Dielectric Response and Electric Properties of Organic Semiconducting Phthalocyanine Compounds

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Abstract:

In this study, the dielectric function of phthalocyanine compounds (ZnPc, H₂Pc, CuPc, and FePc) were investigated by analyzing the measured capacitance and loss tangent data. The dielectric function was found to be strongly temperature and frequency dependent. The real part of dielectric constant ε_1 increases at temperatures above room temperature and low frequencies, while at low temperatures and high frequencies it saturates to a constant value.

The dependence on the frequency was expressed as: $\epsilon_1 = A\omega^s$, where A is a constant, the index s assumes negative values (s < 0). The type of electrode material was found to have no effect on the behavior of real part of the dielectric constant but it is affect the value of dielectric constant. The values of real part of dielectric constant for Au electrodes are larger than those of the values of Al electrodes. In addition, data analysis shows that the

imaginary part of dielectric constant depends on frequency as $\epsilon_2 = B\omega^m$. The values of index m were found to be less than zero. Also, the values of m decreases with increasing temperature for Au-ZnPc-Au. The imaginary part of dielectric constant ϵ_2 is frequency and temperature dependent. At low frequencies and all temperatures, a strong dependence is observed, while at higher frequencies, a moderate dependence is obvious especially for the Auelectrode sample.

Maximum barrier height has been estimated for ZnPc with different electrodes and found to be in range of (0.17 to 4 eV). For both electrodes the maximum barrier height increases with increasing frequency and decreases with temperatures until to zero Kelvin temperature. The values of maximum barrier height of Al-ZnPc-Al are less than those observed for Au-ZnPc-Au sample.

The relaxation time, τ , was calculated for ZnPc and FePc films as a function of frequency. τ increases with decreasing frequency for both phthalocyanine compounds (ZnPc, FePc), but the values of ZnPc are closer to each other than FePc values.

The activation energy of ZnPc and FePc were calculated from the slopes of τ versus 1/T curves at low temperatures and found to be 0.01 eV and 0.04 eV respectively. The low values of activation energy suggest that the hopping of charge carriers between localized states is the dominant mechanism. In general, the behavior of dielectric properties of the different phthalocyanine compounds are qualitatively almost the same, but there are some differences in their values. This variation may be related to the type of electrodes, thickness of sample, and growth conditions.

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