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Strengthening and modification of polypropylene by utilizing talc and calcium carbonate

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ABSTRACT

In order to modify and improve the polypropylene properties, it has to be reinforced enriched with some inorganic materials such as Talc and calcium carbonate. Enriched reinforced polypropylene composites including Talc and calcium carbonate, are produced by extruding method in certain mass gravimetric range (0-15 mass %). To improve the composition of polypropylene and stiffeners mentioned above, the surface of the stiffeners shall be modified with a conjugated silane agent. In this study, after preparation of compositions with different weight percentages, the effects of stiffeners on polypropylene hardness were investigated. Results of experiments show that in the same concentration, Talc enhances the hardness of polypropylene more than calcium carbonate.

KEYWORDS

Polypropylene;
Stiffener;
Hardness;
Talc;
Calcium carbonate.

INTRODUCTION

Polypropylene is widely used in template materials, films and plates. Efficient plasticity, high resistance against water, gasoline and other chemicals, low density and low production costs are the main reasons for high consumption of polypropylene. But Beside these good properties, in low temperatures, polypropylene has a weak impact property. To overcome this disadvantage, polypropylene should be reinforced with suitable fillings. In general, fillers reduce polymer consumption and thus reduce costs of the materials obtained from polymers. On the other hand, some of fillers increase hardness, softening temperature, tensile strength and thermal conductivity coefficient. Usually for improvement of polypropylene properties, fillers such as calcium carbonate, Talc, wood fibers, titanium dioxide, magnesium hydroxide and glass fibers, etc. are used. Besides, processing of filler's surface can improve the filler and polypropylene interaction. Generally, the following three groups are applied as processing agents:

1) Saturated and unsaturated fatty acids and their derivatives
2) Compounds that have active surface such as active cationic agent and ionic and non-ionic active agent
3) Conjugated groups such as titanite

In this study, the effects of talc and calcium carbonate on polypropylene hardness have been investigated.

EXPERIMENTS

In this study, commercial isotactic polypropylene (Spain Respol Quimica S.A Puertollane) Isplen.051 with the following specifications has been used:

Molecular weight : 248.297
Molecular weight distribution : 6.24

Melt flow index in 230°C : 5.4 gr/min

The applied Talc and calcium carbonate were of Lu-1445 (Tuzenac, Toulouse, flance) and Lu-147 types. For processing of the filler surface, PC-1A and PC-1B were used. For better processing of the surfaces, per each kilogram of Talc, we had to use a solution of 240cc methanol, 60cc water and 2cc silane (The volume ratio of PC-1A to PC-1B was 3 to 1). After this process, fillers were dried during 24 hours under a temperature of 60°C.

HARDNESS MEASUREMENT

Hardness determination is done based on DIN50-1420/65 standard. In this experiment the sample is first placed on the surface and then a ball bearing with a pressure of 18.5 KPa enters to a portion of the sample which has a minimum distance of 10mm from the edge. After applying the force with time duration of 10 to 60 seconds, penetration depth is measured with an accuracy of 0.005mm. This experiment was repeated 10 times for each sample. Having the penetration depths for n experiments, standard deviation is measured according to following formula:

$$\delta_h^2 = \frac{h_{max} - h_{min}}{Z}$$

In which σh2 is the variance; hmax is the maximum penetration depth; hmin is the minimum penetration depth and Z is selected from TABLE 1.

