AC CONDUCTIVITY AND DIELECTRIC STUDIES OF POLYPYRROLE-PAPAIN COMPOSITE

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Abstract

Enzyme doped polypyrrole polymer were synthesized by in situ polymerization where ferric chloride works as an oxidizing agent. The different weight percent of papain was added at the time of polymerization. The polypyrrole-papain composite of various composition was analyzed for its dielectric and a. c. conductivity by using LCR meter at room temperature. Dielectric constant and loss decreases, with escalation in frequency. The variation in dielectric constant and dielectric loss was also noted with change in papain percentage in pyrrole.

Keywords: Dielectric; Dielectric Loss; Papain; A.C. Conductivity.

1. Introduction

In recent years, intrinsic conducting polymers have fascinated the people as advanced materials, because of its electrical and optical properties which are generally seen in inorganic materials. Electrically the difference in conducting polymers and inorganics materials is that the conducting polymers are molecule in nature and have long range order [1]. out of many conducting polymers available polypyrrole, poly aniline, and many more polymers like polypyrrole composites are more promising for various marketable applications because of its environmental stability and higher conductivity. Polypyrrole can be used as biosensor [2,3] also as gas sensor [3,4] solid electrolytic capacitor [5,6], etc. polypyrrole have an exceptional thermal stability so there carbon composits are used for coating [7]. Polypyrrole and composite polymer can be used as drugs delivery and also bio-molecules [8], polypyrrole polymer blends can guard the metals from corrosion [9].

Papain, cysteine protease taken from the latex of papaya plant and has been used as defensive mechanism for the plants against insects [16]. The papain enzyme has high optimal temperature up to 65 ^{0}C and a varied pH range from 5-8 for its activity. [17]. Mapping of the active site shown that papain has specificity for amino acids with aromatic cross chains such as Phenylalanine and Tyrosine at the P2 position [18].

2. Materials and Methods

Monomer, pyrrole and fecl3 were acquired from M/S Chemical International, Mumbai. The enzyme Papain was obtained from local supplier in kalyan. All chemicalas were of AR grade and papain was of purest form**.**

2.1. Synthesis

Pure(p) and papain-pyrrole composite of (sample -2,3,4) with varied combination of papain was produced by in situ polymerization in presence of ferric chloride (oxidizing agent). The method for polymerization of pure and polypyrrole composite is reported in our earlier paper [10].

3. Results and Discussions

3.1. DC Conductivity of Pure Polypyrrole and its Papain Composite

Dc conductivity of pure polypyrrole and its papain composite was taken by using two probe methods. Figure 3.1. shows voltage and current for pure and papain composite samples. Pure pyrrole has more conductivity in comparison with papain composite. Dc conductivity rises with increase in the percentage of papain in the pyrrole polymer.
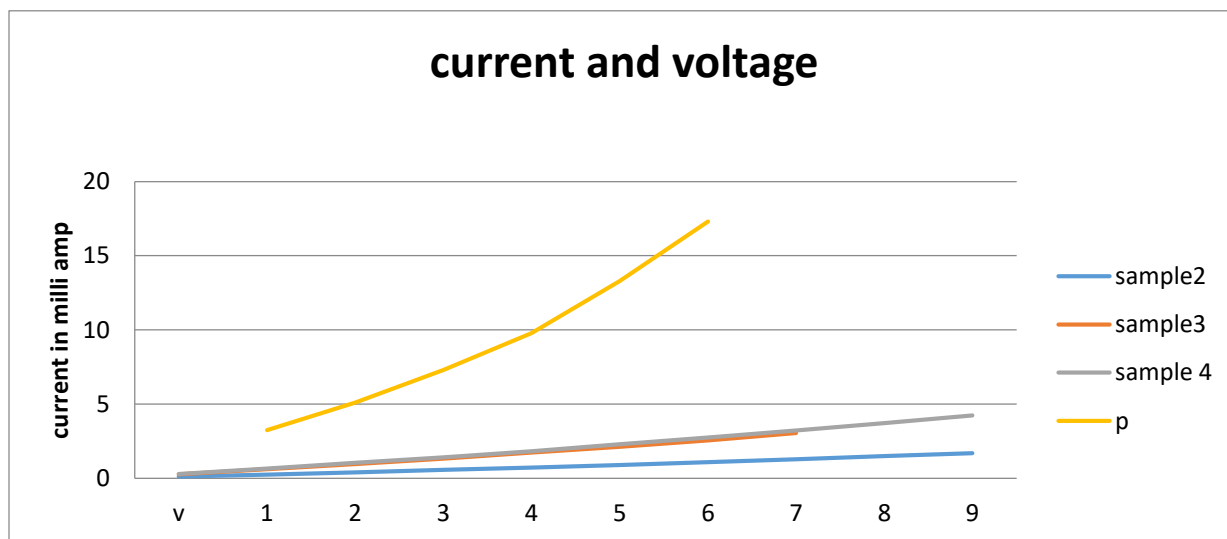

