MECHANICAL PROPERTIES AND DC RESITIVITY OF POLYSTYRENE CARBON FIBER COMPOSITES

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Abstract

The electrical resistivity and mechanical properties of carbon fiber (8 μm diameter and 3 mm length) reinforced polystyrene composites with different loading have been reported. The dc resistivity indicates that the percolation threshold is below 5% w/w of carbon fiber. The resistivity shows a lowest value for loading around 25 % w/w The mechanical strength measurements indicate a higher strength for 25 % w/w of loading. It is also shown that for a longer fiber (6 mm in length), the mechanical strength further improves.

Keywords: Polystyrene Carbon fiber composite, conductivity

1. Introduction

Composites are a class of engineering materials consisting of mixture of two or more components present in separated phases and combined to improve a given property of each individual component. In particular, the development of conducting composites consisting of conducting particles embedded in a polymeric matrix have been pushed forward by the necessity of having light materials combining the inherent process ability of polymers with the electrical conductivity of metals. Depending on the nature of the filler, the mechanical and electrical properties of the composite change.

Various fillers in the form of powders, fibers and nano tube carbon block have been tried with various polymer bases and studied previously by different people [Rejon et al,2000; Valente et al, 1999]. Recently, carbon nano fiber reinforced liquid crystal polymer has been synthesized for the study of electromagnetic interference [Haggenmueller et al, 2000].

In an electrically insulating polymer matrix, addition of conducting fibers or particulates is expected to increase the conduction mechanism [Ezquerra et al, 2001]. It is well known that the conduction mechanism at dc is mainly due to the physical transfer of the charge through the path of conduction. Therefore, path of conduction must be established for realizing an increase in the conductivity. In an insulating polymer matrix, addition of very low content of the conducting filler may not improve the conduction process but as the addition crosses a critical concentration, the path of conduction is well established and thereby shows a sharp increase in the conductivity. The improvement in the electrical conduction has applications for electromagnetic shielding [Lee et al, 2001], sensor design [Ogura et al,2000; Flandin et al, 2001; Xiangcheng Luo et al, 2001] etc. The improvement in the conductivity also depends on the geometry of the filler particles like spheres, cylinders and fine fibers.

Apart from the improvement in the electrical properties, mechanical strength undergoes a drastic change when the polymer matrix is filled with fibers. With loading of the fiber, the mechanical strength of the polymer is expected to increase and attain a maximum at a critical loading and start decreasing for further loading.

In this paper, we report the variation in the electrical and mechanical properties with loading of different weight percentages of carbon fibers in the polystyrene matrix.

2. Experimental details

2.1. Preparation of polystyrene – carbon fiber composite

The carbon fibers (CF) (diameter 8μm) from Indian Petrochemicals Ltd., Baroda, India, polystyrene (PS) granules (LG 1012: and

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Mw = 2,50,000) from LG Chemicals, India and the solvent tetrahydrofuran (THF) from Sisco Research Laboratories, Mumbai, India. The chemicals were used without further purification. Initially, a solution of polystyrene in tetrahydrofuran was prepared. Known weights of the carbon fibers cut into 3 mm in length were added to the above solution (THF+PS) to obtain specific concentrations of CF in PS (say 1%). The solution was stirred well for long time to ensure uniform distribution of CF throughout the matrix. This solution was allowed to dry for solidification. Sheets of required thickness were obtained by pressing this material using a hydraulic press at a temperature of 180^{0}C. While CF having lengths 3 and 6 mm were used for the study of mechanical property, length of 3 mm was used for the electrical conductivity measurements. Weight percentage of CF was varied from 1 to 40%.

2.2. Mechanical properties

The measured tensile strength and hardness values (of discontinuous and randomly oriented reinforced material) for different loadings of CF for two different lengths of the fibers were recorded in Table 1. From the table it can be observed that both the tensile strength and hardness initially increase till about 25% w/w and then decrease. The maximum tensile strength at a critical loading is mainly due to the loosened structure and increase of porosity in the composite resulting from poor spreading of polymer melt or incomplete wetting characteristics [Liello et al, 1990]. It may also be observed that the tensile strength is high for 6 mm CF compared to that of 3 mm. This shows that it is better to use lengthier carbon fiber for better mechanical property. This also indicates that the diameter of the fiber may also play a crucial role in the improvement of mechanical strength.

