

# Mica as a Filler for ABS/Polycarbonate Blends

M. T. PASTORINI, R. C. R. NUNES

Universidade Federal do Rio de Janeiro, Instituto de Macromoléculas Professora Eloisa Mano, P.O. Box 68525, 21945-970 Rio de Janeiro, Brazil

Received 16 December 1998; accepted 25 March 1999

**ABSTRACT:** Mica was incorporated in ABS/PC:65/35 blends prepared on a Haake Torque Rheometer System 9000 with Rheomix 600 mixer. To improve the polymer/filler interaction, a treatment using silane on mica surface was performed. Studies were conducted concerning mechanical properties (flexural and impact strength), thermal properties (DSC and Vicat softening temperature), rheology, and flame retardancy. The composition with 30 phr of mica gives the best properties and efficiency in reducing the rate of burning, then becoming an alternative material to be explored and possibly meet the new requirements sought by these market blends. © 1999 John Wiley & Sons, Inc. *J Appl Polym Sci* 74: 1361–1365, 1999

**Key words:** ABS/PC blend; mica; surface treatment; rheology; flammability

## INTRODUCTION

Blends of Acrylonitrile-Butadiene-Styrene (ABS) and Polycarbonate (PC) are one of the most successful commercial polyblends known for the complementary properties of the components. PC provides good mechanical and thermal properties while ABS contributes for processability and lower cost. These good profiles have been found to be useful particularly in the automotive industry since 1980.<sup>1–3</sup>

An intensive globalization process is presently in course in the automotive industry. Because of it, there are many opportunities to enlarge the range of applications of the ABS/PC blends and, consequently, to invest in new technologies.

On the other hand, inorganic fillers have been widely added to as an attractive route to obtain new materials due to the reduced cost and combined properties. These new characteristics may be offset by a decrease in impact strength among others properties. The filler particle has poor in-

teraction with the polymer matrix, and can act as stress concentrators contributing to the fracture process in the composite. Surface treatments have been found particularly effective to improve interfacial bonding and enhance mechanical properties. Coupling agents, the most commonly used silanes, have shown a profound effect upon the properties of composites and play an important role in reinforcement composites studies.<sup>4–7</sup>

Within filler class, mica flakes are being used as reinforcement in polymers and blends, and have penetrated new markets, replacing or supplementing glass fiber and others fillers. This expansion of the market may be attributed mainly to the commercial availability of grades with a high aspect ratio, to the introduction of special grades and to extensive development work on processing and surface treatment, as mentioned before.<sup>7–9</sup>

Mica is the group name for a broad class of aluminosilicate minerals of the phyllosilicate family. The moscovite and phlogopite are the two classes that have found commercial use. Mica has an advantage over the fibers because it provides reinforcements in a plane instead of along a single axis, and may be used as a cheaper substitute of fiberglass, with double the modulus, and the ben-

---

Correspondence to: M. T. Pastorini.

*Journal of Applied Polymer Science*, Vol. 74, 1361–1365 (1999)

© 1999 John Wiley & Sons, Inc.

CCC 0021-8995/99/061361-05

**Table I** Materials Used and Their Characteristics

Material	Source	Properties
ABS 42	Nitriflex S. A. Ind. Com.	Density: 1.05 g/cm <sup>3</sup> MFI: 0.6 g/10 min
PC IN 2700	Policarbonatos do Brasil	Density: 1.20 g/cm <sup>3</sup> MFI: 2.2 g/10 min
Mica 215 B (moscovite)	Brasilminas Ind. Com.	Density: 1.05 g/cm <sup>3</sup> Particle size: 13.5 μm
Silane A-1100	Union Carbide	Density: 0.95 g/cm <sup>3</sup> Specific area: 353

efit of being abundant throughout the world. In general, mica reinforced thermoplastics offer: high rigidity, excellent chemical resistance, good dielectric properties, low thermal expansion, reduced flammability, increased heat distortion temperature, and good paint adhesion, among others properties.<sup>7-9</sup>

Based on the above-mentioned reasoning, this study tries to meet the development requirements for ABS/PC blend market with the incorporated of mica, an inexpensive filler abundant in Brazil, and get a composite with better thermal properties, flammability characteristics, and low cost.