Figure 3.1: Dc Conductivity of pure and papain composite of polypyrrole

3.2. Ac Conductivity and Dielectric Study

The AC conductivity and Dielectrical property for polypyrrole-papain composite were analyzed for variation of frequency, which ranges from 100 Hz to 1MHZ by using HP-LCR Meter (HIOKI-3532-50 hi tester). The series and parallel capacitance, series resistance with loss factor were noted from meter. Capacitance for pure and maximum papain sample was less than moderate papain composite.

3.2.1. Dielectric Constant

The dielectric study was done for disc pellet under two probe contacts in the range 100hz to 1MHz at room temperature. Dielectric constant (relative permittivity), dielectric loss were calculated from the readings of capacitance, loss tangent received from LCR meter after calibration was done. In pyrrole-papain composite polymer ,maximum dielectric constant was observed for composite 2 and 3 with low doping of pappain in comparison with pure polymer of pyrrole .dielectric constant(fig 3.2.1) decreases with increase in frequency due to fast periodic reversal of applied field giving no time for ion diffusion to cope up with the direction of electric field and dipole lags behind the applied electric field resulting in loss of dielectric constant.[11-12] the dielectric constant reduces for maximum papain doped composite may be due to loss of interfacial polarization at matrix interface. For lower frequency 100hz to 1000HZ dielectric constant for sample 2 and 3 increases with frequency and for higher frequency it reduces sharply, maximum for this sample is at frequency 1000HZ.At lower frequency dipoles do not follow ,the dielectric constant falls quickly at relaxation time. Table 3.2.1 indicate change in dielectric loss with reference to log of frequency.
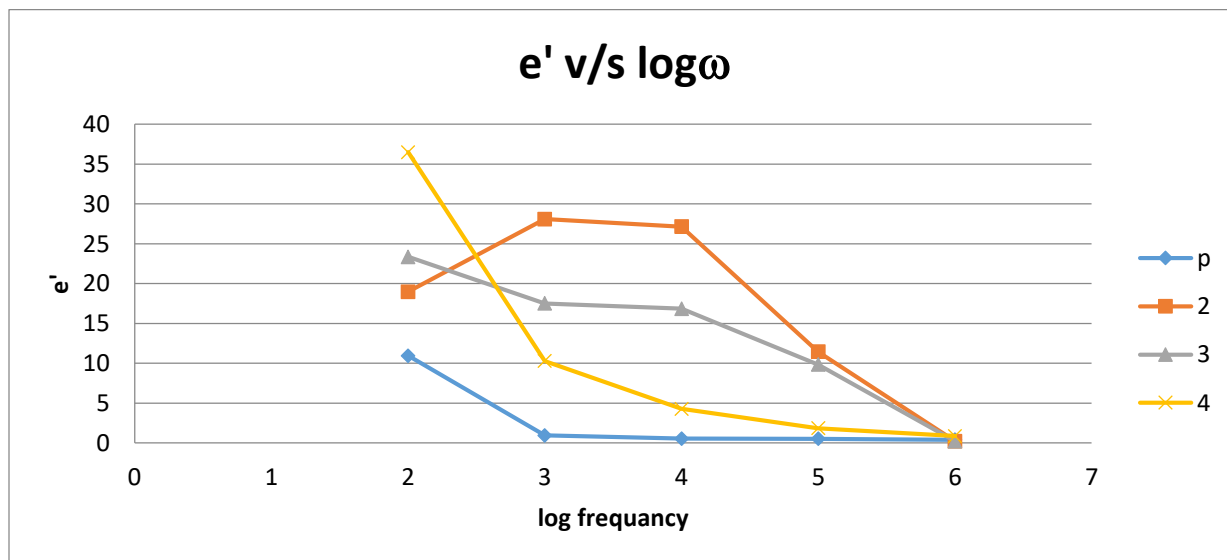

Figure 3.2.1: Dielectric constant v/s log frequency pyrrole -papain composite and pure polypyrrole

Table3.2.1: Dielectric loss v/s log F

Log F	Pure ppy	Sample 2	Sample3	Sample4
2	109.39	189610	233370	364
3	9.39	280720	175000	102.8
4	5.4	232760	168000	30.99
5	5.29	10650	11623	3.99
6	1.78	28.2	35	0.72

