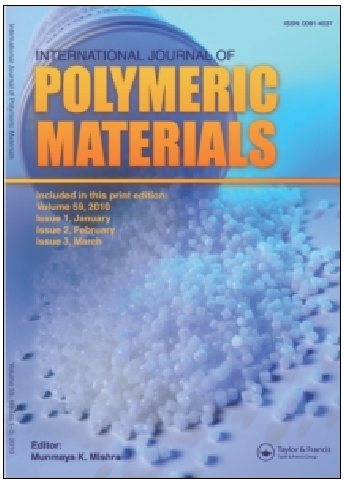

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Physical and Mechanical Properties of Polypropylene Reinforced with Fe Particles

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The physical and mechanical properties of Polypropylene (PP) and Fe-PP polymer composites containing 5, 10, and 15 vol% Fe were investigated experimentally. After preparing PP and Fe–PP polymer composites with a twin screw extruder and injection molding, the following properties were determined: yield and tensile strength, the modulus of elasticity, % elongation, hardness (Shore D), Izod impact strength (notched), melt flow index (MFI), Vicat softening point, Heat deflection temperature (HDT), and melting temperature (Tm) of PP and metal-polymer composites. As compared to PP, It was found that by increasing the vol% of Fe in PP, notched Izod impact strength, yield and tensile strength, and % elongation decreased. On the other hand, the modulus of elasticity, hardness, MFI, vicat softening point, and HDT values increased with the amount of iron.

Keywords: polymer composite, polypropylene, Fe powder

INTRODUCTION

Metal–polymer composites exhibit some properties of both metals and polymers and have been the subject of extensive research over the last two decades. Various kinds of polymers and polymer matrix composites reinforced with metal particles have a wide range of industrial applications due to their low density, high corrosion resistance, ease of fabrication, and low cost [1–3]. The physical and mechanical properties of the composite materials depend on the volume fraction of the fillers and additives such as metal or ceramic, on their shape, such

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as powder or fiber, and on the interfacial compatibility between the metal particles and the matrix [4]. Such fillers and additives are introduced to the system to improve thermal and electrical conductivity, and to stiffen the matrix [3,5–11].

In this article, 5, 10, and 15 vol% of Fe powder as fillers and PP as polymer matrix were used to prepare metal-polymer matrix composites. The physical and mechanical properties of PP and Fe-PP polymer composites were investigated experimentally.

EXPERIMENTAL PROCEDURES

Metal–polymer matrix composites were prepared by using the following materials: PP known as Petoplen was obtained from PETKIM, Petrokimya Holding A.S., Turkey. Iron powder known as Ancorsteel 1000HP was obtained from Hoeganaes, USA. The purity of Fe was 99.75% and the average particle size was 50 microns. Morphology of iron powder is irregular. To investigate the effect of iron particles on the physical and mechanical properties of the composite system, 5, 10, and 15 vol% of Fe were introduced into PP using a twin screw extruder (Maris-TM40MW-Maris America Corporation, Baltimore, USA). The extrusion temperature, pressure, and screw speed were 180–230°C, 20 Bar, and 24 rpm, respectively. To prepare the samples for thermal and mechanical tests, the following injection conditions were used: injection temperature was 210–230°C, injection pressure was 40 Bar, dwel time in the mold was 10 s and cooling water temperature was 40°C.

Tensile test samples were prepared according to the ISO 294 standard by using an Arburg injection molding machine (Arburg GmbH Co., Lossburg-Germany). Tensile tests were conducted according to ISO 527.2 at a crosshead speed of 50 mm/min. Izod notched impact test were done according to the ISO 180 standard by using a Zwich type impact machine (Zwich GmbH, Ulm-Germany). MFI values were obtained according to the ASTM D 1238 standard with Zwick test equipment. To determine the glass transition temperature, DSC studies were carried out by using a SETERAM DSC 131 (Scientex Pty. Ltd. Victoria, Australia). HDT and Vicat softening point values of the composites were obtained by using a CEAST 6505 equipment (Ceast SPA, Pianezza, Italy). To characterize the surface morphology, samples were coated with about 40 Å thickness carbon by using POLARON SC 7640 (Gala Instrumente GmbH, Bad Schwalbach, Germany). After that, the coated samples were studied by using a EFI Srion SEM (EFI Company, Netherlands) operated at 15 kV.