## EXPERIMENTAL

### Materials

Materials are listed in Table I. The polymers and mica were dried before blending for 8 h at 100°C.

### Mica Surface Treatment

The treatment success depends on the right choice of the silane. Some preliminary investigations were done and, an amino silane, i.e., the  $\gamma$ -aminopropyltriethoxy silane, was selected due to its compatibility with polycarbonate. After calculating the necessary quantity of silane, as described in the literature,<sup>10</sup> mica treatment was performed in aqueous solution for which pH was adjusted at 4.5, at room temperature. The hydrolysis time was limited to 15 min, at the end of which mica was added to the solution. The suspension was continuously stirred, and after 40 min mica was removed by filtration, washed, and dried.

### Blend and Specimen Preparation

The blends, in a component weight ratio of ABS:PC—65:35, and 10, 20, and 30 phr of treated mica

were prepared by a melt technique in a Haake Torque Rheometer System 9000 with a Rheomix 600 mixing chamber and roller blades rotors. The required torque for polymer melts was measured at 250°C and 50 rpm, as a function of mixing time, 15 min.

The resulting blends were compression molded into sheets, in a heated Carver hydraulic press, model C, at a pressure of 3 MPa and 230°C. The specimens were cut from these sheets, according to the ASTM methods.

### Flexural Tests

Flexural strength and modulus were obtained according to ASTM D 790, and the tests were carried out on an Instron Tensile Tester, Series IX, automated machine, model 4204. The crosshead speed was 1.1 mm/min, and the results are average values of five specimens tested.

### Impact Tests

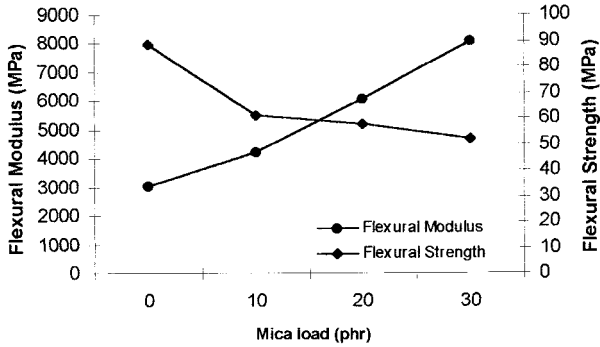
Charpy impact test was performed according to an adaptation of ASTM D 256, by using a pendulum-type tester. The tests were carried out at room temperature, on notched specimens, and the data obtained represent the average value from at least 10 test specimens.

### Thermal Property

The Vicat Softening Temperature was obtained according to ASTM D 1525, Rate B (120°C/h) on a Vicat Karl Frank GMBH apparatus.

### DSC Measurements

For DSC investigations samples were heated under nitrogen atmosphere from 50 to 200°C at a heating rate of 10°C/min in a Perkin-Elmer DSC-7 equipment. To eliminate the thermal history of the samples, a heating/cooling cycle was applied. The data



**Figure 1** Effect of mica addition on flexural properties of the ABS/PC blend.

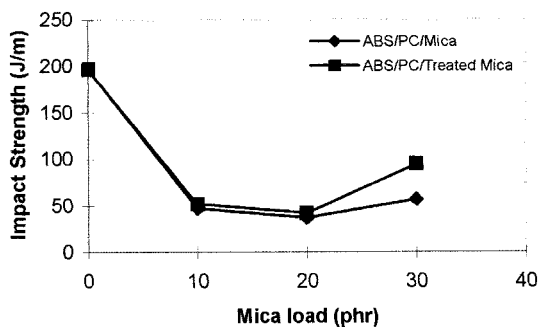
obtained in this analysis were the glass transition temperature,  $T_g$ , and  $T_g$  width,  $\Delta T_g$ .<sup>11</sup>

