Electrical Properties of Fluoropolymer-Carbon Nanotubes

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Abstract

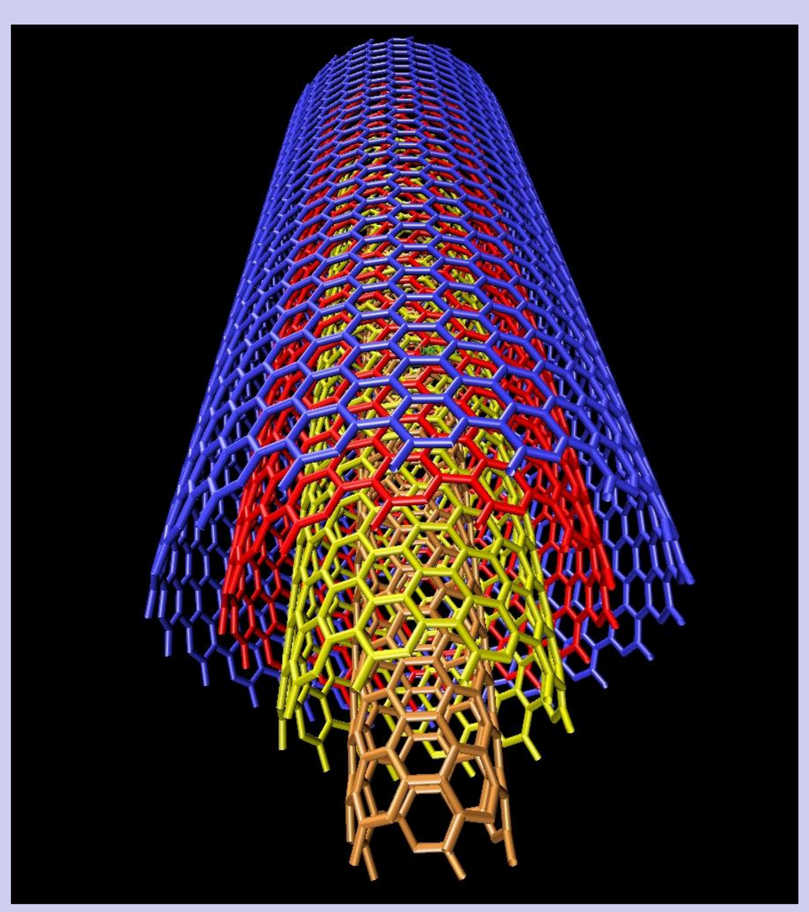
Our samples of Polyvinylidene Fluoride Carbon Nanotubes were prepared by the mixing of PVDF with a weight percentage of Carbon Nanotubes. 10 samples were made and each ranging from 0%-10%. The samples were then mixed, using 1-Methyl-2-Pyrrolidinone, in a magnetic stir. After, the samples were cooked for 2 hours at 120oC. The samples were then prepared for testing, using a high temperature furnace and a Precision LCR Meter. From the results we saw that we experienced a high dielectric constant at low frequencies and a greater affect on the sample due to temperature change at this same frequency.

Introduction

Polyvinylidene Fluoride (PVDF) is a highly non-reactive and pure fluoropolymer. It is used in applications requiring purity, strength, and resistance to solvents, acids, bases and heat. Compared to other fluoropolymers, it has an easier melt process because of its relatively low melting point of around 177 ° C. It can be injected, molded or welded and is commonly used in the chemical, semiconductor, medical and defense industries.

Carbon Nanotubes (CNTs) are allotropes of carbon with a cylindrical nanostructure. CNTs have been constructed with length-to-diameter ratio of up to 132,000,000:1. This is significantly larger than any other material. These carbon molecules have unusual properties, which are valuable for nanotechnology, electronics, optics and other fields of materials science and technology. Because of their extraordinary thermal conductivity, mechanical and electrical properties, CNTs find applications as additives to various structural materials.

