CONDUCTIVITY AND ELECTRICAL PERCOLATION IN POLYMERS AND POLYMER MATRIX MICRO/NANO-COMPOSITES

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ABSTRACT

Generally speaking, the term electrical properties of materials refers to the materials response under the influence of an applied electric field. Electrical conductivity is the physical quantity, which characterizes how easy electric charge carries can flow through materials. Its values extend in a very wide range approaching the 30 orders of magnitude, qualifying the electrical behaviour of materials[1]. Alternating current (ac) conductivity sums all dissipative effects including an actual ohmic conductivity, caused by migrating charge carriers on isolated or adjacent conductive sites or clusters, as well as a frequency dielectric dispersion[2]. At low frequency region the applied electric field, forces the charge carriers to drift over large distances and their transport is significantly restricted by the presence of isolated conductive sites. When frequency is increased the mean displacement of the charge carriers is reduced and localized charge carrier motion takes maximum advantage of conducting regions. Disordered systems are non-metals and have no extensive crystal structure. Disordered systems exhibit a strong dispersion of ac conductivity: (i) at low frequencies remains almost constant, while (ii) at higher frequencies becomes strongly dependent, varying approximately as a power of the frequency. This response is known as the "ac universality law"[3] which has been found to describe satisfactorily the ac response of numerous different materials, which can be classified as disordered solids. In polymer matrix-conductive filler composites the concentration of the inclusions is a crucial parameter, governing the insulator to conductor transition of the systems. At a critical concentration of the filler an abrupt increase of conductivity occurs[4-10]. According to the classical percolation theory at this critical concentration of the filler a physical path is formed, through which the current can flow percolating the whole system. In the present study the conductivity of polymers and polymer matrix micro/nano-composites is studied and discussed in tandem with the occurring conduction mechanisms in these systems.

KEYWORDS: Conductivity, Percolation, Hopping conductance, Metallic-type conductance

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