Electronic Supporting Information

Polymer-Doped Molten Salt Mixtures as a New Concept for Electrolyte Systems in Dye-Sensitized Solar Cells

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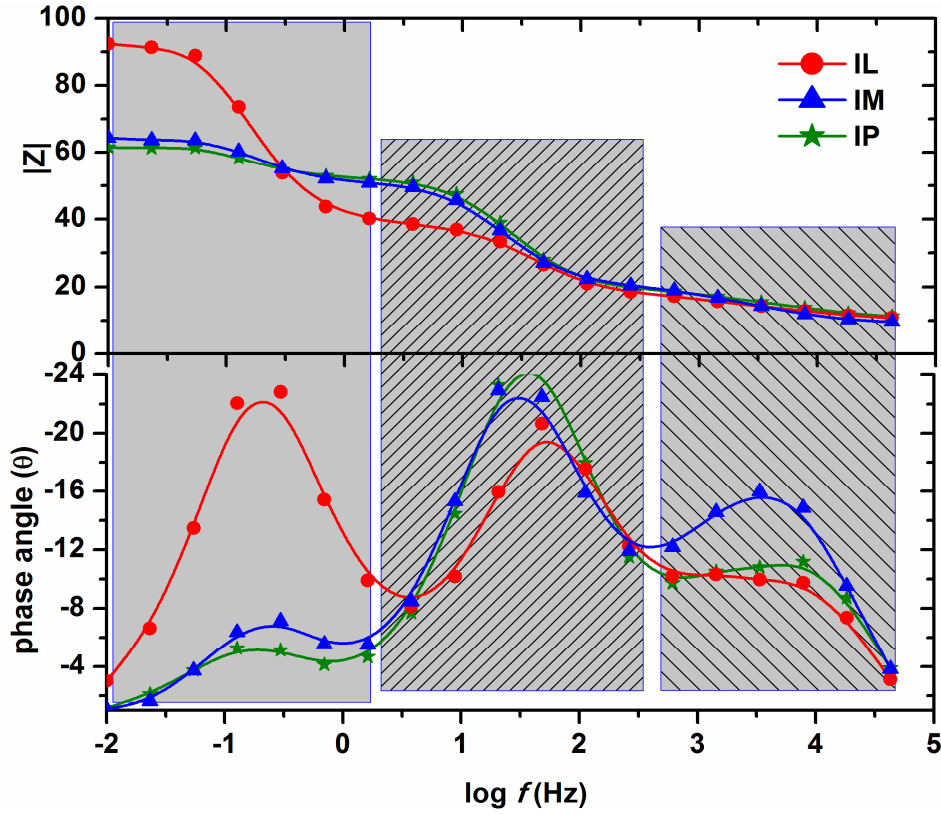
Figure S1. The modulus of impedance and phase angle as a function of frequency for the **IP**, **IM** and **IL** based cells.

Another way of presenting the complex impedance is by displaying the frequency response of the modulus of impedance and phase angle, for the DSSCs based on the **IL**, **IM** and **IP** electrolytes. The modulus impedance is defined as $|Z| = \sqrt{(Z'(\omega))^2 + (Z''(\omega))^2}$ and the phase angle (θ) is defined as $\theta = \tan^{-1}(Z''/Z')$. This gives the frequency response of gain and phase of the systems studied. As discussed in the complex impedance plot, three processes can clearly be distinguished as a function of frequency in the analysis. In the low-frequency region, the phase shift for **IL** based cells is more predominant than for the **IM** and **IP** based cells. This indicates that the diffusive transport overrule the charge transfer between the electrodes in this case. On the other hand, in the intermediate frequency region, the phase angle of the **IP** based cells deviates indicating that the charge transfer (loss) is larger in such cells.

