Journal of Optoelectronics and Advanced Materials Vol. 6, No. 3, September 2004, p. 1081 - 1084

SOME CHARACTERISTICS OF CONDUCTIVE POLYMER COMPOSITES CONTAINING STAINLESS STEEL FIBERS

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Rheological tests (torque, melt flow rate, melt viscosity), mechanical tests (tensile strength, elongation at break, impact strength), dc electrical conductivity on ABS copolymer/ stainless steel fibber composites with fibber concentration between 0 and 5% (vol.) are reported. Tensile strength and relative modulus are not affected by the presence of stainless steel fibbers in the range 0…5% (vol.). Elongation and impact strength decrease drastically even at low concentration of fibbers. Low concentrations of metallic fibbers (which are necessary for static dissipative properties) have a little influence on rheological behaviour. A fluidisation trend is observed when stainless steel fibbers are introduced in ABS. Non-linear behaviour is observed at high electrical fields.

(Received April 20, 2004; accepted June 22, 2004)

Keywords: Polymer composites, Electrical conductivity, Conductive fibbers

1. Introduction

Polymer/metal composites, are extrinsic electrical conductivity materials, made from a polymer matrix and a variety of metal conductive fillers [1-5].

The electrical properties of polymer/metal composites have been the subject of many papers [6-8]. Less work is concerned with the correlation of rheological, mechanical and electrical features of these materials and with the understanding of conduction mechanisms taking place.

The aim of this paper is to discuss the rheological, mechanical and electrical properties of ABS/stainless steel fibber composites.

2. Experimental

An ABS copolymer from DOW CHEMICALS and stainless steel fibbers from BEKAERT (GR75/C12-E/5), with a length of 5 mm, were used to obtain the conducting composite. The copolymer, the conducting stainless steel fibbers and a dispersing agent were mixed in a rotational mixer at room temperature for 10 minutes. The resulting blend was injection moulded to obtain specimens for mechanical and electrical tests using an injection-moulding machine Engel ES 40/17 (D 25, max. volume 34 cm^3) in the following conditions:

- temperature range 180 – 220 ^oC;
- injection pressure: 1200 daN/cm^2.

Samples A0, A0.5, A1, A1.5, A2, A2.5, A3, A4, A5 are composites with 0, 0.5, 1, 1.5, 2, 2.5, 3, 4 and 5% (volume percentages) stainless steel fibbers obtained from the injected mix.

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Secondly, the copolymer, the conducting stainless steel fibbers and the dispersing agent were mixed in a rotational mixer at room temperature for 10 minutes and extruded using a Gottfert extrusiometer (L/D 20, rheological screw with a diameter of 25 mm), then granulated and injection moulded in the same conditions. Samples B0, B0.5, B1 are composites with 0, 0.5 and 1% (volume percentages) stainless steel fibbers obtained by extrusion (Göttfert) and injection moulding.

The composites were investigated from the standpoint of mechanical properties, electrical conductivity and their processing ability.

Tensile properties of the composites were determined according to ISO 527-93 using an FPZ-100 Universal Testing Machine (specimens type I, 5 mm/min). Izod impact strength of the composites was determined according to ISO 180-93 using an Izod Pendulus – Ceast (notched specimens).

Conductivity measurements were carried out using a Keithley 6517 electrometer with a measurement cell connected to PC-Pentium III computer for resistance above 10 MΩ (Fig. 1). For elevated currents, conductivity was measured using a digital electrometer Keithley 616 and contacts of highly conductive silver paste.

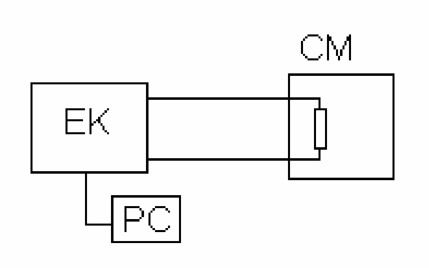

Fig. 1. Electrical schema for current measurements, EK: Keithley electrometer 6517; CM: measurement cell.

Melt rheological properties of the composites were determined using a Göttfert Extrusiometer with torque, pressure and force measuring devices.

3. Results and discussion

The mechanical characteristics of the composite materials obtained by injection moulding (A series) are presented in Figs. 2 – 4.

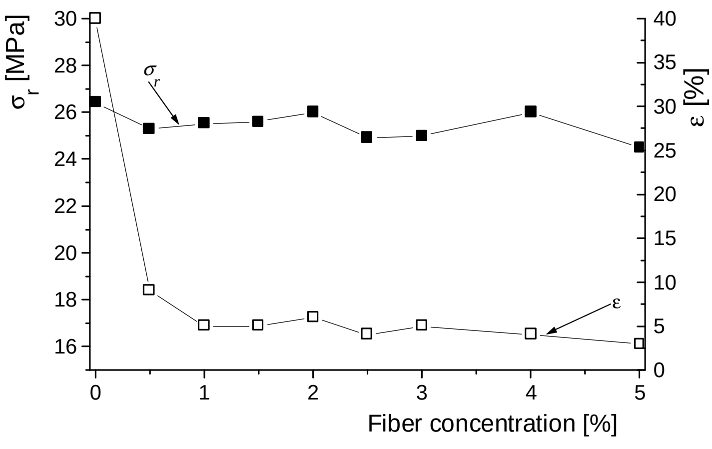

Fig. 2. Variation of tensile strength and elongation at break in function of fibber concentration.

