

Effect of Aluminum Oxide Nanoparticles on the Electrical and Thermal Conductivity and Thermal Stability of a Novel Polyurethane

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Abstract. This study investigates the influence of aluminum oxide (Al_2O_3) nanoparticles on the thermal and electrical properties of a novel two-component polyurethane system (2C PUR) intended for electrical insulation applications. Nanocomposites containing 0.5, 1.0, 2.0, and 2.5 wt.% Al_2O_3 relative to the polyurethane matrix were prepared using a direct dispersion method. Thermal conductivity and bulk electrical conductivity were evaluated to determine the effect of filler incorporation on the functional behavior of the material. The results revealed a clear dependence of both properties on Al_2O_3 content. Thermal conductivity increased monotonically with filler concentration, reaching the highest value at 2.5 wt.% Al_2O_3 , which indicates enhanced heat transport due to thermally conductive particles and improved phonon transfer pathways. In contrast, bulk electrical conductivity showed an overall decreasing trend, confirming improved insulating performance. Thermogravimetric analysis of the composite containing 2 wt.% Al_2O_3 showed that significant degradation began at approximately 220 °C, with the maximum degradation rate at 295 °C and about 50% mass loss at 400 °C. These findings demonstrate the potential of Al_2O_3 doped polyurethane nanocomposites for advanced electrical insulation requiring improved thermal management and low electrical conductivity.