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Polypropylene-based ternary nanocomposites for recyclable high-voltage direct-current cable insulation

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Abstract

Polymeric high-voltage direct-current (HVDC) cables are the core equipment in energy internet, which enable the long-distance large-capacity electric power transmission, large-scale utilization of renewable electric power and flexible interconnection of large power grids. Performance of the HVDC cables are determined by the properties of their insulation material. However, the traditional polymeric HVDC cable insulation material, crosslinking polyethylene (XLPE) is limited to relatively low working temperature which restricts the power capacity of HVDC cables. XLPE with thermosetting characteristics also presents a major barrier to material recycling and environmental pollution reduction. Here we report the ternary nanocomposites of polypropylene (PP), thermoplastic polyolefin (TPO) and MgO nanoparticles as an efficient way to recyclable HVDC cable insulation material that simultaneously possess excellent thermal, mechanical and electrical properties, especially at high temperatures. At an optimal composition, the ternary nanocomposites integrates the complementary properties of the multi-components to raise the mechanical flexibility at room temperature and greatly improve the electrical properties at high temperatures (including suppressed space charge accumulation and increased breakdown strength and volume resistivity) while retaining high melting temperature comparable to PP of about 160 ºC. This work may pave a way for synergistic optimization of the overall properties of insulation materials and enabling the successful development of recyclable insulation material for large-capacity HVDC cable application.

Keywords: Polypropylene; A. Nano composites; Recyclable insulation material; High-temperature properties; B. Electrical properties