



**BHARATA MATA COLLEGE  
THRIKKAKARA**

Re-accredited by NAAC with A+ Grade

**DEPARTMENT OF PHYSICS**

AFFILIATED TO  
**MAHATMA GANDHI UNIVERSITY**  
**(2020-2023)**

A PROJECT REPORT ON  
**“COMPARATIVE STUDY ON OPTICAL AND  
DIELECTRIC PROPERTIES OF PVA AND  
SILVER DOPED PVA”**

SUBMITTED BY:  
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## **CERTIFICATE**

This is to certify that the project report entitled “ **COMPARATIVE STUDY ON OPTICAL AND DIELECTRIC PROPERTIES OF PVA AND SILVER DOPED PVA**” is an original work carried out by **SANDHRA SEBASTIAN**, Reg. no. **200021036544**, for partial implementation of the requirement for the award of a degree BACHELOR OF SCIENCE IN PHYSICS through the Research And Post Graduate Department Of Physics, Bharata Mata College, Thrikkakara, affiliated to Mahatma Gandhi University, Kottayam, Kerala.

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## DECLARATION

I, **SANDHRA SEBASTIAN**, at this moment, declare that this project report entitled “**COMPARATIVE STUDY ON OPTICAL AND DIELECTRIC PROPERTIES OF PVA AND SILVER DOPED PVA**” is an original work carried out during my course of study under the guidance of Dr. Anu Philip, Head of the Department, Research And Postgraduate Department of Physics, Bharata Mata College Thrikkakara.

SANDHRA SEBASTIAN

## ACKNOWLEDGEMENT

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I also profoundly acknowledge my gratitude towards my family, who always supported me morally and economically.

## ABSTRACT

The paper entitled “ **Comparative Study on Optical and Dielectric Properties of PVA and Silver Doped PVA.**” Solution casting was used to assemble the PVA nanocomposite film. PVA (polyvinyl liquor) cross-breed nanofibers using an electrospinning procedure. The obtained nanofibers were confirmed using UV-Vis, X-ray diffraction (XRD), and Fourier transform infrared (FTIR) spectroscopy. PVA (polyvinyl liquor) cross-breed nanofibers using an electrospinning procedure. The obtained nanofibers were secured using UV-Vis, X-ray diffraction (XRD), and Fourier transform infrared (FTIR) spectroscopy. This study focuses on finding the most simple and effective PVA and Silver Doped PVA method.

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## CHAPTER - 1

### INTRODUCTION

Polymeric materials are exciting in scientific and technical research because they may be modified to satisfy specific needs for various applications. Polyvinyl alcohol (PVA), derived primarily from hydrolysis polyvinyl acetate, is easily degradable by biological organisms and is a water-soluble crystalline structure polymer. PVA is an artificial polymer widely utilized in the first part of the twentieth century. This is mainly owing to its small weight, high mechanical strength, optical, x-ray diffraction, band gap, and dielectric characteristics. Polyvinyl alcohol (PVA) is an essential polymeric substance since it has various applications in industry and is very inexpensive to produce. It has the potential to be employed as a solid polymer electrolyte. In a solid-state electrochromic display doped with phosphoric acid, solid-state Photocells or steric stabilizers are used to generate conducting polymer dispersion. PVA is one of the few biodegradable synthetic resins derived from petroleum that can reduce white environmental pollution. PVA film materials are outstanding in barrier, transparency, toughness, and biocompatibility. PVA is a water-based emulsion of a common glue type known as wood, white, carpenter, school, or PVA. PVA primarily increases stress and anti-shrink qualities in glass fiber-reinforced polymers. PVA is employed in various medical applications due to its biocompatibility, low protein adhesion propensity, and low toxicity. Particular applications include cartilage replacements, contact lenses, and eye drops. Polyvinyl alcohol is used to help in the polymerization of suspensions. Its most widespread application is in China as a protective colloid to manufacture PVA dispersions. Its principal use in Japan is the manufacturing of vinyl on fiber. This

fiber is also produced in North Korea for self-sufficiency because it does not require oil. Photographic film is another use. PVA-based polymers are commonly utilized in additive manufacturing. Polyvinyl alcohol is a versatile solvent with outstanding film-forming, emulsifying, and adhesive capabilities. It is also oil, grease, and solvent resistant. It has a high tensile strength, is flexible, and has excellent oxygen and scent barrier qualities. However, these qualities are humidity dependent: water absorbed at greater humidity levels is a plasticizer, lowering tensile strength while boosting elongation and grip strength.