TABLE 1 Melting Temperature, HTD, and Vicat Softening Point Values of PP and PP–Fe Polymer Composites

Sample	T_m (°C)	HDT (°C)	Vicat softening point (°C)
PP	174.0	50.3	118.7
PP (5 vol% Fe)	176.7	52.1	151.5
PP (10 vol% Fe)	146.8	56.8	152.4
PP (15 vol% Fe)	170.9	57.8	157.1

RESULTS AND DISCUSSION

Melting temperature, heat deflection temperature, and Vicat softening point of PP and Fe–PP polymer composites studied here are given in Table 1 and the measured DSC curves are given in Figure 1. As seen from Table 1 and DSC curves, fluctuation in the melting temperature was observed with the amount of Fe powder. However, a smooth increase in HDT values with the vol% of Fe was seen. Introduction of Fe powder into PP had more impact on the Vicat softening point

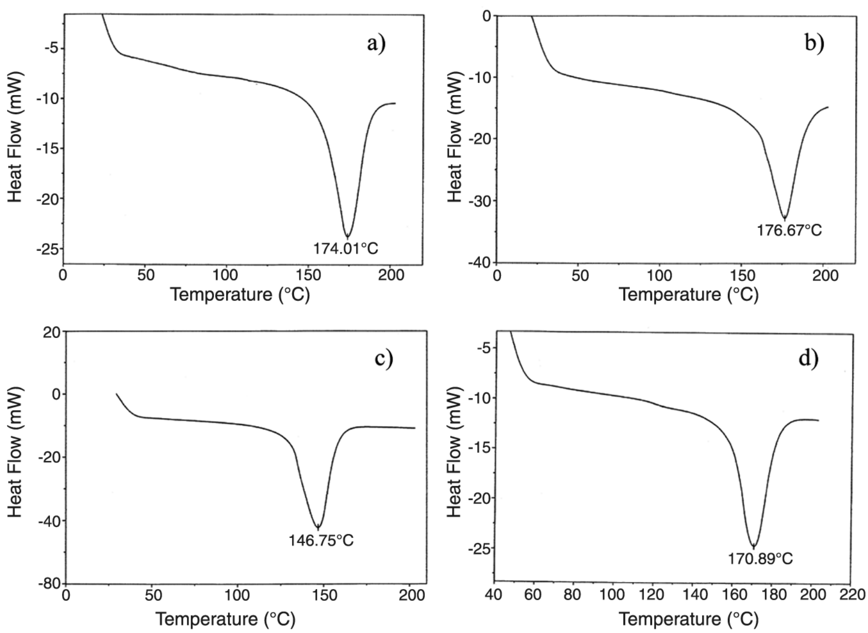

FIGURE 1 DSC curves of: (a) PP, (b) PP containing 5 vol% Fe, (c) PP containing 10 vol% Fe, and (d) PP containing 15 vol% Fe.

TABLE 2 The MFI Values of PP and PP–Fe Composite Systems

Samples	MFI (g/10 min)
PP	4.80
PP (5 vol% Fe)	5.27
PP (10 vol% Fe)	6.11
PP (15 vol% Fe)	8.32

values than on the melting and HDT values, such that the addition of 5 vol% Fe sharply increased the Vicat softening point of PP.

The measured MFI values of the samples are given in Table 2 and also plotted in Figure 2. From Table 2, it is seen that the MFI values increased continuously with the vol% of Fe in PP.

