HCl, methanol. PVA-ZnO composite has been characterized by FTIR. The presence of the O–H group on the PVA polymers was identified by the remarkable Fourier transform-infrared (FT-IR) analysis. These materials have found use in applications such as photovoltaics, semiconductors, electrodes, seed germination, sensors, biomedical, and water purification etc. In present study, the impact on intensity of %transmittance and stretching vibration band due to ZnO in PVA-ZnO composite is observed.

**Keywords:** Novel Material, 2D material, Physico chemical analysis.

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### I. INTRODUCTION

Several efforts have been made to modify the structures of transition-metal oxides with the use of template techniques, chemical processes, and replication techniques. High-performance sensors can be developed using the characteristics of 2D materials. Materials classified as (2D) are crystalline, single-layer materials made up of a single atomic layer. Transition metal oxides, are compounds made of transition metals and oxygen having characteristic physical and chemical properties, they are essential in many scientific, industrial, and technical applications. To improve these characteristics, TMO works with 2D materials.

The main objective of this research paper is to reveal the study of physicochemical analysis of some transition metal oxides for the applicability to contribute in electrical properties enrichment of 2D materials. These materials have found use in applications such as photovoltaics, semiconductors, electrodes and water purification [1-4].

This research paper is to reveal some information of novel compounds, predicted to be easily exfoliable from a parent bulk compound, with anisotropies that largely outscore those of already known 2D materials. Outcomes of this work will provide a comprehensive reference for future studies of anisotropic response in thin crystals and point to new materials for the next generation of anisotropic 2D devices. Transition metal oxides are preferred materials for catalytic applications due to their half-filled d-orbitals that make them exist in different oxidation states.

However, they show lower catalytic activity toward ORRs. To improve this shortcoming, it is to be hybridized with inert metals or carbon-based materials. The hybrid cathode will show highest power density as compared with pure MnO<sub>2</sub> catalyst.

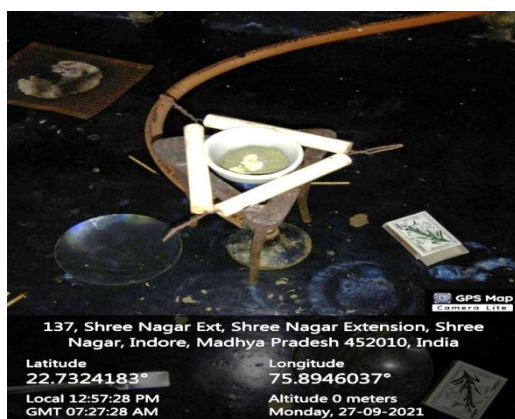
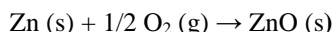
In this paper future prospects, and challenges for the development of sensors based on 2D materials are also discussed for future advancements. 2D-nanomaterial-based electrochemical sensors [5-8] that can be used to check for contaminations from heavy metals, organic/inorganic compounds, poisonous gases, pesticides, bacteria, antibiotics, *etc.*, in water or air, which are severe risks to human wellbeing as well as the environment. It has also been discussed the advances made in the field of infrared photodetectors and electrochemical sensors and how the structural properties of 2D nanomaterials affect sensitivity and performance.

## II. MATERIALS AND METHODS

Applications for zinc oxide (ZnO) are numerous and include electronics, biomedical devices, optics, and catalysis. Depending on the desired morphology, purity, and use, different preparation techniques are used. These are common methods for ZnO synthesis.

### SYNTHESIS OF ZINC OXIDE

Zinc oxide (ZnO) was prepared by thermal oxidation process. 11.63 g of zinc dust (grey powder) was taken in crucible then heated directly on flame for 2 hr off-white color powder consist of zinc oxide appears. Thermal oxidation takes place but at very less extent. For complete oxidation of zinc dust requires 3-4 hr heating around 400 to 800 °C temperature in muffle furnace.