### Rheology

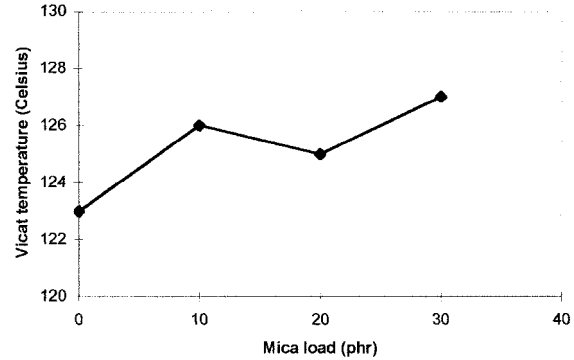
In this work, a method suggested by Laguna and Goodrich was followed, and the torque and speed data from the rheometer were converted in terms of absolute rheological parameters like shear stress, shear rate, and apparent viscosity. The method described in a previous article assumes the mixing chamber used was composed of two adjacent coaxial cylinders, which would require the same torque as the roller rotors. So, by using the known equations for coaxial cylinders shear stress and shear rate are calculated correlation to torque and speed, respectively<sup>12–15</sup>.

### Flammability Tests

The tests were carried out according to ASTM D 635-91, and the data obtained were the rate of burning of the materials.



**Figure 2** Effect of mica addition on the impact strength of the ABS/PC blend.



**Figure 3** The ABS/PC blend vicat softening temperature as a function of mica load.

## RESULTS AND DISCUSSION

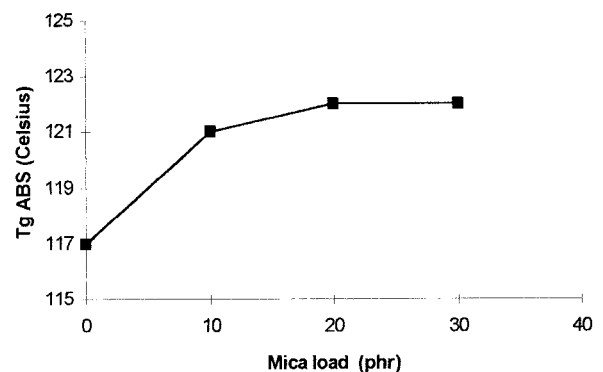
### Flexural Properties

The data obtained from the tests performed on the pure blend and on blends with 10, 20, and 30 phr of mica are reported in Figure 1. As would be expected, flexural strength decrease with the addition of the first load of mica. This could be attributed to a reduction in the polymer matrix mobility due to the presence of the filler particle.

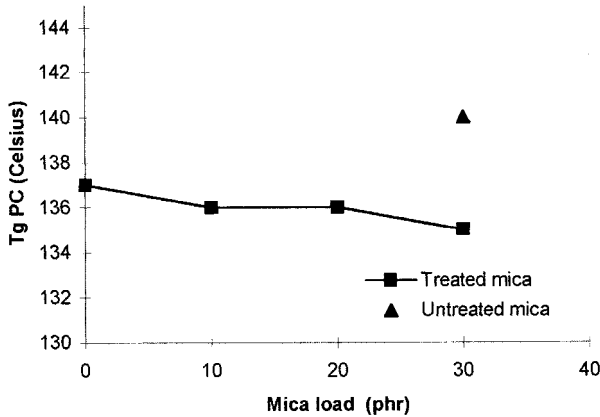
An opposite behavior was noted for blends modulus that raised with increasing concentration levels of filler. It was also expected that with the addition of a higher modulus material, like mica ( $1.72 \times 10^5$ ), the polymer would exhibit a modulus increase.<sup>8</sup>

### Impact Properties

The impact strength, as mentioned earlier, shows a dramatic decrease with the addition of the inorganic filler. The surface treatment could mini-



**Figure 4** Effect of mica addition on the transition temperature of the ABS phase of the ABS/PC blend.



**Figure 5** Effect on the PC phase transition with the addition of mica of the ABS/PC blend.

mize this problem, but further studies would be necessary. Figure 2 shows notch Charpy impact strength data as a function of the level of mica. The impact strength decreased sharply for the sample with mica, but a positive effect due to the treatment could be actually noted when compared to blends with no treated mica.

