Preface

To understand the behaviour of dielectric material in an e.m. field, it is intended to investigate the various phenomena taking place. Dielectric measurements of a substance are essentially based on the quantitative measurement of its interaction with the electromagnetic fields. At low frequencies the polarization of a dielectric material is determined by the static dielectric constant of that material. On applying higher frequency electric field, a time lag is observed in the response of the material to the change in the applied electric field. As a result dielectric relaxation takes place and the dielectric dispersion occurs. The dielectric dispersion due to the orientation polarization occurs mainly in the microwave frequencies and hence the measurement of the dielectric parameters at these frequency regions has of great importance. The dielectric behaviour at these frequencies is determined by the complex dielectric constant and the relaxation time of the materials.

The object of the present study was to prepare pure and doped polymer films with varying concentration of different materials and to investigate their dielectric relaxation and to carry out the measurements of various dielectric parameters at microwave frequencies. In order to investigate dielectric behaviour of solids in the form of films, we have chosen polyvinyl alcohol (PVA) as a host polymer, having important technical application due to its various interesting physical properties. The advantages of PVA, such as high mechanical strength and water solubility
have played as main role for this selection as compared to other polymer. The concentration of the dopant used in this work was varied in order to investigate the influence of dopant compositions on the dielectric properties of the composite polymer.

The main study on the dielectric properties of a polymeric material is to obtain information on molecular motion and structural transitions. As PVA is a semicrystalline polymer, containing a mixture of amorphous and crystalline regions. The dielectric behaviour were carried out by finding out the dielectric constant (\(\varepsilon'\)) and loss factor (\(\varepsilon''\)) for pristine and composite polar polymer (PVA) films. The average thicknesses of prepared film were of the order of 100 \(\mu\text{m}\), which was determined by a micrometer having a least count of 1 \(\mu\text{m}\). The dielectric data so obtained was used to evaluate various dielectric parameters like the relaxation time, loss tangent, ac conductivity and also the optical constant viz., extinction coefficient and index of refraction.

The evaluation of dielectric relaxation time and distribution parameter is helpful to understand the relaxation process and the variation of relaxation time in polymer composite films. The temperature variation of relaxation time and dielectric loss factor is helpful in determining the activation energy and understand relaxation process in polymer composite films. Generally the dielectric properties of a polar polymer will depend on whether the dipoles are attached to the main chain or not and the dipole polarization will depend
on segmental mobility, which is low at temperatures below the glass transition temperature.

Realising the importance of dielectric properties of PVA and its composite for the technical applications in the form of films, efforts have been made to investigate dielectric properties of polymer composite. Such studies may be helpful in understanding the electronic polarization polymer-dopant interaction of these materials through microstructural, charge transport prevalent and electronic polarization of these materials. If the dielectric data of such composite materials is made available, it may prove important in deciding their use for the industrial application like fabrication of capacitors and other such devices employing dielectrics.

In order to fulfill the objectives of this research work, we have carried out investigations on the following materials–

(i) Dielectric studies of PVA and doped PVA with inorganic metal salts at room temperature.
   a. PVA and PVA/FeCl$_3$ composite films.
   b. PVA and PVA/CuSO$_4$ composite films.
(ii) Dielectric studies of completely biodegradable polymer film based on PVA
   a. PVA and PVA/starch composite films
   b. PVA and PVA/gelatin composite films.
(iii) Optical properties of PVA and its composite with biodegradable natural polymers
a. PVA and PVA/starch composite  
b. PVA and PVA/gelatin composite  

(iv) Effect of functional group of additives on the dielectric properties of PVA at various temperature  
a. PVA  
b. PVA and oxalic acid composite films  
c. PVA and malic acid composite films  
d. PVA and tartaric acid composite film  
e. PVA and citric acid composite film  

Various studies carried out for achieving the above objectives have been presented within seven chapters in the thesis.

The first chapter deals with the general introduction, which contains electrical behaviour of dielectrics at different frequencies and survey of important dielectric studies of the relevant substances. It also contains the introduction about the UV-visible spectroscopy in terms of transmittance, absorbance and concentration with a review on optical studies of the polymers and their composites.

The second chapter gives the information about the material used for this study and their procurement status. It also concern with the experimental techniques and procedure for the determination of different dielectric parameters in solid films dielectric at microwave frequency following the method for the preparation of sample in the form of film and provides the
information about the different supporting characterization techniques used in this work. The UV-visible spectroscopy with adequate information about the electronic transition in organic/inorganic compounds has been described in the last section of this chapter.

Third chapter presents the results of the work done on dielectric properties of PVA and PVA/inorganic metal salts composite films at 9.03 GHz frequency and at room temperature. These studies were made on the pure PVA and doped PVA with different concentration of dopants such as FeCl$_3$ and CuSO$_4$ by holding the samples longitudinally along the symmetry axis of a waveguide in the TE$_{10}$ mode. The values of dielectric constant ($\epsilon'$), dielectric loss ($\epsilon''$), loss tangent (tan$\delta$), relaxation time ($\tau$), ac conductivity ($\sigma'$), optical constant viz. extinction coefficient (k) and refractive index (n) have been evaluated from the measured data. These results suggest that the doping of PVA with metal salt may be used for fabricating device based on dielectrics.

Fourth chapter presents the similar dielectric data for the completely biodegradable polymeric films of virgin PVA and doped PVA with varying concentration of starch/gelatin, as per the procedure followed in the chapter third. The results are sufficient to produce low coast biodegradable polymeric films, which may be used in technical applications at higher frequencies.
Chapter fifth devoted to the optical studies of PVA and its composite films with natural biopolymer. Starch and gelatin were used as composite material. The optical studies show that increasing starch and gelatin concentration, affect the optical energy band gap ($E_g$) and Urbach energy ($E_u$) of the PVA itself. These results suggest the use of these polymer composite films to reduce and control UV radiation in optical devices.

Chapter sixth deals with the dielectric properties and degree of crystallinity of PVA film with the functional groups i.e. hydroxyl and carboxyl group, of additives. In the PVA matrix, oxalic acid, malic acid, tartaric acid and citric acid having different number of functional groups have been mixed as additives. The results of measured dielectric parameters at 9.035 GHz frequency and at different temperature verified that both hydroxyl and carboxyl group as a functional groups increased the dielectric strength of the film while the XRD studies show the polycrystalline nature of the films except PVA/malic acid composite film. DSC studies confirm the miscibility of additives into PVA lattice. The lower value of activation energy indicates that the conduction mechanism may be due to electrons rather than ions, so that it can be used in the electronic devices for the achievement of optimum value in conduction process.

The seventh chapter concludes the entire work done on behalves of the results and discussion. It also throws a light on the future scope of the findings.