For optoelectronics applications, solution-cast nanocomposite films of polyvinyl alcohol (PVA) and silver (Ag) are synthesized. The X-ray diffraction (XRD), transmission electron microscopy (TEM), and UV absorbance measurements all verified that the nanocomposite films with uniform silver nanoparticles (Ag) incorporated in the PVA blend were successfully synthesized. The optical bandgap of PVA/PANI blends and PVA/Ag nanocomposites is evaluated by UV absorbance, which is lower than that of a pure PVA film. Meanwhile, the Urbach energy, absorption edge ( $E_d$ ), and several carbon clusters ( $N$ ) were calculated. PVA and Ag effects on reflection, refractive index, extinction coefficient, real and imaginary dielectric constants, and optical conductivity are also studied. The findings show that the visual characteristics of PVA polymer are excellent. We chose the polymer polyvinyl alcohol (PVA) as the hosting matrix for this study because of its high dielectric strength ( $>1000$  kV/mm) and dopant-dependent electrical characteristics. Doping  $Ag^+$  in a polymeric system is predicted to improve its electrical features since  $Ag^+$  is a fast-conducting ion in various materials. Composite parts can be enhanced further using UV-irradiation, annealing, and Gamma-ray irradiation. Irradiation is a widely used method for modifying the attributes of nanocomposite



films. The current experiment will use an electrometer and an RLC Bridge to investigate the influence of irradiation on the electrical and dielectric characteristics of PVA-Ag nanocomposite films. The dielectric permittivity of the bulk material may disclose the presence of dipoles. One benefit of studying dielectric behavior is that it aids in understanding the conductivity behavior of polymer electrolytes. UV irradiation can be used to create anti-reflective coatings and bandpass filters. With increased UV exposure duration, the reflectance of these irradiated nanocomposites has reduced, resulting in a rise in refractive index (RI) across the visible region. The optical energy gap of the PVA film was decreased from 4.92 to 4.57 eV after doping with Ag nanoparticles, and it was further reduced to 4.1 eV after 300 minutes of UV exposure. This decrease in optical energy gap can be attributed to the creation of charge transfer complexes inside the base polymer network due to the incorporation of Ag nanoparticles, which improves with increasing exposure time. Such complexes may also be to blame for the higher molecular density of composite films, which corresponds to a drop in reflectance that corroborates the reported results. In this correspondence, we center around dielectric unwinding and electrical conductivity conduct of PVA-Ag nanocomposite films at room temperature with differing convergence of artificially pre-arranged silver nanoparticles. Numerous analytical methods, Fourier Transformation Infrared Spectroscopy (FTIR), Ultraviolet-Visible Spectroscopy (UV), and X-ray Diffraction (XRD), have been utilized to assess the polymer. To investigate how silver affects the optical characterization of the polyvinyl alcohol (PVA) – silver composites, we look into combining the characteristics of organic and inorganic materials.

## CHAPTER - 2

### MATERIALS AND METHOD

#### 2.1 - CHEMICAL METHOD

##### MATERIALS

PVA with different weight percentages and Silver Nitrate with varying weight rates was taken from our college's chemistry laboratory.

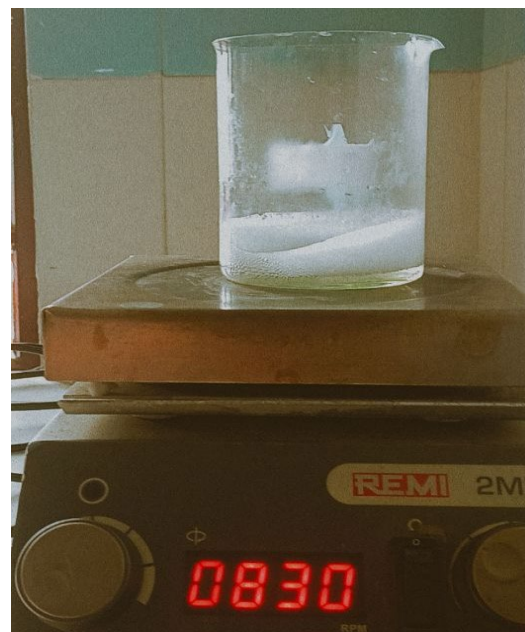
##### METHOD

The solution casting method prepared the PVA solution films with different amounts of AgNo<sub>3</sub> dopant. 0.75g of PVA powder was added to a beaker with 20 ml of distilled water and stirred for 30 minutes. 10 ml of standard PVA solution was poured into a Petri dish. Silver nitrate weighing 0.125g was taken in a classic flask and made with redistilled water. PVA with the same weight percentage was added to 20ml of distilled water and stirred for 20 minutes. After that, add 5 ml of silver nitrate to the solution and stir for another 10 minutes. 10 ml of silver doped PVA solution poured into a petri dish. Homogenous films were obtained after drying in an air oven for 48 hrs at 60 degrees Celsius. The characteristics absorption peak of pure PVA 190nm-280nm. The frequency, optical and dielectric properties of pure PVA and silver-doped PVA films are obtained.