According to Papathanassiou, the fractional exponent n attributes the nature of morphology of conduction network, however he reported for single conduction processes.[S1] In our case, the variation n is not corresponding to single conduction mechanism, rather three types of conduction mechanisms involved as explained in complex impedance plot. These results can be ascribed to the evidence of multiple ac conduction mechanisms exist in DSSCs. Thus the total conduction in the DSSC can be written as,

$$\sigma_{ac} = \sum_{j=1}^{3} \sigma_{ac} \qquad (3)$$

here the integer j can take real values from 1 to 3, corresponding j^{th} individual conduction mechanism. Each jth conduction mechanisms are assigned namely: (i) corresponding to conduction processes relating to charge transfer around FTO/Pt-electrolyte interface at the counter electrode, (ii) conduction processes relating to charge transfer around FTO/porousTiO$_2$/dye-electrolyte interface at working electrode and (iii) conduction processes relating to diffusion impedance of the ionic species in the electrolyte. Thus, each conduction processes constitutes individual conduction path length L_{jk}, where integer k defines a finite possible ac conduction path length within each jth conducting network with $L_{jk} \geq L_{jc} = \upsilon / \omega_{jc}$, where L_{jc} is the critical length and υ is the mean velocity of charge carriers. Thus, to generalized conduction mechanism,

$$G(\omega) = G_{dc} + \sum_{j=1}^{3} \sum_{L_{jk} \geq L_{jc}} G_{jk}\left(L_{jk}\right) \qquad (4)$$

where G_{dc} defines the dc conduction and second term in above equation is for multiple conduction processes defined by $G_{jk} \propto L_{jk}$ of the DSSCs. The presence of dc conduction is also confirmed by plotting the conductivity normalized plot as shown in **S2**. The conduction path length L_{jk} gives the accessible individual conduction path length under the external electric field for the charge carriers with respect to conduction environment that is driven by potential energy distributed around the conductive region. Hence the fractional exponent n is not only frequency dependent and also environment of the conducting network.