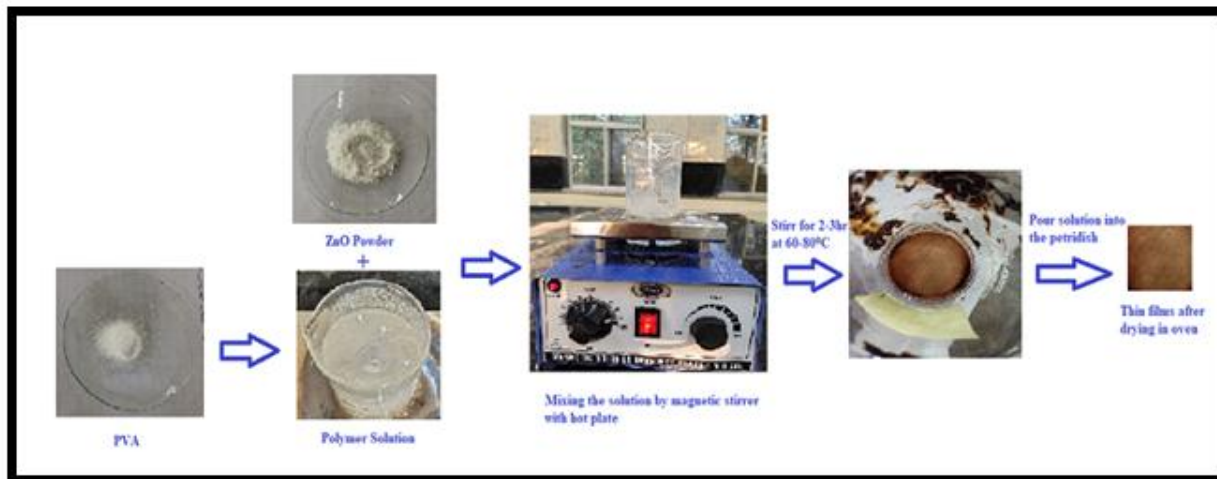
*Scheme 1. Displays the preparation of ZnO formation.*

### PREPARATION OF POLY VINYL ALCOHOL

Exactly 1 gm of Polyvinyl acetate (PVAc) is dissolved in a mixture of ethanol and water. The temperature has been maintained at around 60–80°C to ensure proper dissolution. The solution stirred continuously to achieve a homogeneous mixture, a measured amount of sodium hydroxide solution has been added to the PVAc solution [9]. The catalyst facilitates the hydrolysis (saponification) of PVAc into PVA and acetic acid. The reaction mixture has been maintained at 60–80°C and stir continuously. The reaction progress monitored [10]. Partial hydrolysis yields partially hydrolyzed PVA, while complete hydrolysis produces fully hydrolyzed PVA. Once the desired degree of hydrolysis is achieved, the reaction mixture has been neutralized by adding a weak acid (e.g., acetic acid or hydrochloric acid). This step prevented further reaction and stabilizes the PVA solution. The PVA precipitated by pouring the reaction mixture into a large volume of cold water. The PVA precipitate has been collected by filtration or centrifugation. The precipitate washed multiple times with water to remove residual catalysts and by-products. The washed PVA dried under in an oven at a low temperature (50–70°C) until a constant weight is achieved.

### III. PREPARATION OF PVA-ZNO COMPOSITE THIN FILMS

Exactly 1g of PVA dissolved in 30 ml of distill water. The temperature has been maintained at around 60-80°C to ensure proper dissolution. The solution stirred continuously to achieve homogeneous mixture. 0.1 g of ZnO is dissolved in methanol by continuous stirring at room temperature reaction pH is maintained between 4-6 by adding few drops of HCl. Then ZnO solution was added dropwise to PVA solution with continuous stirring for 2-3 hr. The reaction temperature is maintained between 60-80°C until solution get concentrated and turns into transparent brown viscous fluid of PVA-ZnO composite. Thin film has been made by spreading the fluid in glass dishes. And left for drying in oven at 35°C for five days.



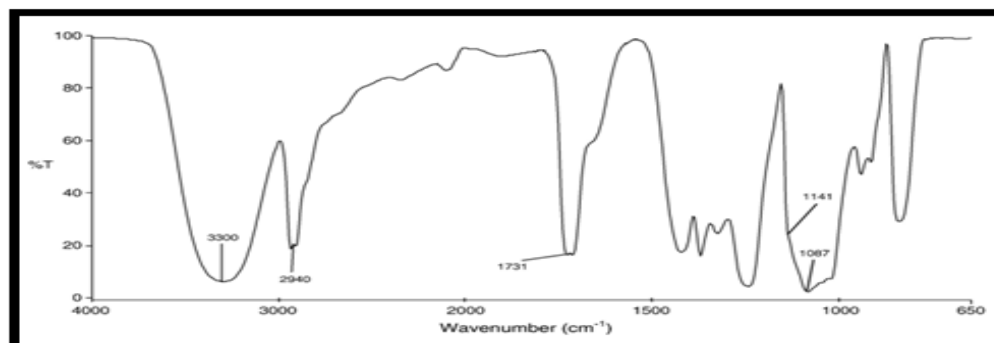
*Scheme. 2. Illustration of the preparing sheets using the solution casting technique.*