The mechanical properties of PP and the metal–polymer composites are listed in Table 3. As shown in Table 3, the introduction of Fe particles into PP resulted in a sharp decrease in % elongation of the PP such that 5 vol% of Fe reduced the % elongation of PP about 42%. When the vol% of Fe was increased to 10 and 15, the rate of decrease in % elongation was small. In addition, the yield, tensile, and Izod impact strength of PP and the polymer composites decreased

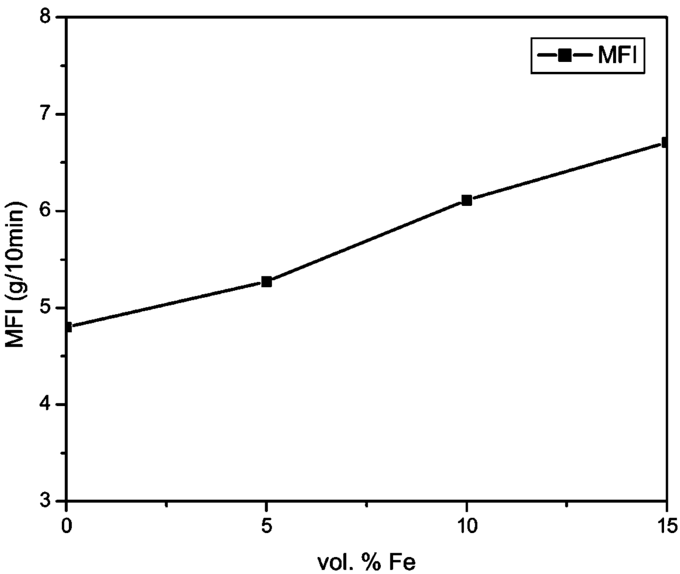

FIGURE 2 The MFI values of PP and Fe–PP polymer composites.

TABLE 3 The Mechanical Properties of PP and PP–Fe Polymer Composites

Mechanical properties	PP	PP (5 vol% Fe)	PP (10 vol% Fe)	PP (15 vol% Fe)
Izod Notched Imp. Strength (kJ/m^2)	8.80	8.73	8.16	5.83
Hardness (Shore D)	60.00	61.50	62.23	63.00
Modulus of elasticity (MPa)	255.31	294.20	388.79	400.80
Tensile strength (MPa)	28.18	26.33	21.19	20.08
Yield strength (MPa)	27.27	25.83	20.47	19.58
% elongation	45.13	26.35	24.96	20.71

continuously. Figure 3 shows the rate of change in both Izod impact strength and % elongation. On the other hand, addition of Fe powder to PP improved the modulus of elasticity and Shore D hardness of PP.

The effect of Fe on the yield and tensile strength and Shore D hardness can be seen from Figure 4. The ratio of Shore D hardness to the modulus of elasticity as a function of vol% of Fe is given in Figure 5. As shown in the figure, a decrease occurs in the ratio of the hardness to the modus of elasticity with the vol% of Fe.

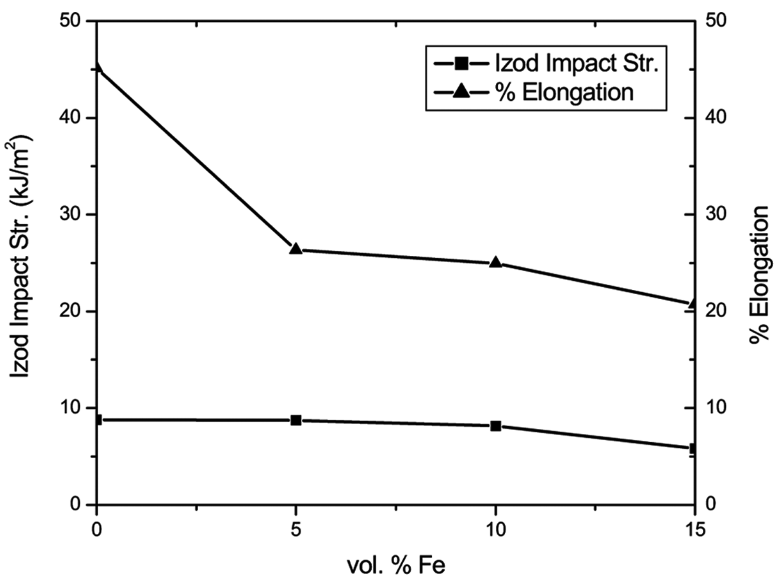

FIGURE 3 The effect of Fe particles on Izod impact strength and % elongation.