3. Conclusions

The dc resistivity for the polystyrene-carbon fiber composites indicates that the percolation threshold is below 5% w/w of the loading. The tensile strengths of the composites attained a maximum at around 25% w/w of loading. It may be concluded that the mechanical strength improves with higher length of the carbon fiber.

Table-1: Variation of the tensile stress and hardness with carbon fiber percentage in PS.

Carbon fiber wt. percentage	Tensile strength of composites (MPa)		Hardness (Shore-D)	
	3 mm	6 mm	3 mm	6 mm
1	7.3	15	37	43
2	14.9	21.6	45	51
5	20.5	34.2	75	78
10	42	45.7	81	83
20	54.3	63	83	90
25	65.2	75.6	85	93
30	56.2	60	77	81

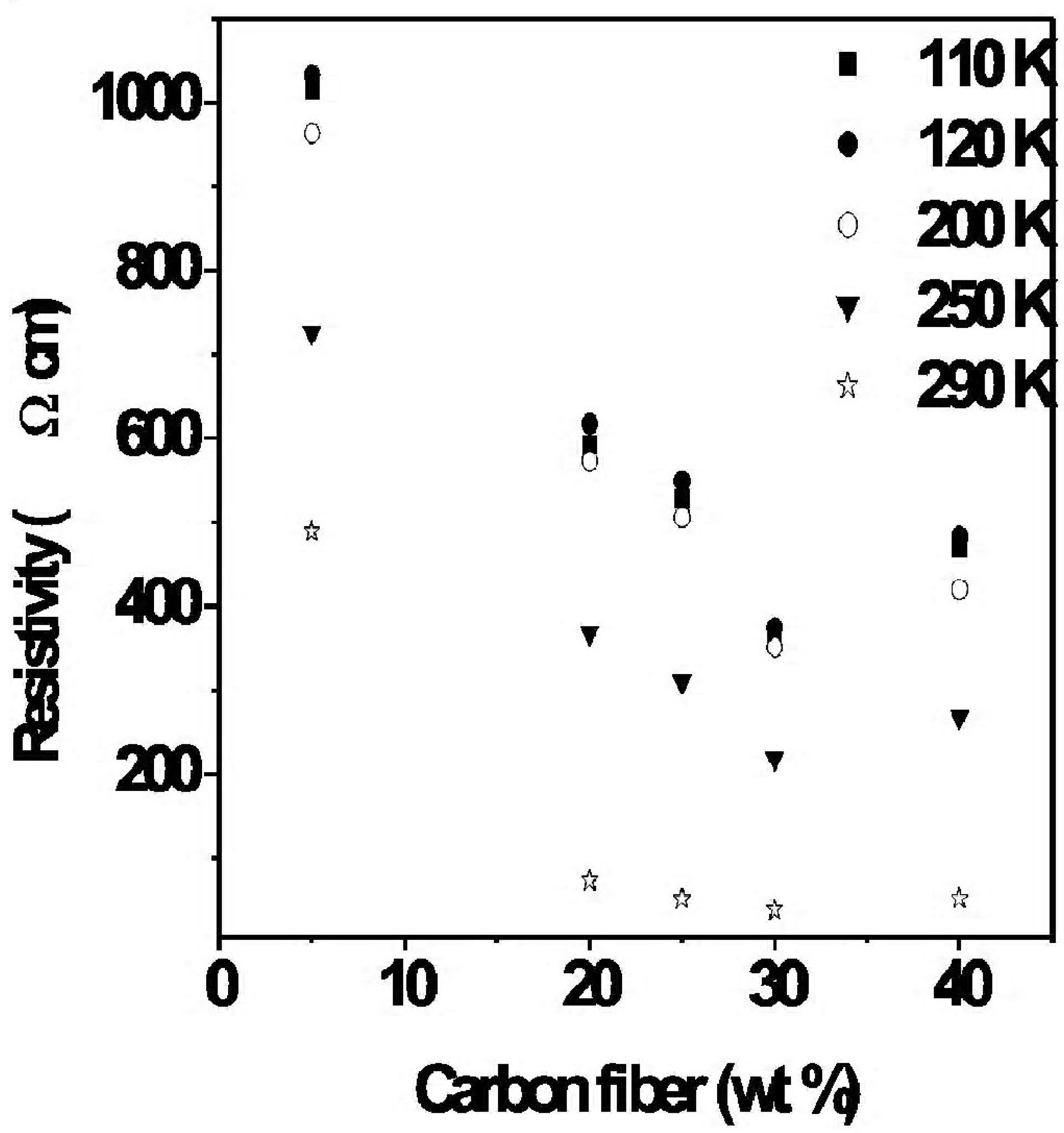

Fig. 1 Variation of dc resistivity as a function of weight percentages of carbon fibers at five different temperatures.