#### Thermal Resistance

The Vicat softening temperature may be taken as the material ultimate use point for a short period of time. It is widely employed for quality control and material development in the automotive industry. Figure 3 reports the Vicat temperature for the blends with different mica levels. It can be observed that a significant enhancement of the Vicat point with mica addition process. This behavior was expected since mica has high modulus and thermal stability.

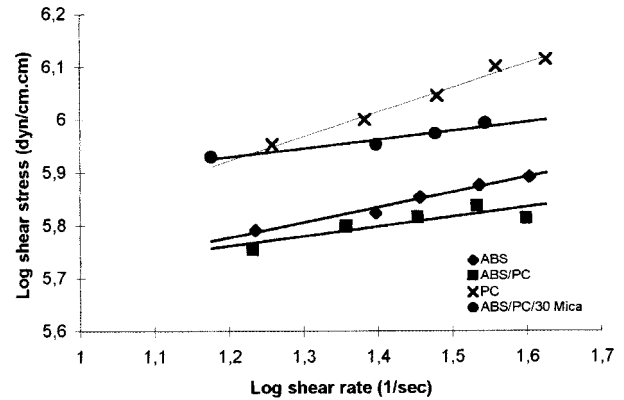
#### Thermal Behavior

Values for ABS/PC blends calorimetric parameters as a function of the mica load are shown in

**Table II** Influence of Mica Addition on ABS/PC Blend Calorimetric Parameters by Graphic Analysis of  $T_g$

Sample (phr-Treated Mica)	$\Delta T_{g1}^a$	$\Delta T_{g2}^a$
ABS/PC/10 Mica	18	6
ABS/PC/20 Mica	9	7
ABS/PC/30 Mica	9	6

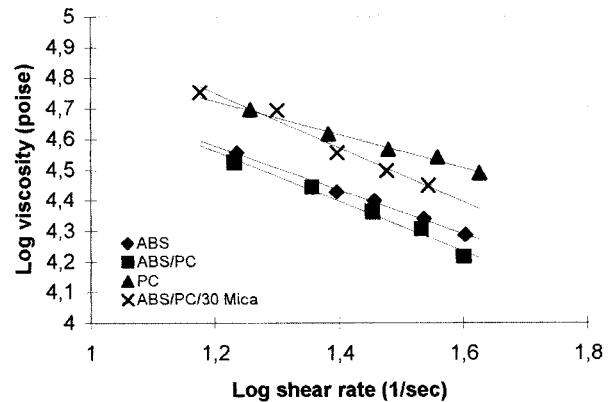
<sup>a</sup>  $\Delta T_{g1}$ , ABS phase;  $\Delta T_{g2}$ , PC phase.



**Figure 6** Rheological behavior of the ABS, PC, and ABS/PC blends.

Figures 4 and 5. It is possible to observe from Figure 4 that the first addition of mica leads to an increase in the ABS phase transition value ( $T_{gABS}$ ) but, higher levels of mica do not have significant effects on the ABS phase transition temperature. This fact indicates a lower ABS matrix mobility as a result of the filler addition. For the transition in the polycarbonate phase ( $T_{gPC}$ ), shown in Figure 5, the blends with mica exhibit values very close to that without mica. However, when the sample with untreated mica was analyzed, a higher value was found that could indicate that a better mica/PC interaction can be promoted by treatment of mica with a silane selected for polycarbonate.

Data of the  $T_g$  width are also reported in Table II. This parameter could be employed to study the homogeneity of blends. It can be noted, that for the sample with 30 phr of mica, both  $T_{g1}$  and  $T_{g2}$  values were lower than for the others samples,



**Figure 7** Influence of mica incorporation on the viscosity of the ABS/PC blend.

**Table III Effect of Mica Addition on the Burning Rate of the ABS/PC Blend**

Sample	Burning Rate (cm/min)
ABS/PC	3.7
ABS/PC/30 phr mica	1.9

which indicates a higher homogeneity and corroborates with the better properties obtained for this filler amount.

