Crystallinity and Dielectric Response in SWNT-Thermoplastic Composites

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ABSTRACT: This experiment measured the capacitance, dissipation, and dielectric of different samples of polyethylene (PE) with different concentrations of single wall carbon nanotubes (SWNT). Single wall nanotubes are cylindrical carbon tubes that have a diameter of only a few nanometers, but can be up to a few millimeters in length. These nanotubes have been known to be semi-conducting as well as conducting. This depends on the chirality of the nanotubes as shown in Figure 1. When combined with an insulating material with very high resistance such as polyethylene, the conductivity of the sample can be influenced substantially. In this experiment, the different concentrations of polyethylene had a net percentage ranging from 10 to 22 percent and were noted PE-15 and PE-22. The PE-10 and PE-22 samples were prepared with concentrations of either 0.1%, 0.3%, or 1% of SWNT, resulting in six samples total.

RESULTS:

The two different variables of the polyethylene samples were the net percentage and the concentration of single wall carbon nanotubes (SWNT).

The Capacitance Graphs show that the higher the net percentage (PE-22 vs. PE-15), the more insulating the sample, reaching a lower capacitance. Likewise, in comparing PE-15% SWNT vs. PE-15 0.3%, the lower percentage of SWNT, the more insulating the sample and the lower the capacitance.

Overall, in all the samples the results show that the higher the frequency, the lower the capacitance.

The Dissipation or Conductance Graphs show that the lower the net percentage (PE-20 vs. PE-15), the more conducting the sample, resulting in a higher dissipation.

Again comparing the concentration of SWNT to PE-15, the results show the higher concentration of SWNT results in a higher dissipation.

The relationship between frequency and dissipation shows that the higher the frequency, the higher the dissipation in all samples.

DISCUSSION:

Three graphs of the Loss Factor vs. Real Permittivity were shown for each sample's dissipation measurements.

The formula for Conductance is given in the formula:

\[ G = \frac{C}{\omega} \]

Where \( G \) = constant (8.854 x 10^-12 F/m), \( \omega \) = angular frequency and \( C \) = the capacitance.

In order to get the values of the dissipation factor (tan \( \delta \)), the formula:

\[ \tan \delta = \frac{G}{\omega} \]

was derived. The Loss Factor [tan \( \delta \)] can also be calculated using the formula:

\[ \tan \delta = \frac{G}{\omega} \]

Overall, we can derive the following formulas:

\[ G = \frac{1}{\omega C} \]

CONCLUSION:

After measuring the different behaviors of the samples through various graphs and diagrams, the best concentration for the samples was PE-15% SWNT. The samples PE-22% SWNT resulted in the lowest capacitance for all samples but did not show a sufficient increase in conducting as the SWNT concentrations in the samples were increased.

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EXPERIMENTAL TECHNIQUES:

1. The capacitance sample was made with the nanotubes coated on the sample.
2. The resistance sample was measured using the Nanointerface technology.
3. The setup used in this experiment is shown in Figure 5.