Dielectric loss and log of frequency

3.2.2. Tangent Loss

Figure 3.2.2. shows change in tangent loss with respect to log F at room temperature for pure and different composition of polypyrrole. For 100K frequency tangent loss remains constant for pure polypyrrole where as at around 1K to 10K sharp change is observed in papain composites of polypyrrole.
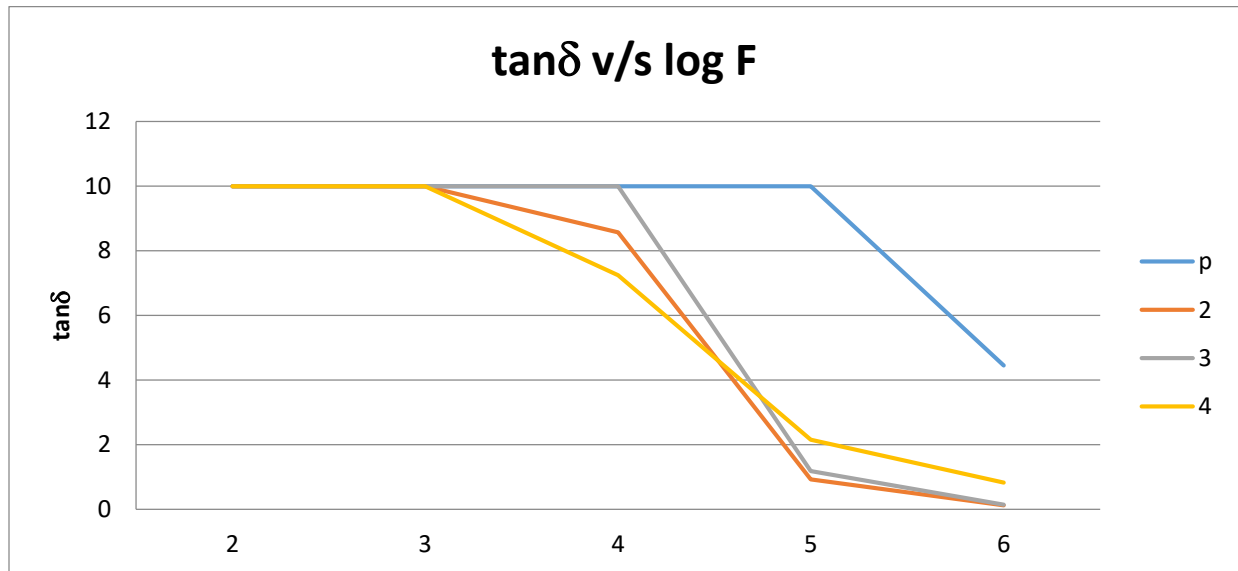

Figure 3.2.2: Tangent loss of pure and papain-pyrrole composite

3.2.3. Power Factor

The power factor is amount of energy absorbed by material, in process of dipole align with alternating current change. the power factor is evaluated by [15].

$$PF=1+\frac{tan\delta}{\sqrt{1+tan\delta}}$$

In the plot of power factor and log F in Figure 3.2.3. for papain –pyrrole composite, power factor remains constant up to 10KHz. The maximum energy absorbed by polymer with low concentration of papain and for maximum concentration of papain and pure sample for higher frequency the absorption of energy is reduces but this reduction is maximum for sample with low concentration of papain in sample.
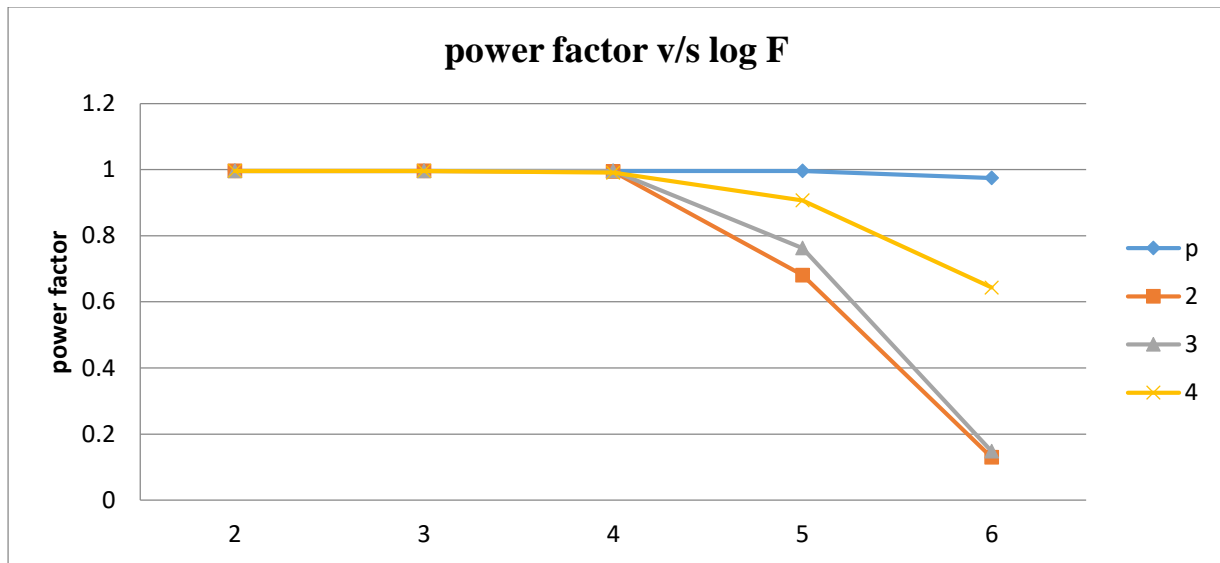
Figure 3.2.3: Power factor v/s log F of pure and papain-pyrrole composite