PURE PVA FILM



SILVER DOPED PVA FILM



## 2.2 – CHARACTERIZATION TECHNIQUES

### FOURIER TRANSFORM INFRARED SPECTROSCOPY (FTIR)

An infrared spectrum of a solid, liquid, or gas's absorption or emission can be obtained using this method. Over a broad spectral range, an FTIR spectrometer simultaneously collects high-resolution spectral data. On the other hand, a dispersive spectrometer measures intensity over a limited number of wavelengths at once, providing a significant advantage. The fact that a mathematical procedure known as a Fourier transform is required to transform the raw data into the actual spectrum is where the term "Fourier-transform infrared spectroscopy" comes from. The objective of techniques for absorption spectroscopy is to determine the amount of light absorbed by a sample at each wavelength. The "dispersive spectroscopy" method, which shines a monochromatic light beam at an example, measures how much of the light is absorbed, and repeats for each distinct wavelength, is the most straightforward approach. The same information can be obtained using the less intuitive method of Fourier transform spectroscopy. Instead of focusing on a monochromatic light emission in the example, this procedure focuses on a pillar containing numerous frequencies of light immediately. It measures the amount of that bar consumed by the model. The following step adds a new set of frequencies to the beam, resulting in a second data point. Over a brief period, this procedure is rapidly repeated numerous times. After that, a computer processes all the data and works backward to deduce absorption wavelengths. The Fourier transform is a standard algorithm; this is the necessary processing. The Fourier changes over one space into its converse area

(wavenumbers in  $\text{cm}^{-1}$ ). The crude information is called an "interferogram". Stray light, or radiation that appears at a different wavelength in the spectrum affects it less. Accidental reflections in dispersive instruments and flaws in the diffraction gratings cause this. Since the interferometer's modulation frequency determines the apparent wavelength, FT instruments have no direct equivalent.

### **UV-VISIBLE SPECTROSCOPY**

The term "UV spectroscopy," also known as "UV-visible spectrophotometry," "UV-Vis," or "UV/Vis," refers to both absorption and reflectance spectroscopy in the visible and ultraviolet portions of the electromagnetic spectrum. Being somewhat economical and effectively executed, this technique is broadly utilized in different applied and significant applications. The primary prerequisite is that the example retains in the UV-Vis district, for instance, be a chromophore. Fluorescence spectroscopy can be used in conjunction with absorption spectroscopy. Other than the wavelength of the measurement, the parameters of interest are the absorbance (A), transmittance (%T), or reflectance (%R) and how they change over time. UV/Vis spectroscopy is frequently used in analytical chemistry to quantify various analytes or samples, including biological macromolecules, highly conjugated organic compounds, and transition metal ions. The spectroscopic examination is usually completed in arrangements, yet solids and gases may likewise be contemplated. Absorption peaks' wavelengths help determine a molecule's functional groups because they can be linked to the kinds of bonds in that molecule. For instance, a set of empirical observations known as

the Woodward–Fieser rules are used to predict  $\lambda_{max}$ , the wavelength at which conjugated organic compounds like ketones and dienes absorb the most UV/Vis light. However, the spectrum is not a specific test for any given sample. The solvent's nature, the solution's pH, temperature, high electrolyte concentrations, and contaminating substances can affect the absorption spectrum. Experimental variations like the spectrophotometer's slit width (adequate bandwidth) will also alter the range. These variables must be controlled or accounted for to identify the substances present and apply UV/Vis spectroscopy to analysis. In addition, the semiconductor industry uses UV–Vis spectroscopy to measure thin films' thickness and optical properties on a wafer. The Forouhi–Bloomer dispersion equations can be used to analyze the reflectance measured by UV–Vis spectrometers to determine a film's index of refraction and extinction coefficient across the estimated spectral range.