Figure 1- Multiwalled Carbon Nanotube



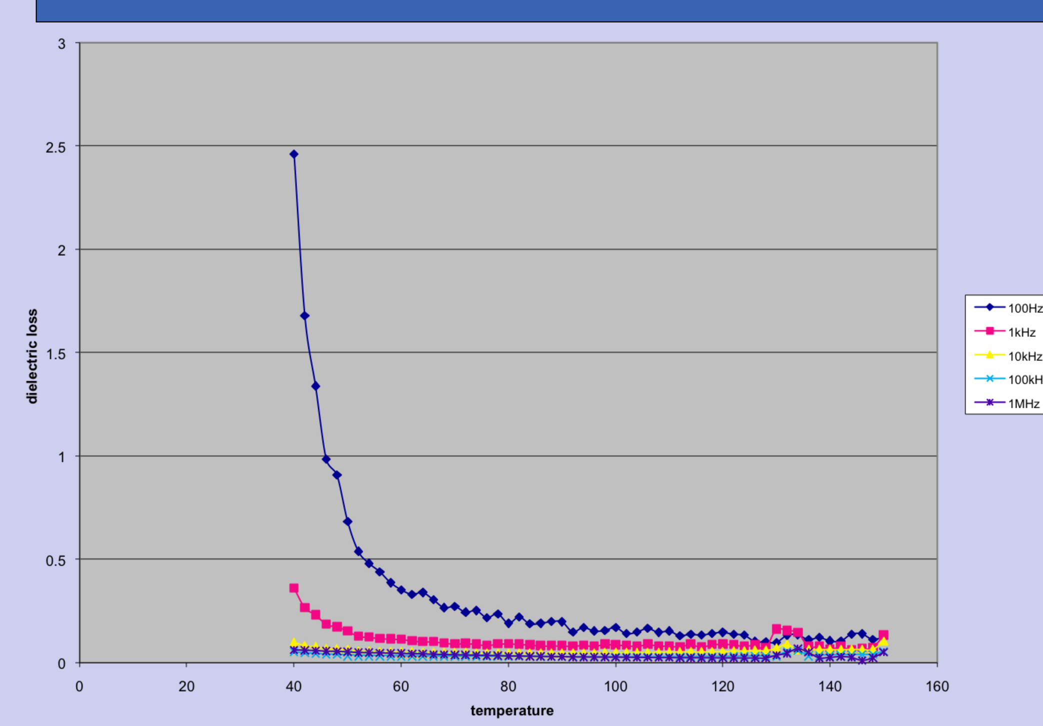
Methods

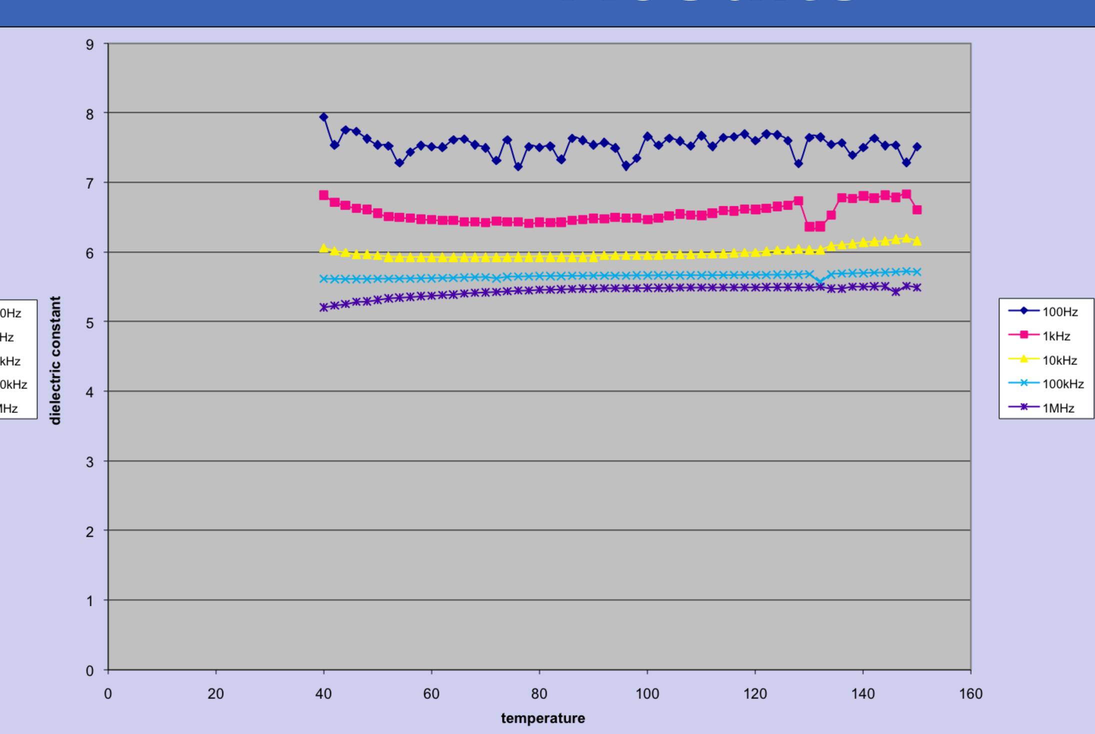
Our samples were made using 2 grams of PVDF and a weight percentage of CNTs. The weight percentages used ranged from 0-10 in increments of 1. The next step was adding 10 ml of 1-Methyl-2-Pyrrolidinone and mixing by hand for 5 minutes. This was followed by the use of a a magnetic stirrer to mix the sample for 1 hour. Our next step was to cook the sample in a furnace for 2-3 hours at 120^{o}C, this was just enough time to completely evaporate the 1-Methyl-2-Pyrrolidinone and ensure a sample of only PVDF and CNTs. We measured the thickness of the sample and began preparations to take our measurements.