3.3. A.C. Conductivity

As per Jonscher's law, total ac conductivity depends on dc as well ac conductivity given as

$$\sigma_{Ac}=\sigma(dc)+\sigma(ac)=\sigma_0+A\ \omega^s$$

Table 3.3.1 shows, 'S' values for the pure and ppy-papain composite samples calculated from Figure 3.3.1 Slope. The 'S' value is calculated from the graph in fig 3.3, helps in understanding charge transportation method where 'S' value represents degree of interaction of mobile ions with lattice surrounding them having range 0 to 1. [13,14] Hopping between localized state is inferred from frequency dependence of conductivity same is observed from the graph of log σ_{Ac} and log ω(figure 3.3). the 's' value also confirms presence of multiple relaxation time.
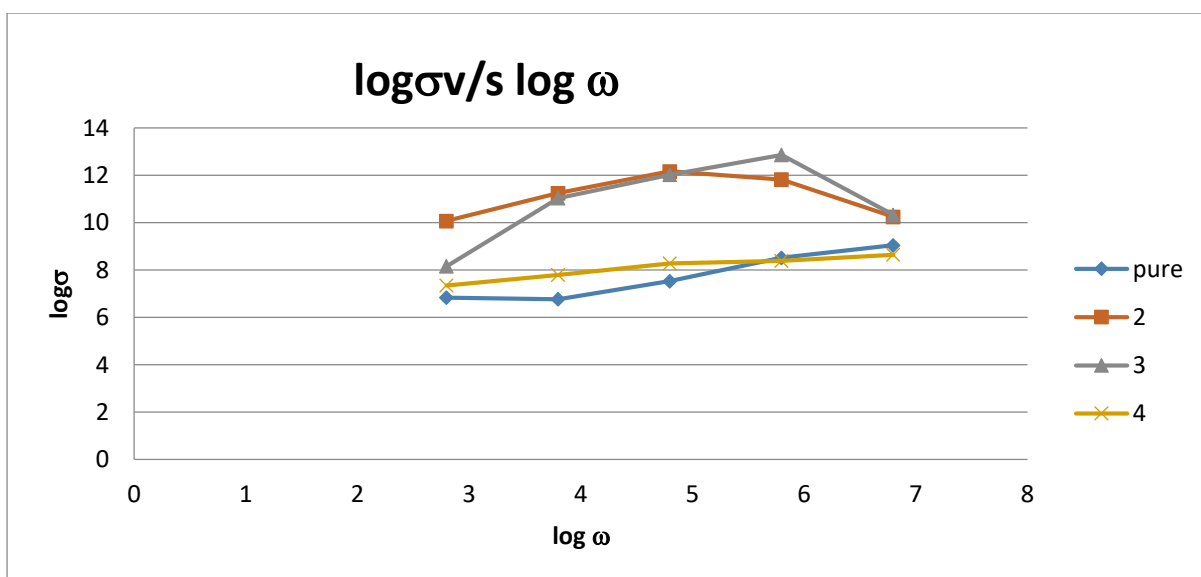

Figure 3.3.1: Curve of ppy and ppy-papain composite

Table 3.3.1: 'S' values for different composite

	s'	values
	region1	**region2**
pure	0.009	0.022
sample2	0.02	0.002
sample3	0.01	0.135
sample4	0.03358	0.5616

4. Conclusions

The sample of pure and papain composite of polypyrrole were tested for Dielectric constant, dielectric loss and tangent loss. Results are in coordination with other worker. For AC conductivity's' value confirms presence of multi-relaxation time with understanding charge transportation method by hopping between localized state. The calculation of power factor indicates at higher frequency the absorption of energy reduces but this reduction is maximum for sample with low concentration of papain in sample.

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