Study of Non-Crystalline Structure of Polymer Solid by Utilizing Motion of Impurity Ion

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Abstract

Investigation of the complex-permittivity dispersion gives us a lot of useful information about the molecular motion of polymers and the structure of polymer aggregates. However, the large dispersion of permittivity at low frequencies due to dc conduction of impurity ions often covers the dispersion originated from polymer motion. In experimental investigation, many researchers have tried to remove the dc conduction experimentally or analytically for a long time. Regarding this problem, our laboratory chose another way of research from the point of view of a reversal in thinking. Namely, the way of this research is to use the impurity ions in the dc conduction as a probe to detect the motion of polymer molecules and to investigate a non-crystalline structure of polymer. In melt-crystallized polymers, free spaces with inhomogeneous size exist in a non-crystalline part among crystallites. This inhomogeneity of free spaces results from a thermal motion of the polymer molecules with amorphous conformation under the spatial restriction made by crystallite morphology. The impurity ions mixed in processing in the crystalline polymers move through these inhomogeneous free spaces. This motion of ions reflects the microstructure of the non-crystalline part. The ionic motion of impurity ions is investigated for several polymers by using the complex permittivity and the complex electric modulus. The polymers under investigation are as follows: low density poly(ethylene) (LDPE), plasticized poly(vinyl chloride) (p-PVC), poly(ethylene terephthalate) (PET), isotactic poly(propylene) (iPP), poly(chlorotrifluoro ethylene) (PCTFE), poly(vinylidene fluoride) (PVDF). Consequently, it was found that there are two group of polymers; one of the group is characterized by small conductivity relaxation time and large permittivity, and another is characterized by large conductivity relaxation time and small permittivity.

Keywords: permittivity, electric modulus, conductivity relaxation time, ionic motion, dc conduction, non, crystalline structure

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