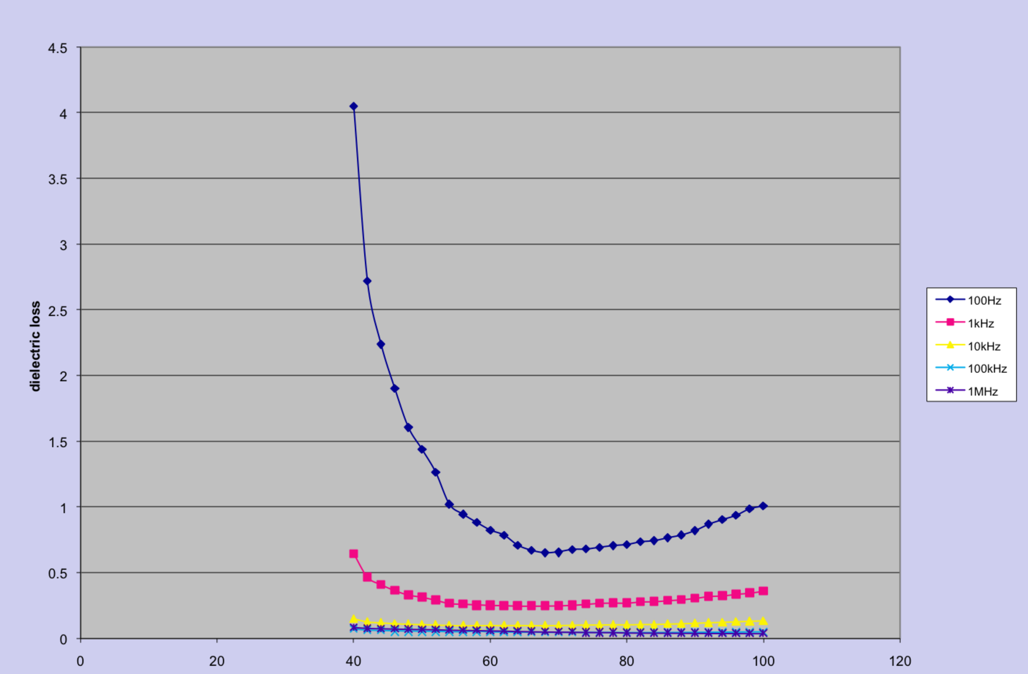
In order to prepare the samples for this testing we coated each with a thin layer of platinum and measured the length and width of each sample. We then attached wires to both sides of the sample using silver paste to hold the wires in place. After the paste was dry, we placed the sample inside a high temperature furnace and connected it to a Precision LCR Meter and began our testing. After entering our measurements for length, width and thickness our data reflected the electrical properties of our sample based on its surface area.