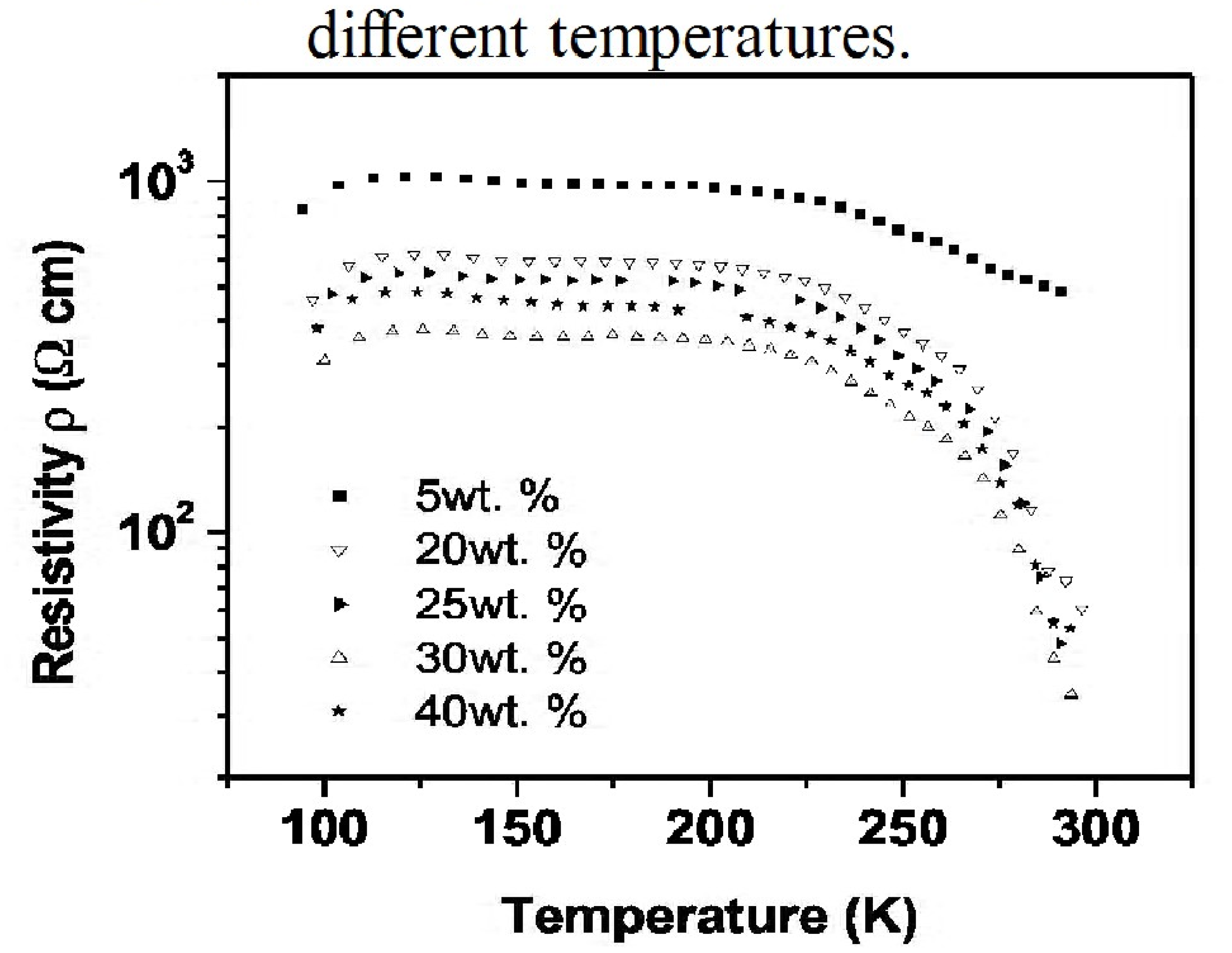

Fig.2 Variation of dc resistivity as a function of temperature at different weight percentages of carbon fiber.

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