### Processability

Shear stress  $\times$  shear rate was determined as previously mentioned, and plotted on a log-log scale for PC, ABS, and their blends, as shown in Figure 6. The Power Law index,  $n$ , can be obtained from the slopes and suggests a non-Newtonian behavior for these polymer melts. The index  $n$  is lower for the blend with mica showing the increase of non-Newtonian behavior in this material as compared to pure blend.

The viscosity was determined from the relation of shear stress, and shear rate and the viscosity  $\times$  shear rate plot is shown in Figure 7. For all polymers the pseudoplastic characteristics can be observed from the decrease of viscosity with shear rate. Pseudoplasticity gives important information about polymers melt behavior, and can be used to optimize transformation processes because it allows reduced energy and cycle. The addition of mica effectively promotes a higher viscosity. This increment is not in agreement with some other authors, and will be studied in details in future works. Shear rate range studied includes compression and calendaring processes ( $1\text{--}100\text{ s}^{-1}$ ).<sup>16</sup>

Although the complex geometry of torque rheometers could make difficult the interpretation of data in terms of fundamental parameters, this method seems to be an efficient way to enlarge the application of this instrument in the polymer industry.

### Flammability

The rate of burning was obtained for pure blend and sample with 30 phr mica, which shows the best properties. The results can be seen in Table III, and show the effectiveness of mica in reducing

the ABS/PC rate of burning to nearly 50%. These data supported the known mica flame-retardancy characteristics.

### CONCLUSION

The results obtained from this preliminary study allow to say that, to meet the requirements of the automobile industry, the major market of these blends, the developed composite, (1) has better thermal properties than the ABS/PC blend with an increment of up to 10°C; (2) could lead to a reduction in weight for molded parts because it is possible to be molded into thinner parts with the same rigidity; (3) shows that mica is efficient in the reduction of the rate of burning. Despite the poor impact properties obtained, many interesting studies could be done concerning surface treatment and incorporation of increasing levels of filler; and (4) gives an alternative way to explore and get a composite with good properties together with lower cost and a nontoxic fire retardancy.

### REFERENCES

- Greco, R.; Astarita, M. F.; Dong, L.; Sorrentino, A. *Adv Polym Technol* 1994, 13, 259.
- Lombardo, R. S.; Keskula, H.; Paul, D. R. *J Appl Polym Sci* 1994, 54, 1697.
- Wu, J. S.; Chang, F. C. *J Appl Polym Sci* 1993, 50, 1379.
- Katz, H. S.; Milewski, J. V. *Handbook of Fillers for Plastics*; Van Nostrand: New York, 1987, p. 292.
- Seibel, S. R.; Moet, A. *Antec'95*, 1995, 2, 3966.
- Favis, B. D.; Blanchard, L. P.; Prud'home, R. E. *Polym Compos* 1984, 5, 11.
- Woodhams, R. T.; Xanthos, M. *Handbook of Fillers and Reinforcements for Plastics*; Van Nostrand, New York, 1984, p. 383.
- Xanthos, M. *Plastic Compound*, 1989, July, 19.
- Schott, N. R.; Perez, M. A. *Antec'94*, 1994, 1, 2846.
- Dynasytan bonding agents, User's guide.
- Thaumaturgo, C.; Monteiro, E. C. *J Thermal Anal* 1997, 49, 227.
- Goodrich, J. E.; Porter, R. S. *Polym Eng Sci* 1967, 7, 45.
- Laguna, O.; Arroyo, V. M. *Rev Plastico Moderno* 1982, 312, 633.
- Laguna, O.; Vigo, P.; Arganza, R. *Rev Plastico Moderno* 1983, 327, 261.
- Babbar, I.; Mathur, G. N. *Polymer* 1994, 35, 2631.
- Bretas, R. E. S. *Plastico Moderno* 1987, 176, 28.