MICROWAVE HEATING OF CARBON BASED ACRYLONITRILE-BUTADIENE-STYRENE NANOCOMPOSITES

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Objectives

1. To modify the electromagnetic properties of Acrylonitrile-Butadience-Styrene (ABS) by incorporating various type of nano sized carbon fillers.

2. To determine the effect of various loadings of nano sized carbon based fillers on the dielectric properties of ABS nanocomposites.

3. To determine the effect of various types and loadings of nano sized carbon based fillers on the microwave heating behavior of ABS nanocomposites

Introduction

Microwave heating of polymers is based on the conversion of alternating electromagnetic (EM) field energy into thermal energy. It is a process where microwave energy is used as a heating source by interacting directly with the polar molecules of a material (polarization) i.e., by raising their rotational energy level and thus the temperature. The microwave heating ability of any material depends on its dielectric constant (ε') and dielectric loss (ε''). ABS is a material with a low dielectric constant (2.6 at 2.45GHz); therefore, microwave heating of neat ABS polymer is not favourable.

Normally, to get a high dielectric constant in any polymer it must be filled with a suitable filler or receptor [1]. An ABS polymer matrix may be filled with metallic or high dielectric ceramic powders as previously reported by Moulart et al [2]. They found that the dielectric constant value of ABS polymer, (i.e., 1.5-2.5) could be improved over 8 times with the addition of 30% barium titanate by volume into the ABS polymer but the mechanical properties suffered a negative effect.

This work investigated whether the ABS could be made more responsive towards EM waves by incorporating a carbon based nano-sized conducting filler to change its dielectric properties.

Method and Equipment

A Split Post Dielectric Resonator (SPDR) was used to measure the dielectric properties of the ABS nanocomposites. A Microwave oven and optical IR thermal sensor was used to measure the microwave heating behavior of the ABS nanocomposites.

a. Data Acquisition

b. Recorded Temperature Rise

Figures 1 (a-b): Equipment setup and data acquisition for microwave heating experiment.

Results and Discussion

Figure1 shows the dielectric constant, *ε'*, for various carbon based ABS nanocomposites measured at room temperature and at 2.47 GHz. *ε'* measures how much of the energy from an external electric field is stored in a material and *ε''* is an indication of a material's ability to convert the stored electromagnetic energy into heat. The higher the *ε'* value the more EM energy can be stored in the nanocomposites at any given *ε''* and the nanocomposites with the largest energy stored will give more heat. This is evident in Figure 2 as the ABS/carbon fibre nanocomposites yield the highest heat.

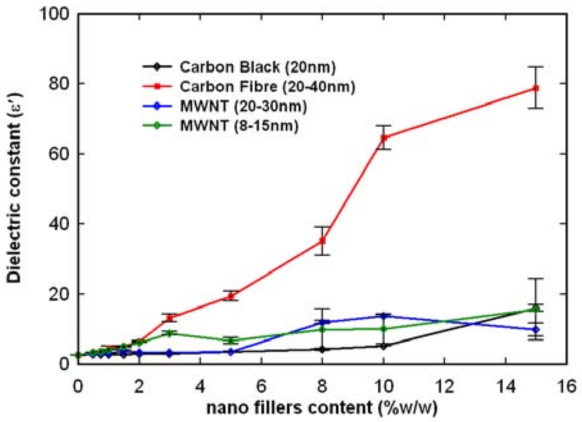

Figure 1: Dielectric constant for 3% w/w Carbon based nanofillers at 300 W microwave irradiation power.

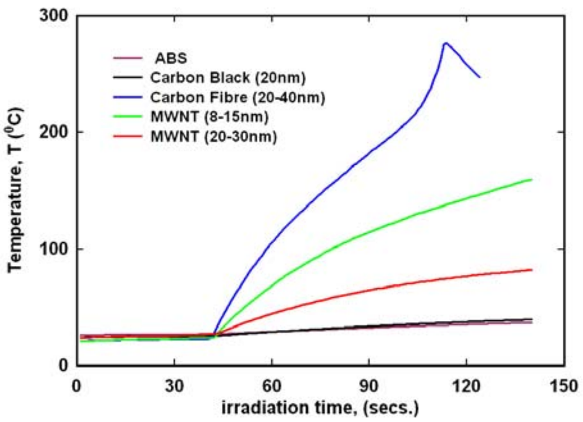

Figure 2: Measured temperature rise for 3% w/w carbon based nanofillers at 300 W irradiation power

Fibrous shape nanofillers (carbon fibre and MWNTs) gave a better response towards the EM waves as compared to the particulate type (carbon black) nanofiller as shown in Figure 2. Within the same type of nanofiller, the smaller sized nanofiller gave the best temperature rise as the surface area increased and therefore there was more contact between the nanofiller and the ABS matrix for polarization to take place.

Figure 3 shows that microwave heating increases with an increase in the nanofiller content. An increase in nanofiller content means that the number of contacts between the nanofiller and the ABS matrix for polarization also increases and more energy from the EM waves can be stored and converted into heat.

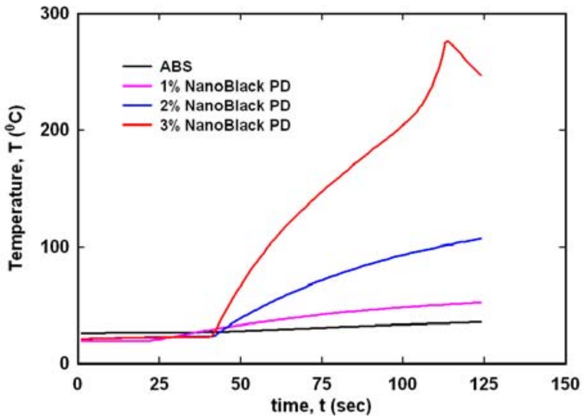

Figure 3: Measured temperature rise for varying levels of nano carbon fibres at 250W of microwave irradiation power.

Conclusions

ABS was changed from a dielectric material into a conductive material which responded well to EM waves by the incorporation of nanosized carbon based fillers. The fillers with the largest surface area and highest dielectric constant, *ε'*, produced the largest microwave heating in the ABS nanocomposites.

References

1. Harper, J.F., Price, D.M. and Zhang, J., "Use of Fillers to Enable the Microwave Processing of Polyethylene", *J. of Microwave Power &*

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2. A.Moulart, C. Marrett, and *J. Colton, Polym. Eng. Sci.*, 44, 588 (2004).