

Nano-Silica Filled Polystyrene: Correlating DC Breakdown Strength and Particle Agglomeration.

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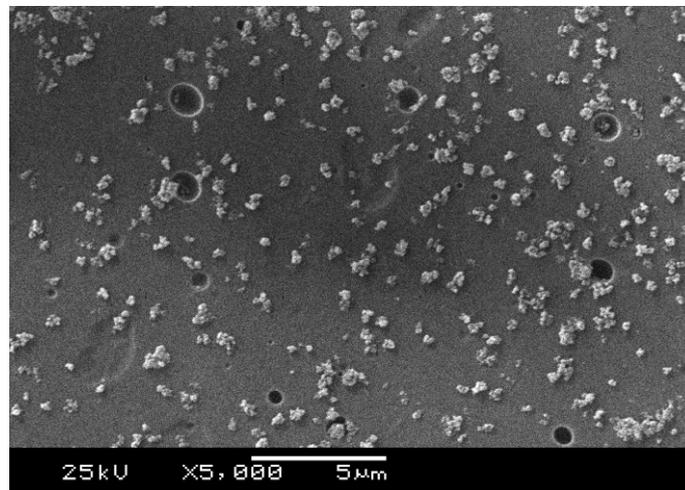
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In the field of polymer dielectrics nano-fillers have attracted a great deal of academic interest since they potentially allow significant modifications of material properties to be made. Despite the high levels of interest, no clear picture has yet emerged because results in the literature show considerable variability. Difficulties in achieving highly uniform nano-filler dispersal are perhaps the main driving force for this variability and have also hampered the adoption of nano-fillers for industrial scale applications. In this work we correlate the results from two analysis techniques in order to deepen our understanding of the action of nano-fillers in polymer dielectrics.

Nano-composites were produced with filler fractions ranging from 0 – 10 %. The filler is composed of fused silica particles with a typical size of 20 nm and the matrix material is polystyrene. Polystyrene was chosen because its amorphous matrix provides a relatively simple and uniform background on which to study the action of the nano-particles. Alternative polymers which may crystallise or exhibit lamella type structures add additional layers of complexity to the study which could obscure the effect of the nano-particles.

Firstly, we show the DC breakdown strength of the composites as a function of filler fraction. Secondly, samples undergo permanganic etching and are then imaged by a Scanning Electron Microscope. The SEM images of the etched surfaces reveal, as a function of filler fraction, the degree of agglomeration that has occurred. Combining these two data sets brings new insight to the action of the nano-filler within our model system as it allows the DC breakdown strength results to be interpreted in light of the agglomeration data.



SEM image of polystyrene with 10% nano-silica filler after a 4 hour permanganic etch. The image clearly shows agglomerates of the nano-silica particles.