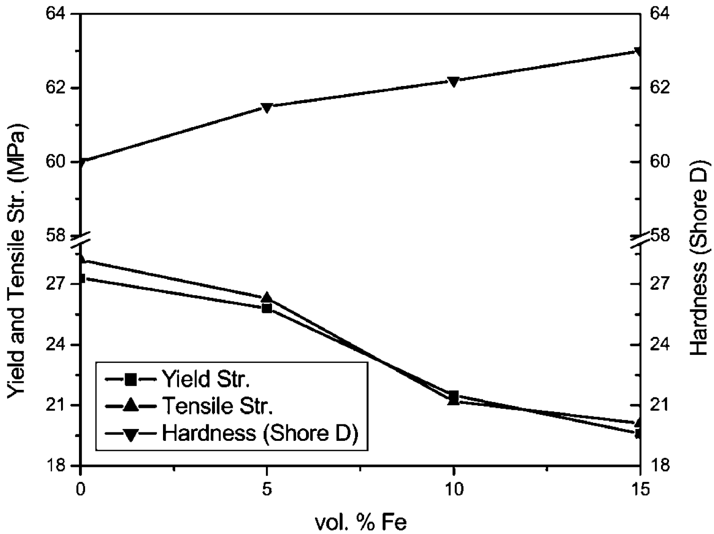

FIGURE 4 The effect of Fe on the yield and tensile strength and hardness of PP.

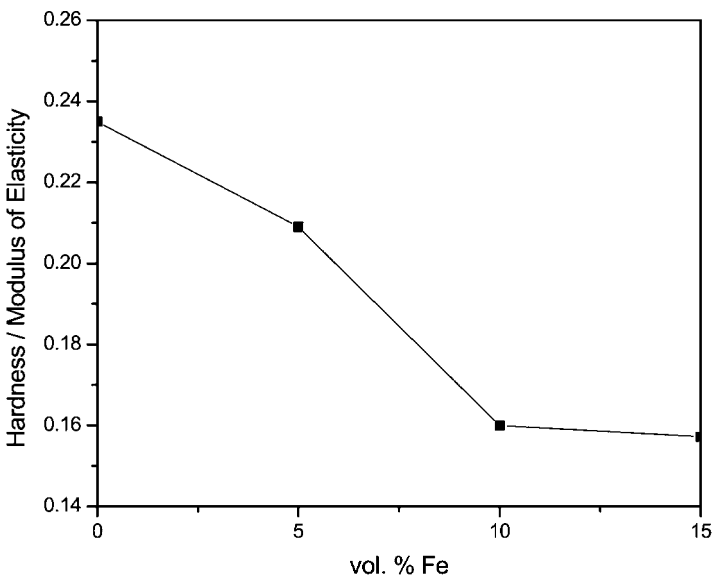

FIGURE 5 The ratio of hardness to the modulus of elasticity as a function of vol% of Fe.