#### IV. CHARACTERIZATION TECHNIQUE FOURIER TRANSFORM INFRARED SPECTROSCOPY CHARACTERIZATION

Fourier Transform Infrared Spectroscopy (FTIR) was used to characterize the presence of specific chemical groups in the materials. PVA films and PVA-ZnO composite were obtained as 1–2 mm thick films and analyzed by FTIR using Transmittance Mode. FTIR spectra were obtained in the range of wavenumber from 4000 to 500  $\text{cm}^{-1}$  during 20 scans, with 2  $\text{cm}^{-1}$  resolution (SHIMADZU 8400 spectrophotometer). The FTIR spectra were normalized and major vibration bands were associated with chemical groups

#### V. RESULTS AND DISCUSSIONS CHARACTERIZATION BY FTIR SPECTROSCOPY

Table 1 shows the most characteristic bands of PVA and their respective assignment. Fig.1 shows the FTIR spectra of PVA. All major peaks related to hydroxyl group were observed. The large bands observed between 3550 and 3200  $\text{cm}^{-1}$  are linked to the stretching O–H from the intermolecular and intramolecular hydrogen bonds (Fig.1). The vibrational band observed between 2840 and 3000  $\text{cm}^{-1}$  refers to the stretching C–H from alkyl groups (Fig.1) and the peaks between 1750–1735  $\text{cm}^{-1}$  (Fig.1) are due to the stretching C=O and C=O from acetate group remaining from PVA.



*Fig-1 FTIR spectra of PVA*

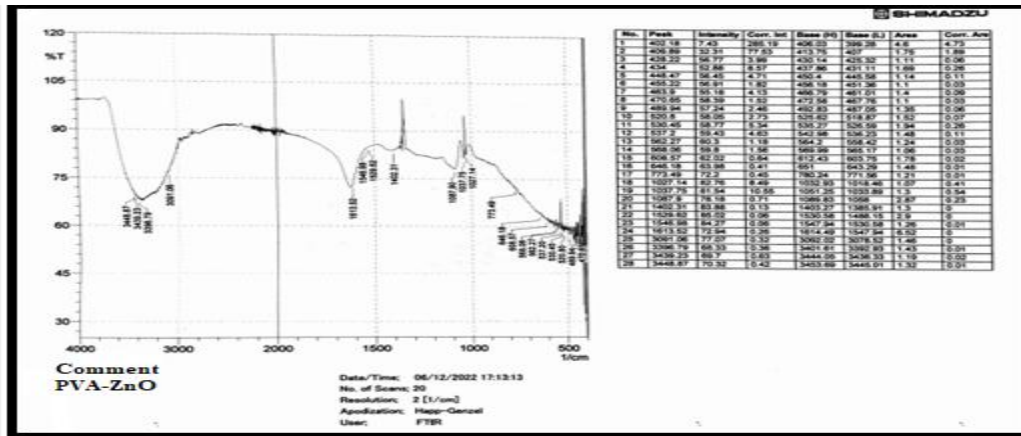


Fig-2 FTIR spectra of PVA-ZnO (Original)

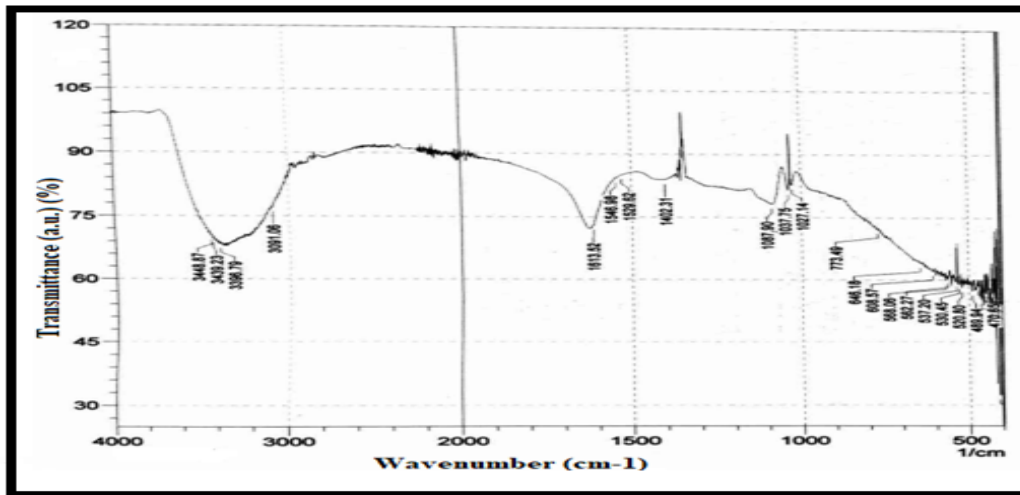


Fig-3 FTIR spectra of PVA-ZnO composite thin film (Extracted)

