Abstract

In this work, positive temperature coefficient of resistivity (PTCR) characteristics of metal filler (pure metal and metal coated powders) filled conducting polymer composites prepared by the conventional melt-mixing method has been investigated with reference to carbon black (CB) filled conventional polymer composites, using high density polyethylene (HDPE), poly(methyl methacrylate) (PMMA), polycarbonate (PC), styrene acrylonitrile (SAN) and polystyrene (PS) as the matrix polymers. The CB filled conductive polymer composites showed a sudden rise in resistivity (PTC trip) near the melting point (T_m) of the semi-crystalline polymer matrix and above the glass transition temperature (T_g) of the amorphous polymer matrix. However, the PTC trip temperature of the composites formulated in this work was appeared well below the transition temperature (T_g or T_m) of the matrix polymer. It is noteworthy, the room temperature resistivity and PTC trip temperature of the metal/metal coated filler filled polymer composites were also very much stable upon consecutive thermal cycles. Addition of nanoclay, which reduced the coefficient of thermal expansion (CTE) of HDPE, did not affect the PTC trip temperature (close to the T_m of HDPE) of HDPE/CB composites, whereas the PTC trip temperature of HDPE/Cu powder composites (well below the T_m of HDPE) shifted to higher temperature region in the presence of nanoclay. Moreover, increase in the PTC trip temperature of the polymer/nanoclay/metal filler composites was related to the temperature corresponds to similar volume expansion of the polymer at the PTC trip temperature of the composites without any nanoclay. We proposed that the mismatch in CTE between the polymer and filler played a key role that led to a disruption in the continuous network structure of the fillers even at a temperature well below the transition temperature (T_g or T_m) of the matrix polymer. The dielectric properties of these PTCR composites indicated possible use of these PTCR composites as dielectric material. Dynamic mechanical analysis (DMA) study showed higher storage modulus of the composites at the PTC trip temperature than that of the CB filled composites. High thermal stability of the composites indicated that these materials can effectively be used as PTCR materials for several heating cycles.

Keywords: PTCR composites, PTC trip temperature, Resistivity, CTE mismatch