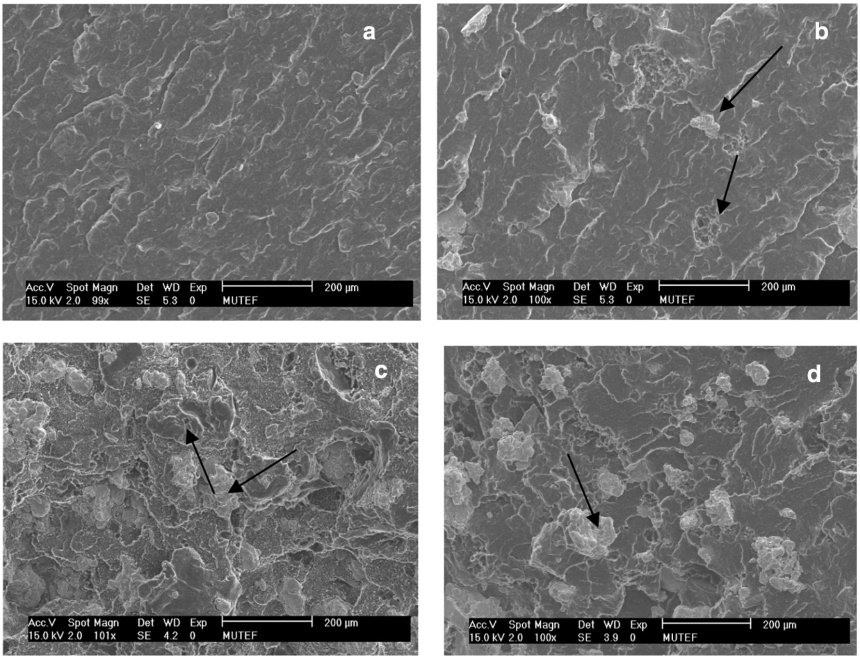

FIGURE 6 SEM micrographs taken from the fracture surfaces of PP and PP–Fe composites: (a) PP, (b) PP containing 5 vol% Fe, (c) PP containing 10 vol% Fe, and (d) PP containing 15 vol% Fe.

The micrographs taken from the fracture surfaces of PP and Fe–PP polymer composites are shown in Figure 6. The arrows on the figures indicate embedded particles in the matrix and the dimples left by the particles after fracture. Large particles indicate that some of the particles coalesced into a single particle during the processing of the composites.

CONCLUSIONS

In this article, the physical and mechanical properties of PP and PP–Fe polymer composites were investigated. It was found that introduction of Fe particles into PP reduced the yield and tensile strength, % elongation, and notched Izod impact strength of PP. The rate of decrease in % elongation was large when 5 vol% Fe first added into PP. Later, increasing the vol% of Fe from 5 to 10 and 15, a slow decrease in % elongation was observed. Small decreases in the yield and tensile strength and Izod impact strength of the composites were found by increasing the vol% of Fe in PP. On the other hand, addition of Fe increased the modulus of elasticity, hardness (Shore D), Vicat softening point, and HDT values of the PP.

REFERENCES

[1] Zhu, K. and Schmauder, S., *Computational Materials Sci.* **28**, 743 (2003).
[2] Rusu, M., Sofian, N., and Rusu, D., *Polymer Testing* **20**, 409 (2001).
[3] Tavman, I. H., *Powder Technology* **91**, 63 (1997).
[4] Cheang, P. and Khor, K. A., *Mater. Sci. and Eng. A* **345**, 47 (2003).
[5] Zois, H., Apekis, L., and Mamunya, Y. P., *Macromol. Symp.* **194**, 351 (2003).
[6] Mamunya, Y. P., Davydenko, V. V., Pissis, P., and Lebedev, E. V., *European Polym. J.* **38**, 1887 (2002).
[7] Ghosh, K. and Maiti, S. N., *Polym. Plastics Technol. Eng.* **35**, 15 (1996).
[8] Tavman, I. H., *J. Appl. Polym. Sci.* **62**, 2161 (1996).
[9] Ghosh, K. and Maiti, S. N., *J. Appl. Polym. Sci.* **60**, 323 (1996).
[10] Maiti, S. N. and Ghosh, K., *J. Appl. Polym. Sci.* **52**, 1091 (1994).
[11] Bigg, D. M., *Polym. Composites* **8**, 115 (1987).