## **X-RAY DIFFRACTION**

X-ray diffraction (XRD) is a versatile non-destructive method for analyzing powder, solid, and liquid samples' physical properties like phase composition, crystal structure, and orientation. Tiny crystallites make up many materials. Their "phase" refers to these crystals' chemical composition and structural type. Materials can be single-stage or multiphase combinations and may contain glasslike and non-translucent parts. In an X-beam diffractometer, different glasslike locations give different diffraction designs. Stage recognizable proof can be performed by contrasting X-beam diffraction designs from obscure examples to

designs in reference data sets. In a crime scene investigation, this procedure is analogous to matching fingerprints. The International Center of Diffraction Data (ICDD) manages the most extensive compound database. You can construct a reference data set from estimated unadulterated stage diffraction designs, designs distributed in the analytical writing, or your estimations. In a multiphase mixture, the total composition of a sample can be ascertained by comparing the relative strengths of the patterns from the various phases. The source's X-rays illuminate the model. It then enters the detector after being diffracted by the sample phase. The intensity is measured, and diffraction data are recorded by moving the tube or sample and detector to change the diffraction angle (the angle between the incident and diffracted beams). Contingent upon the math of the diffractometer and the sort of test, the point between the occurrence shaft and the example can be either fixed or variable and is generally matched with the diffracted bar point. XRD is often the fastest, most accurate, and most dependable method for identifying unknown materials. Due to its low sample preparation requirements, this method is well-liked and suitable for materials research and industrial process applications. Data analysis can be relatively simple if the appropriate analytical software is utilized. It can even be automated for industrial processes, eliminating the need for an XRD expert operator in QC applications. High-resolution heteroepitaxial layers (HR-XRD), the study of which uses both Bragg's Law and dynamical diffraction theory, are other X-ray diffraction techniques for materials that are not polycrystalline, such as single crystal semiconductor wafers or epitaxial layers.

## **DIELECTRIC MEASUREMENTS**

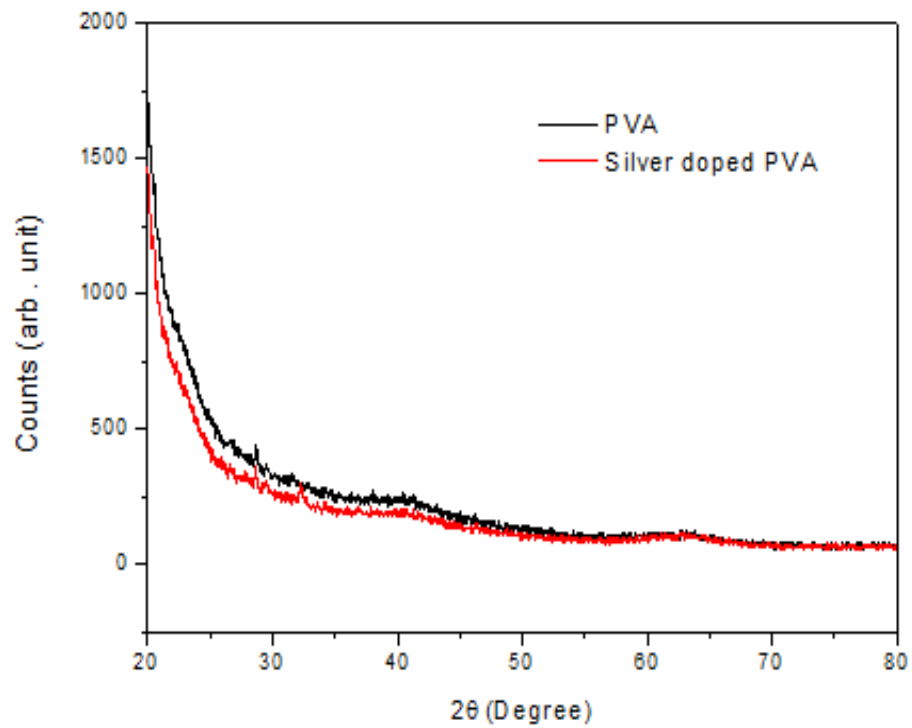
Measures the dielectric properties of a medium as an element of recurrence. It is based on the interaction of the sample's electric dipole moment with an external field, typically represented by the permittivity. Additionally, it is an experimental approach to defining electrochemical systems. The system's frequency response, including the properties of energy storage and dissipation, is revealed by measuring the impedance of a system across a range of frequencies. Typically, a Bode or Nyquist plot graphically represents data obtained through electrochemical impedance spectroscopy (EIS). The components of energy dissipation and energy storage comprise a passive complex electrical system. The opposition to AC or direct current is merely resistance if the system is purely resistive. Materials or strategies displaying numerous stages (like composites or heterogeneous materials) usually show a widespread dielectric reaction, by which dielectric spectroscopy uncovers a power regulation connection between the impedance and the recurrence,  $\omega$ , of the applied AC field. Practically any physicochemical framework, like electrochemical cells, mass-shaft oscillators, and, surprisingly, natural tissue, has energy capacity and dispersal properties; over the course of the past few years, the popularity of this method has skyrocketed. It is now widely used in fuel cell testing, biomolecular interaction, and microstructural characterization, among other scientific fields. Frequently, EIS uncovers data about the response instrument of an electrochemical exchange: The frequency response that EIS displays can assist in identifying the rate-limiting stage because different reaction steps will dominate at particular frequencies.