For our testing we exposed our samples to frequencies ranging from 100Hz to 1MHz at temperatures of 40-100^{o}C, increasing by 2 degrees each time. The data from these tests gave us the results of the dielectric constant and dielectric loss at each frequency. We then took this data, plotted it and came up with conclusions about our results .

Results







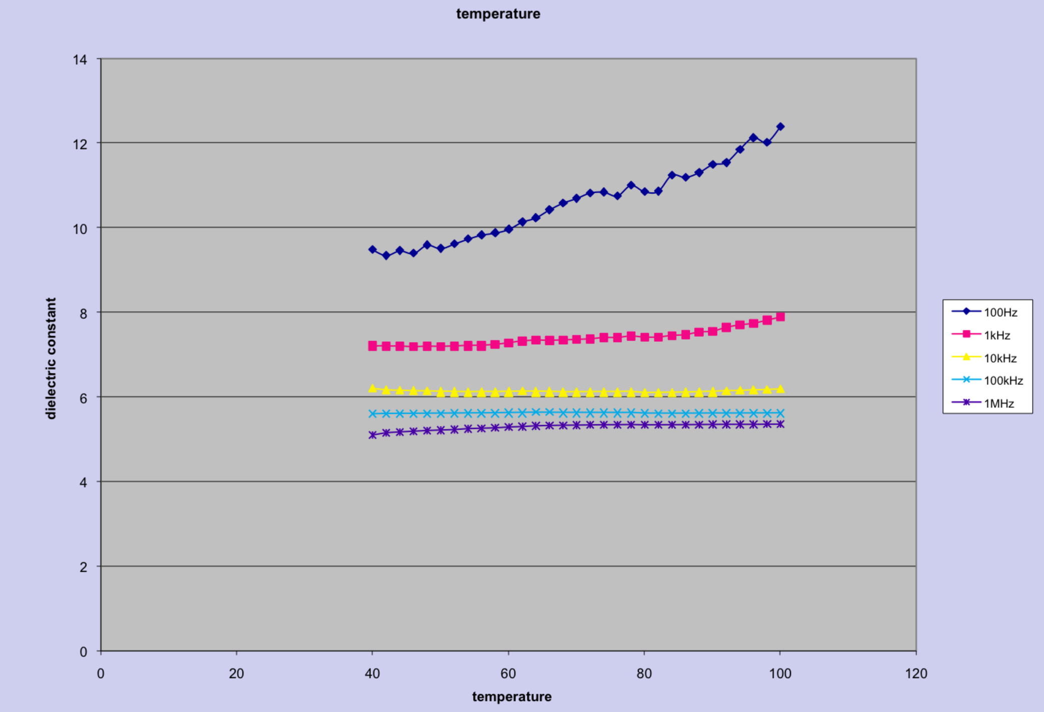


Figure 2(Top Right)- This graph shows the dielectric loss of a PVDF sample with 0%wt CNTs

Figure 3(Top Left)- This graph shows the dielectric loss of a PVDF sample with 0%wt CNTs.

Figure 4(Bottom Right)- This graph shows the dielectric loss of a PVDF sample with 3%wt CNTs.

Figure 5(Bottom Left)- This graph shows the dielectric constant of a PVDF sample with 3%wt CNTs.

Conclusion

Our results showed us that there is a significant increase in the dielectric constant at low frequencies as the temperature was increased. We also see that there is a significant drop in the dielectric loss at low temperatures. We hope to be able to make greater meaning of this in the near future and to be able to apply these results to real world applications.

Acknowledgements

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