(S1) Papathanassiou, A.N.; Sakellis, I.; Grammatikakis, J. Universal Frequency-Dependent AC Conductivity of Conducting Polymer Networks. *Applied Physics Letters* **2007**, *91*, 122911-122913.
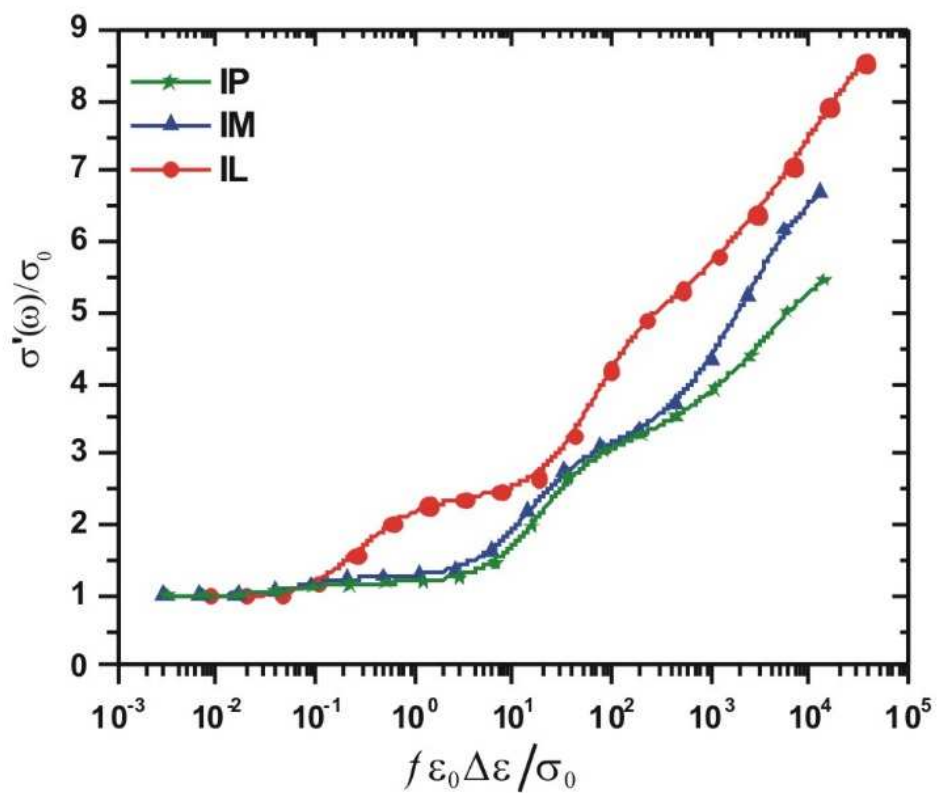
Figure S2. The normalisation of ac conductivity as a function of frequency for the **IP**, **IM** and **IL** based cells.
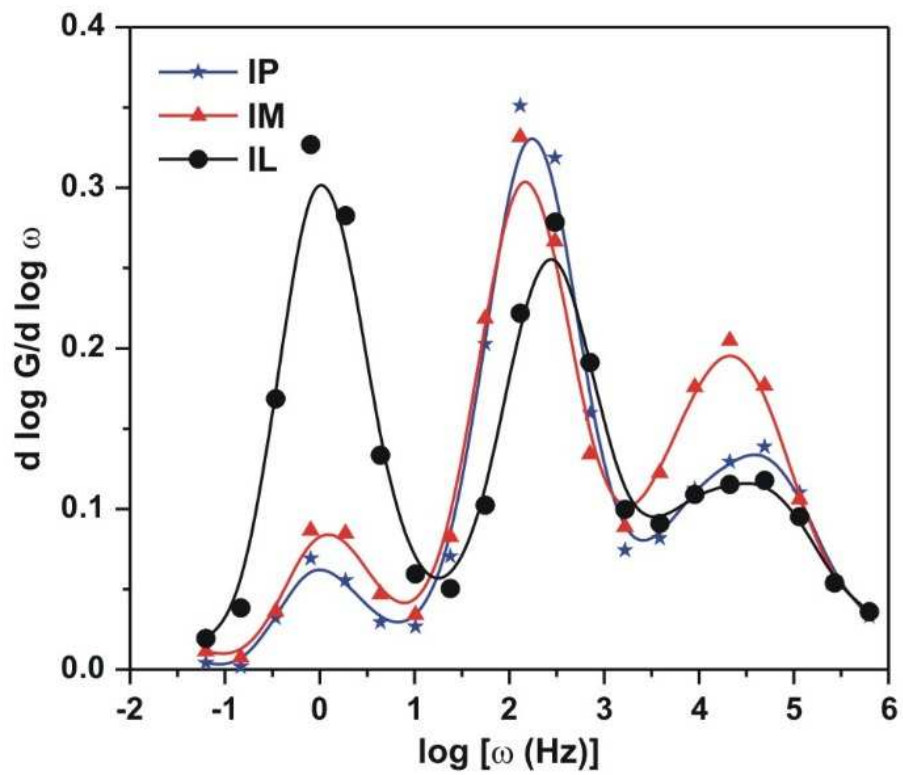
Figure S3. The dlog G/dlog ω function of log ω for the **IP**, **IM** and **IL** based cells.
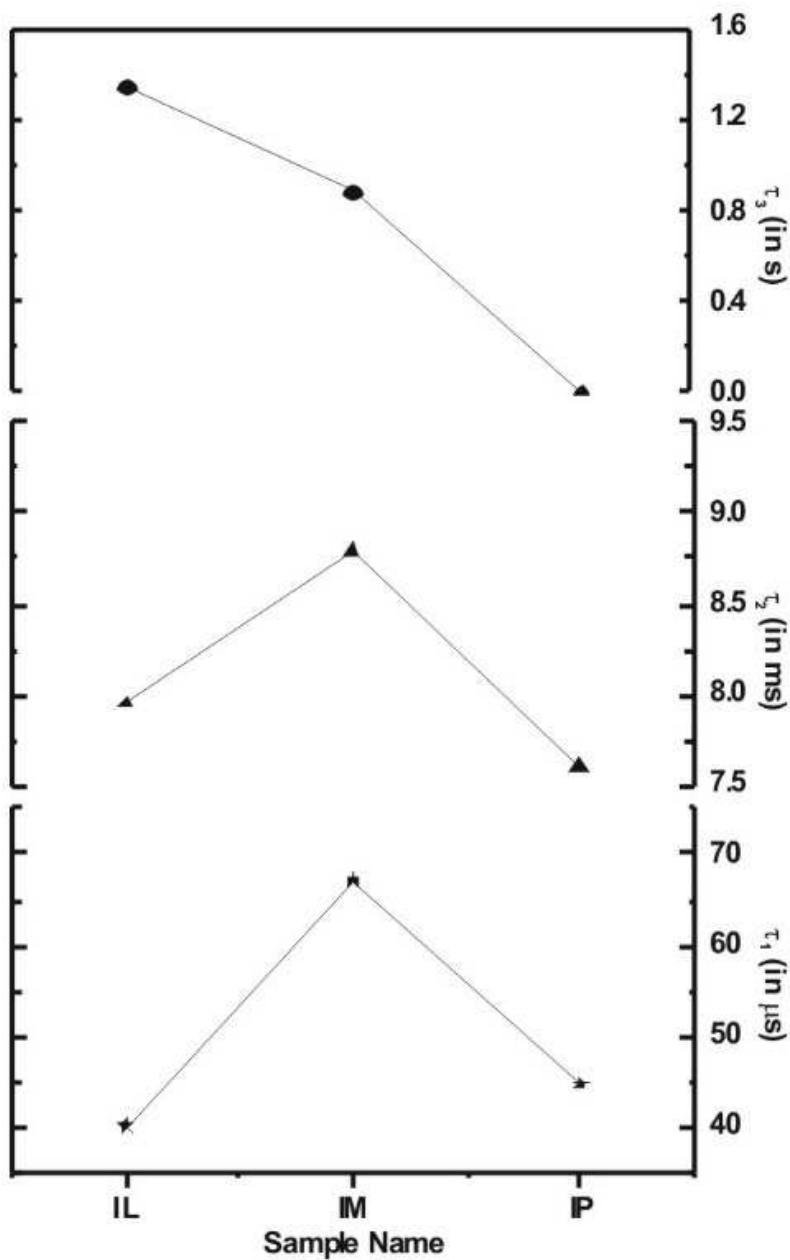
Figure S4. Relaxation time for **IP**, **IM** and **IL** cells.[S2]

