DC electrical conductivity in LDPE-based nanocomposites

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Nanofilled materials have become increasingly popular as insulation materials in various electrical devices owing to the great advancement in their insulation performance. In the case of high voltage direct current (HVDC) cables, where the development of new insulating materials that are expected to operate at enhanced electric stresses is urgent, the use of nanocomposites opens for new design solutions. The objective of this work is to study the effect of nanofillers on dc conductivity in materials for such systems.

Low-density polyethylene (LDPE) filled with nanoparticles of aluminium oxide (Al2O3) and magnesium oxide (MgO) up to 3 wt% were prepared. The nanoparticles were manufactured and were either additionally coated using hydrophobic silanes or by grafting hydrophobic polymethacrylate chains onto the nanoparticles or used without any surface modification. After mixing the particles with LDPE, scanning electron microscope (SEM) images of the resulted composites were obtained showing good dispersion of nanoparticles in the polymer. For electrical conductivity measurements, samples were manufactured as films of 80 µm thick and the polarization current was measured by standardized procedure using a three-electrode system at temperatures of 40 and 60°C and an electric stress of 32kV/mm. A pristine LDPE material was used as a reference.

The measured electrical volume conductivity of the nanocomposites appeared to be approximately one order of magnitude lower than that of the reference material. In addition, the decrease was proportional to the concentration of the nanofillers. The effects of both types of nanofillers as well as coating treatments on material properties were compared. The reduced conductivity of both types of nanocomposites could be attributed to the introduction of deep traps in the interfacial region, resulting in accumulation of immobile charge carriers and reduction of the electric field in vicinity the of electrodes that eventually lowers injected currents. The reduced electrical conductivity is therefore one of the indicators suggesting that nanofilled polyethylene is a potential candidate for use in the new generation of HVDC cables operating at higher electrical stresses.