Table-1 FTIR spectral data for PVA-ZnO Composite thin film

S. No.	Peak	Intensity	Corr. Int
1	402.18	7.43	295.19
2	400	3231	77.53
3	428.22	58.77	3.99
4	434	52.68	8.57
5	448.47	56.45	4.71
6	455.22	50.91	1.82
7	483	55.18	4.13
8	470.65	58.39	1.52
9	489.04	57.24	2.46
10	520.08	58.06	2.73
11	530.45	58.77	5.34
12	537.2	56.43	4.63
13	562.27	60.3	1.18
14	568.06	59.8	1.56
15	608.57	62.02	0.64
16	545.18	63.93	0.41

17	773.49	72.2	0.45
18	10027.14	276	8.49
19	1037.75	51.54	10.55
20	1087.9	28.18	0.71
21	1402.31	83.88	0.13
22	1529.62	85.02	0.06
23	1548.93	54.27	0.06
24	1613.52	72.94	0.26
25	3091.06	77.07	0.32
26	3396.79	68.33	0.38
27	3439.23	68.7	69.7
28	3448.87	70.32	0.42

**Table-2** Vibration modes and band frequencies in PVA and PVA-ZnO composite

Identification	Chemical group		Wavenumber (cm <sup>-1</sup> )	References
1	PVA	O–H from the intermolecular and intramolecular hydrogen bonds	v 3550–3200	[11-14]
	PVA+ZnO	O–H from the intermolecular and intramolecular hydrogen bonds	v 3550–3200	
2	PVA	C–H from alkyl groups	v 2840–3000	
	PVA+ZnO	C–H from alkyl groups	v 2840–3091	
3	PVA	C=O	v 1750–1735	
	PVA+ZnO	C=O	v 1613–1635	
4	PVA	C–O (crystallinity)	v 1141	[15]
5	PVA	C–O–C	v 1150–1085	[11-14]
	PVA+ZnO	C–O–C	v 1150–1085	
6	PVA	CH <sub>2</sub>	δ 1461–1417	[11-14]
7	PVA+ZnO	Zn–O	v 530	

The FTIR spectra to PVA crosslinked with ZnO is presented in Fig.3. The reaction of the PVA with the ZnO results in a considerable reduction of the intensity of the O–H peaks (region (I) in Fig.3) from the composite, indicating a possible formation of acetal bridges. For instance, FTIR spectra of PVA-ZnO samples (Fig.3) reveal bands at ( $\nu=3091\text{--}2840\text{ cm}^{-1}$ ) signifies the C-H stretching, (Fig.3) a duplet absorption with peaks attributed to the alkyl chain [16]. Also, strong band from carbonyl group was verified (C=O at  $\nu=1613\text{--}1635\text{ cm}^{-1}$ ). These bands are overlapping and broadening PVA bands in these regions. In addition to that, by crosslinking PVA with ZnO, the O–H stretching vibration peak ( $\nu=3396\text{--}3440\text{ cm}^{-1}$ ) was relatively decreased when compared to pure PVA. Stretching vibration peak ( $\nu=1141\text{ cm}^{-1}$ ) for C-O crystallinity. C-O-C stretching vibration peak ( $\nu=1085\text{--}1150\text{ cm}^{-1}$ ) which remained almost constant. CH<sub>2</sub> Bending vibration peak ( $\delta=1417\text{--}1461\text{ cm}^{-1}$ ) which is constant. Polymer composite thin films show the same pattern with additional stretching band at ( $\nu=530\text{ cm}^{-1}$ ) which is due to Zn-O vibrations. It is apparent from the fig.3 that the intensity of peaks is getting decrease with addition of ZnO. It is due to the compatibility of ZnO with polymer.

## VI. CONCLUSION

PVA-ZnO Composites are useful in various fields such as:

- *Biomedical*: Wound dressings, drug delivery systems, and antimicrobial coatings.
- *Packaging*: Enhanced UV protection and antimicrobial activity for food packaging materials.
- *Optoelectronics*: Transparent conductive films and sensors.
- *Environmental*: Water purification membranes and pollutant removal systems.

The FTIR analysis provides a comprehensive understanding of the chemical interactions in PVA-ZnO composites, which are crucial for tailoring their properties for specific applications.

In summary, ZnO significantly enhances the physical and chemical properties of PVA by providing improved mechanical strength, thermal stability, UV resistance, and functional properties like antimicrobial activity and

barrier performance. The extent of enhancement depends on the size, concentration, and dispersion of ZnO particles in the PVA matrix.

#### Conflict of Interest

The writers have indicated that they have no conflicts of interest.

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None

#### Authors' Contributions

Author-1 performed experiments and researched literature and conceived the study. Author-2 involved in protocol development. Both authors reviewed and edited the manuscript and approved the final version of the manuscript.

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