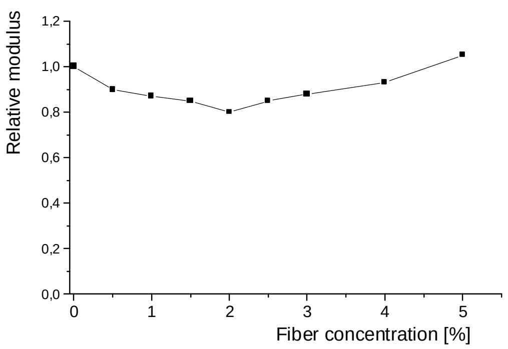

Fig. 3. Variation of tensile modulus in function of fibber concentration.

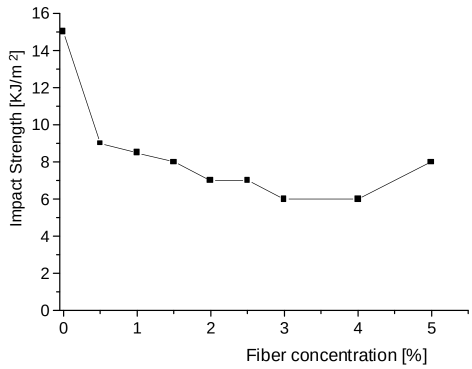

Fig. 4. Variation of tensile modulus in function of fibber concentration.

The mechanical characteristics of the composite materials obtained by extrusion – injection moulding are presented in Table 1.

Table 1. Mechanical properties of composites obtained by extrusion – injection.

Sample	Tensile Strength [MPa]	Elongation at rupture [%]	Relative modulus
B0	28.0	41	1
B0.5	27.4	19.5	1.14
B1	27.4	15	1.26

Tensile strength and relative modulus are not affected by the presence of stainless steel fibbers till 5% (vol.). Elongation and impact strength decreases drastically even at low concentration of fibbers. There is not a large difference between mechanical characteristics of samples obtained by the two methods (injection moulding of the mix and extrusion and injection moulding).

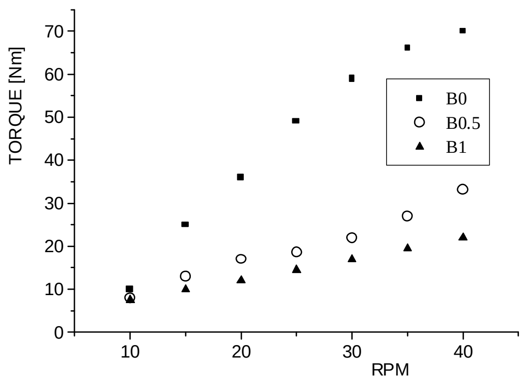

Fig. 5. Variation of torque in function of rotation speed.

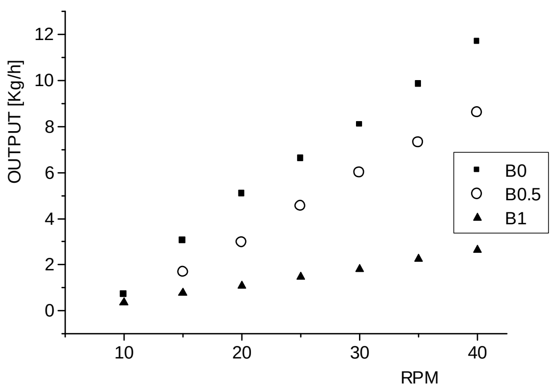

Fig. 6. Variation of output (MFR) in function of rotation speed.

Figs. 5 and 6 show the effect of stainless steel fibber concentration on the torque and output (melt mass-flow rate – MFR) values at various rotations of the screw. Fig. 7 show the variation of viscosity (torque/rpm) with rotation speed (rpm).

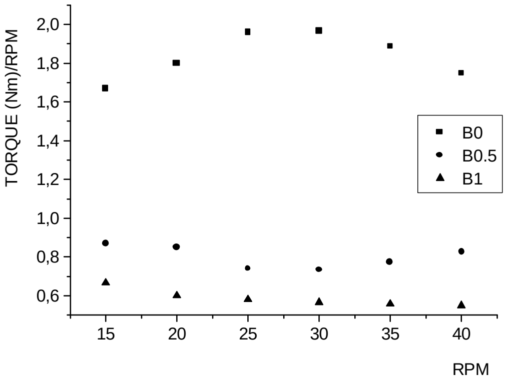

Fig. 7. Variation of viscosity in function of rotation speed.

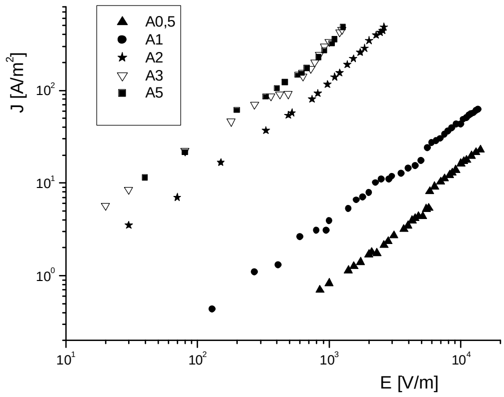

Fig. 8. J(E) dependence for ABS composites with stainless steel fibbers.

The dependence of current density *J* (D.C. measurements) on the electric field *E* is presented in Fig. 8.

Non-linear behaviour is observed especially at high electrical fields. For the same value of the electric field applied increased values are obtained for current density. Differences are greater for fibber concentration in the range 0.5…..2% (volume), in the domain of percolation threshold.

4. Conclusions

Tensile strength and relative modulus are not affected by the presence of stainless steel fibbers in the range 0…5% (vol.). Elongation and impact strength decreases drastically even at low concentration of fibbers. Low concentrations of metallic fibbers (which are necessary for static dissipative properties) have a little influence on rheological behaviour. A fluidisation trend is observed when stainless steel fibbers are introduced in ABS. Non-linear behaviour is observed especially at high electrical fields.

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