## CHAPTER – 3

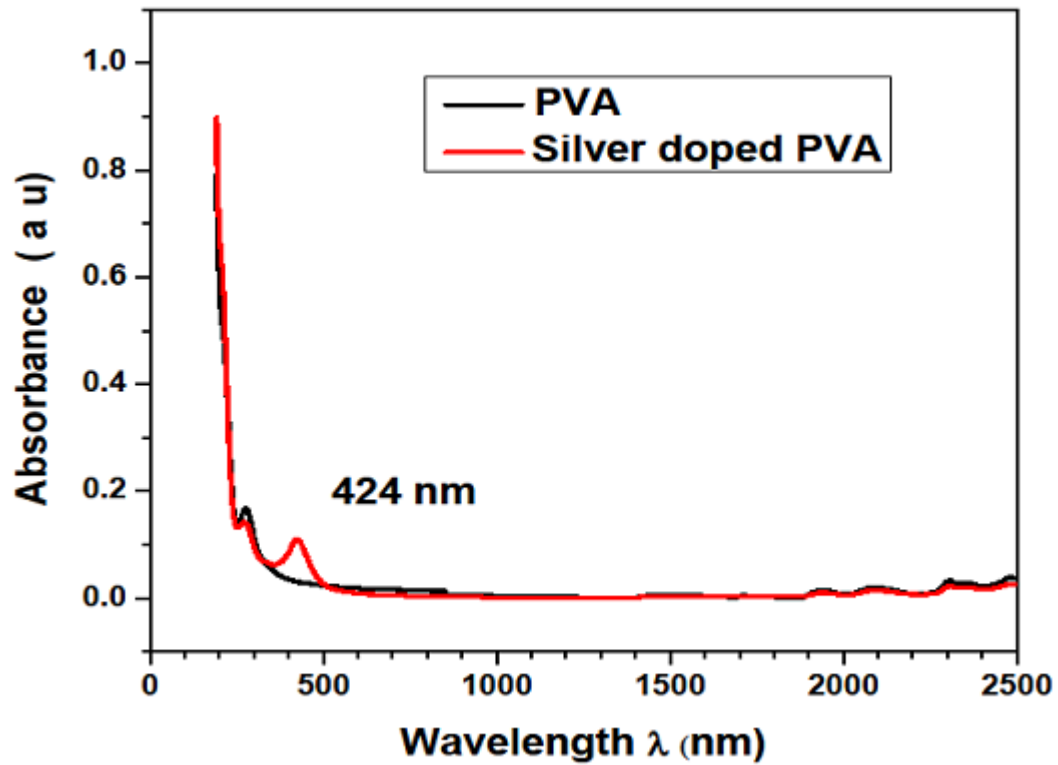
### RESULT AND DISCUSSION

- X-RAY DIFFRACTION ANALYSIS



**Fig 1: XRD Spectra of pure and Silver Doped PVA**

- OPTICAL ANALYSIS

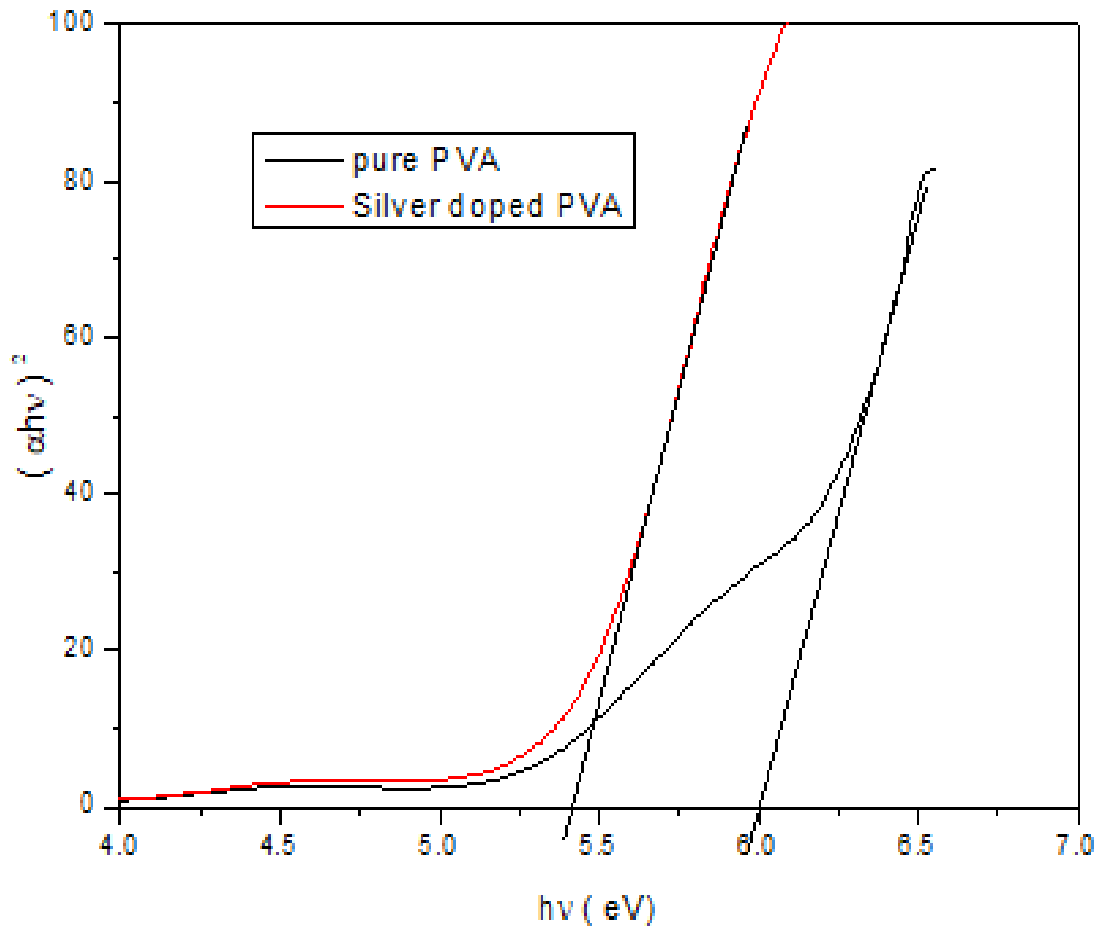


**Fig 2: Visible absorption spectra of pure PVA and