(S2) Gorlov, M.; Yu, Z.; Boschloo, G.; Kloo, L. Synergistic Effect of N-Methylbenzimidazole and Guanidinium Thiocyanate on the Performance of Dye-Sensitized Solar Cells Based on Ionic Liquid Electrolytes. *J. Phys. Chem. C* **2010,** *114*, 22330–22337.
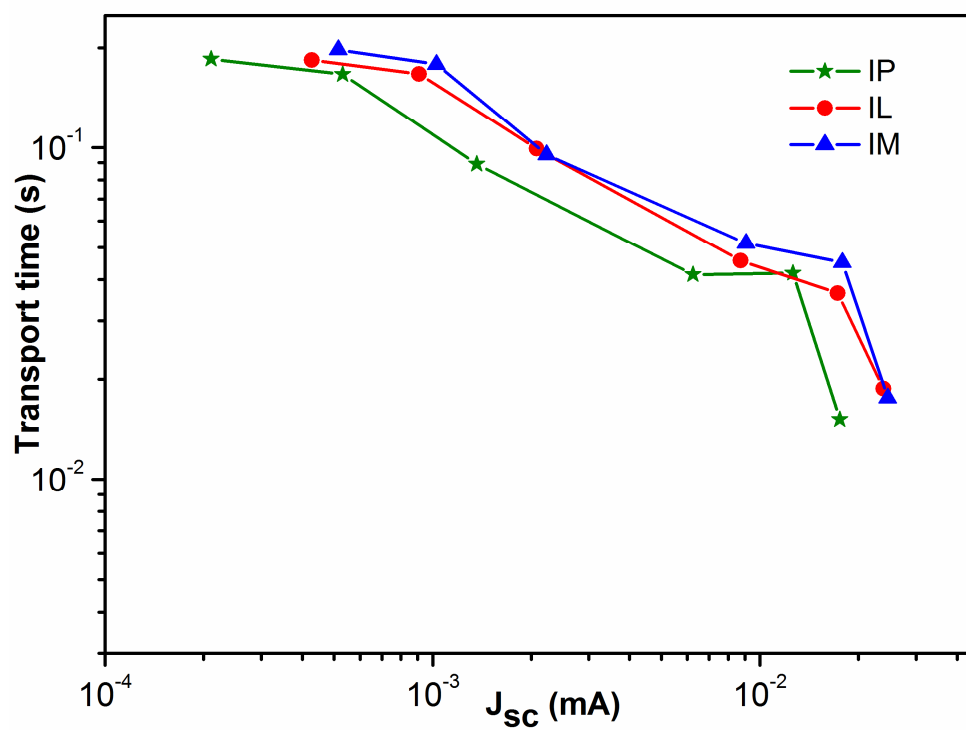
Figure S5. Transport time with respect to current density for the **IP**, **IM** and **IL** based cells.