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Dielectric properties and charge transport mechanism of π-conjugated segments decorated with intrinsic conducting polymer

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Supporting Information

The accelerating nature of the frequency dependent conductivity approximately follows universal power law, represented by equation [1]:

$$\sigma'_{ac}(\omega) = A(T)\omega^{S}$$

Where A(T) is dispersion parameter, ω is frequency and S (0≤S≤1) is dimensionless exponent of frequency. Values of A and S are calculated using power law least square fitting equation all measured temperature are tabulated in table 2 and table 3 for PVA/PVP and PVA/PVP/PANI(20weight%). The variation in the value of S with respect to temperature is further used to verify conduction mechanism in PVA/PVP and PVA/PVP/PANI.

Ac conductivity at (10MHz), low frequency conductivity (DC conductivity) (0.1Hz) and dielectric at 1KHz as well as at 10MHz is shown in table 2 and table 3 for both PVA/PVP and PVA/PVP/PANI (20weight%) respectively for various range of temperature (0°C to 100°C).

Table 1. Dielectric constant and ac conductivity at different frequency and fitting parameter A and frequency exponent S (equation 4) at various temperatures for PVA/PVP films.

PVA/PVP						
Temp. (°C)	σ_{DC} (s/cm) at 0.1Hz	σ_{ac} (s/cm) at 10MHz	A	S	ε' at 1KHz	ε' at 10MHz
0	$1.39x10^{-13}$	$1.67x10^{-6}$	$8.35x10^{-14}$	0.95	6.45	5.07
10	$1.84x10^{-13}$	$1.94\ x10^{-6}$	$1.72x10^{-13}$	0.92	6.86	5.42
20	$3.71x10^{-13}$	$2.35\ x10^{-6}$	$5.00x10^{-12}$	0.72	7.31	5.47
30	$8.21x10^{-12}$	$2.86\ x10^{-6}$	$3.99\ x10^{-10}$	0.25	7.80	5.74
40	$3.05x10^{-12}$	$3.53\ x10^{-6}$	$2.34\ x10^{-9}$	0.19	8.51	6.11

50	2.41x10^{-11}	4.51 x10^{-6}	1.33 x10^{-8}	0.06	9.79	6.63
60	2.85x10^{-10}	6.01 x10^{-6}	1.37 x10^{-8}	0.24	12.3	7.36
70	1.71x10^{-9}	7.90 x10^{-6}	6.66 x10^{-9}	0.50	16.2	8.29
80	6.75x10^{-9}	9.99 x10^{-6}	3.20 x10^{-9}	0.74	21.9	9.36
90	2.18x10^{-8}	1.19 x10^{-5}	1.54 x10^{-9}	0.91	28.3	10.5
100	5.32x10^{-8}	1.36 x10^{-5}	7.74 x10^{-10}	0.97	31.1	11.7

Table 2. Dielectric constant and ac conductivity at different frequency and fitting parameter A and frequency exponent S (equation 4) at various temperatures for PVA/PVP/PANI (20wt%).

PVA/PVP/PANI (20 weight%)						
Temp. (°C)	σ_{DC} (s/cm) at 0.1Hz	σ_{ac} (s/cm) at 10MHz	A	S	ε' at 1KHz	ε' at 10MHz
0	4.05x10^{-7}	2.36 x10^{-5}	3.64x10^{-6}	0.19	52.3	2.2
10	5.21 x10^{-7}	1.98 x10^{-5}	2.39 x10^{-7}	0.18	64.9	2.97
20	8.76 x10^{-7}	2.19 x10^{-5}	4.65 x10^{-7}	0.16	87.8	3.03
30	1.62 x10^{-6}	5.19 x10^{-5}	9.77 x10^{-7}	0.14	1.31x10^{2}	11.9
40	2.98 x10^{-6}	6.64 x10^{-5}	2.08 x10^{-6}	0.11	2.2 x10^{2}	14.2
50	5.03 x10^{-6}	7.88 x10^{-5}	3.95 x10^{-6}	0.096	6 x10^{2}	15.9
60	7.56 x10^{-6}	9.15 x10^{-5}	6.43 x10^{-6}	0.084	6.5 x10^{2}	16.5
70	1.03 x10^{-5}	1.04 x10^{-4}	9.26 x10^{-6}	0.077	1.07 x10^{3}	17.2
80	1.27 x10^{-5}	1.13 x10^{-4}	1.18 x10^{-5}	0.073	1.57x10^{3}	20.6
90	1.43 x10^{-5}	1.14 x10^{-4}	1.39 x10^{-5}	0.069	1.98 x10^{3}	21.8
100	1.48 x10^{-5}	1.17 x10^{-4}	1.43 x10^{-5}	0.068	2.09x10^{3}	22.8

Using CBH mechanism model, hopping distance (R_H) and maximum barrier width (W_m) is calculated for different concentration using equation [2]:

$$R_H = \frac{e^2}{\pi \varepsilon \varepsilon_0} \left(\frac{1}{W_m + k_B T \ln(\omega \tau_t)} \right)$$

$$S = 1 - \frac{6 k_B T}{W_m}$$

Where ε is dielectric constant, ε_o is permittivity of free space, W_m are maximum barrier height, K_B boltzmann constant and T is temperature. The calculated value of R_H and W_M is tabulate in table 4 along with the roughness value obtained for FSPC having different concentration of PANI.

Table 3: W_M , R_H and Roughness of FSPC film for different weight% of PANI.

Weight%	W_M (ev)	R_H (A^o)	Roughness (µm)
5% PANI	0.210	16.10	1.20
10% PANI	0.192	9.89	1.48
15% PANI	0.187	8.48	1.90
20% PANI	0.169	2.35	2.60

Reference

1. W. Cao, R. Gerhardt, Solid State Ionics, 1992, **42**, 213-221.
2. Gmati F, Fattoum A, Bohli N. and Mohamed AB, J. Phys. Condens. Matter., 2008, **20**, 125221-125230.