silver-doped PVA**

**The characteristic absorption peak of pure PVA is 190nm- 280nm**

**SPR peak of silver doped at 424nm.**

- TAUC PLOT – BAND GAP DETERMINATION



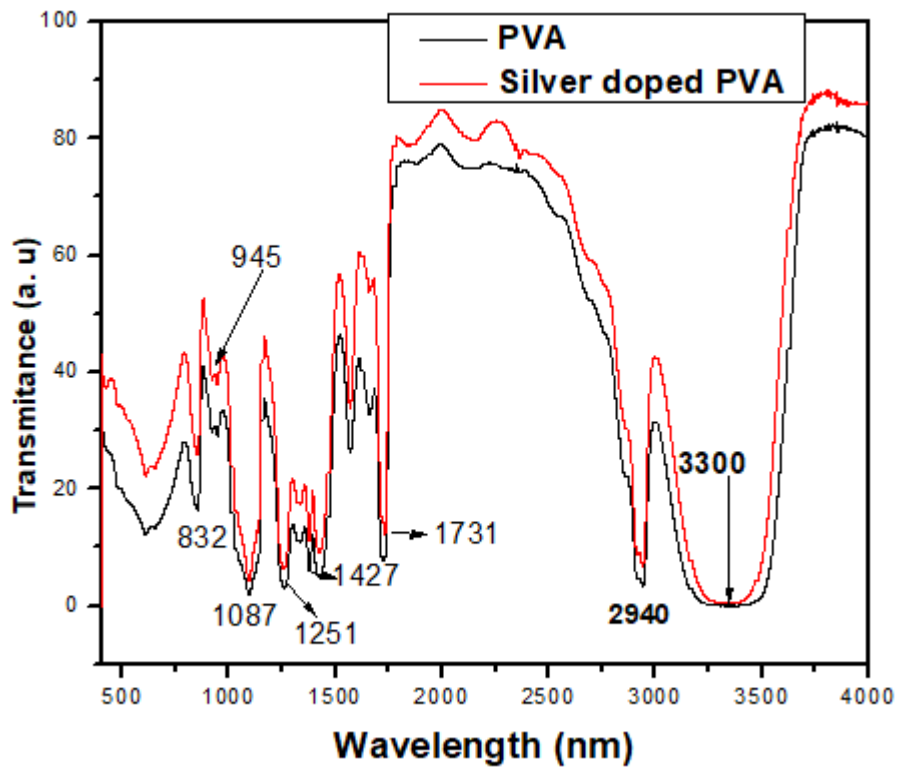
**Fig 3:  $(\alpha h\nu)$  VS  $(h\nu)$  of pure PVA and Silver Doped PVA**

The photon energy ( $h$ ) is depicted on the abscissa (x-coordinate) of the Tauc plot. In contrast, the material's absorption coefficient ( $\alpha$ ) is shown on the ordinate (y-coordinate) and used to decide the optical bandgap. obtained by subtracting  $(\alpha_s(h\nu) = \alpha(h\nu) - c \cdot \alpha_m(h\nu))$

- OPTICAL ANALYSIS

The characteristic bands for PVA

3300cm <sup>-1</sup>	O-H stretching bands
2940 cm <sup>-1</sup>	C-H stretching vibration stretching
1731 cm <sup>-1</sup>	C=O asymmetric
1415cm <sup>-1</sup>	CH <sub>2</sub> scissoring
1251cm <sup>-1</sup>	C-O stretching bands



**Fig 4: FTIR spectra of Pure PVA and Silver Doped PVA**

- DIELECTRIC SPECTRA ANALYSIS

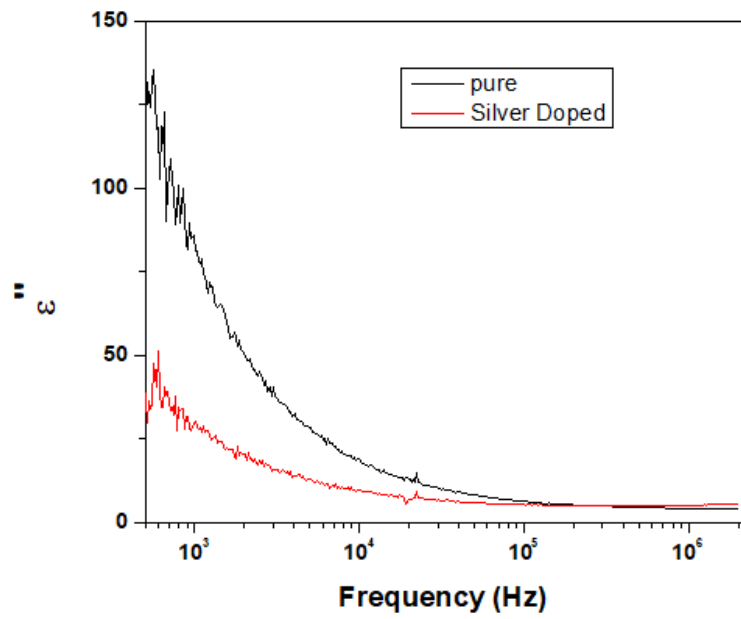
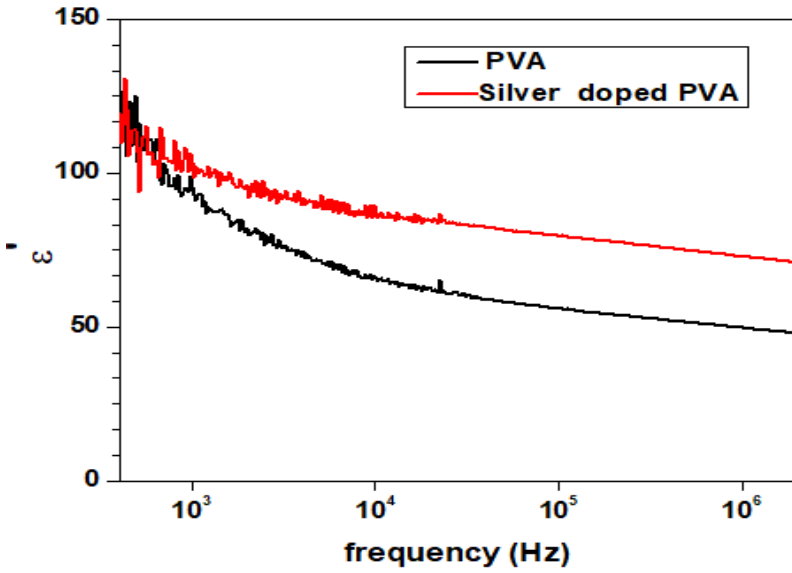
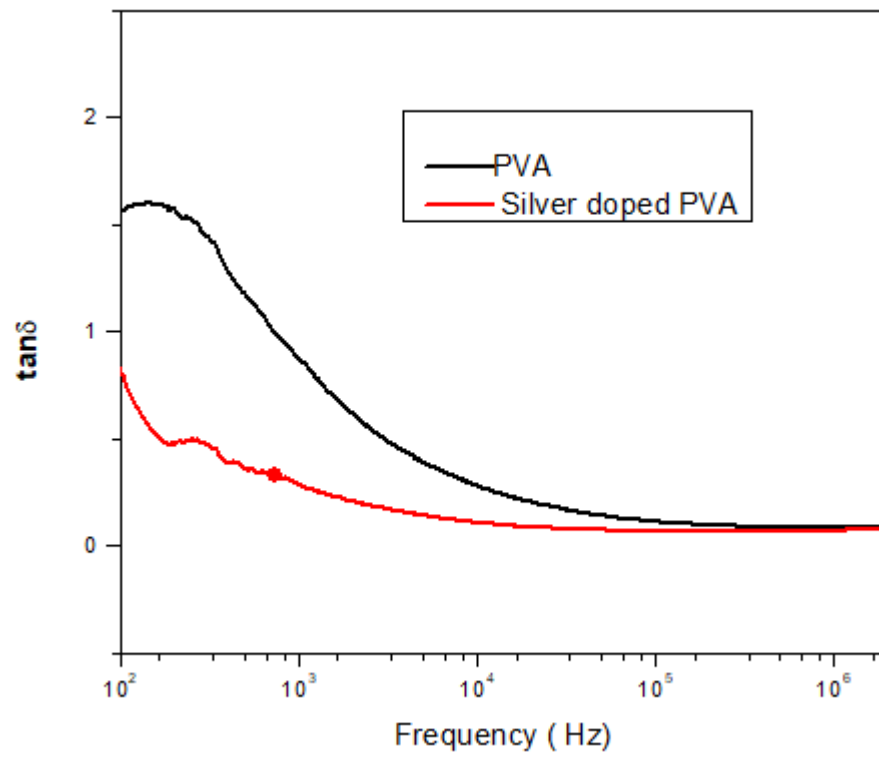


Fig 5: (a) Dielectric Constant vs. log (frequency), (b) Dielectric loss vs. log (frequency)



**Fig 5: (c) The Dielectric Loss Tangent vs. log (frequency)**

## CONCLUSION

A straightforward solution cast technique was successfully used to deposit PVA and Silver-doped thin films. XRD analysis was used to perform the structural characterization of the produced samples, confirming the materials' amorphous nature. The indirect bandgap values decreased when Ag<sup>+</sup> ion doping was applied, as evidenced by UV-Vis absorption spectra. In the FTIR spectra of silver-doped examples, the essential utilitarian gatherings show more prominent sign forces, showing how the carbonyl gathering can work as a functioning electron giver while collaborating with the Ag<sup>+</sup> cation. The frequency dependence of the dielectric properties of pure and silver-doped films at room temperature was investigated. The Cole-Cole diagram depicts the relaxation process in PVA films and Silver-doped PVA films, which features a semicircular trend corresponding to the Debye model. The shift of the corresponding bands in FTIR measurements indicates that AgNO<sub>3</sub> interacts with the PVA polymer. The AgNO<sub>3</sub>dopant reduces the optical energy gap to 1.3 eV for the 5%doping. It has been discovered that doping significantly reduces the optical band gap. The characteristic absorption peak of pure PVA is 190nm-280nm, SPR peak of silver is doped at 424nm. The data doesn't show variation is called amorphous structure. If the frequency increases dielectric medium decreases, and doping increases dielectric medium also increases.

## CHAPTER – 5

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