TABLE 1 : Values of Z via number of tests

No of tests	3	4	5	6	7	8	9	10	12	14	16	18	20
Z	1.69	2.06	2.33	2.53	2.75	2.85	2.97	3.08	3.26	3.41	3.53	3.64	3.73

Average value of the results is obtained from the following formula:

$$\bar{h} = \frac{\sum_{i=1}^{n} h_i}{n}$$

In which h is the average penetration depth. Using formulas 1 and 2, the variation range of the penetration depth is calculated based on the following relation:

$$h' = \bar{h} \pm k\lambda\delta_h^2$$

In which h' is variation range of the penetration depth. If this experiment is repeated 10 times for each sample and all measurements are done with an accuracy of 90%, then K and λ values will be 1.54 and 1.65 respectively. So according to formula 3 we will have:

$$h' = \bar{h} \pm 2/54\delta_h^2$$

Using relation 4, hardness will be derived from the following formula:

$$H = \frac{1}{\pi D} \cdot \frac{F}{h'}$$

In which F and D are 18.5 KP and 5mm respectively. Thus hardness is calculated using the following relation:

$$H = \frac{1/18}{h'}$$

Using relations 4 and 6 the average values of hardness are calculated for each sample whose results are reported in TABLE 2 and figures 1 & 2.

TABLE 2 : Values of average amount of polypropylene hardness

Amplifier mass percent	Average amount of hardness (N/mm^2)	
	Calcium carbonate	Talc
0	44.36	44.36
5	51.91	63.31
10	48.30	58.20
15	46.93	60.59

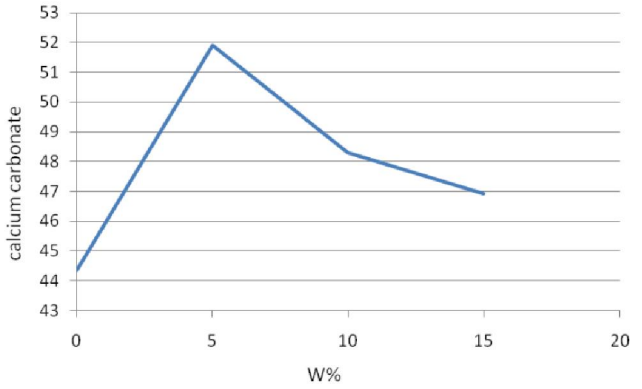

Figure 1 : Variation of polypropylene hardness vs. mass percent of talc

RESULTS

As seen in TABLE 2 and figures 1 & 2, the hardness of polypropylene is increased significantly by adding stiffeners like talc and calcium carbonate which is due to the formation of new bonds between polypro-

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pylene and the fillers.

Also, in the same w%, the hardness of filled polypropylene with talc is more than that with calcium carbonate because the formed bonds between polypropylene and talc are stronger than those between polypropylene and calcium carbonate.

It is observed that increase in w% of calcium carbonate decreases the hardness of polypropylene while increase of talc weight percentage will first increase the polypropylene hardness significantly and then decreases that. Generally, the most suitable composition of stiffeners such as talc and calcium carbonate in polypropylene which results in maximum hardness is 5 w%.

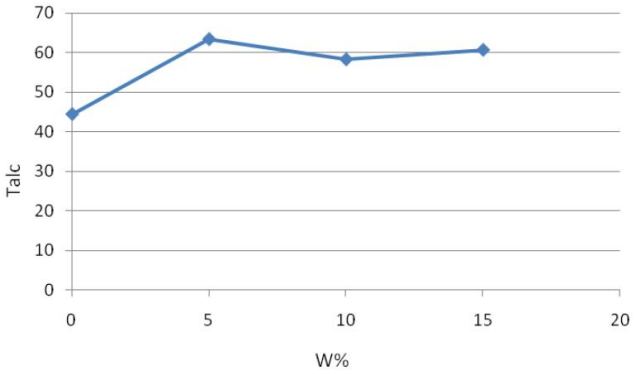

Figure 2 : Variation of polypropylene hardness vs. mass percent of calcium carbonate

EXPERIMENTAL RELATIONS FOR HARDNESS CALCULATION

To calculate the hardness of polypropylene composed with calcium carbonate and talc, the following formula in terms of W% of stiffeners is proposed:

$$L_nH_{pp} = \alpha_1 x^3 + \alpha_2 + x^2 + \alpha_3 x + \alpha_4$$

In which $\alpha 1$ is the equation coefficient; HPP is the hardness and X is the W% of stiffener. The coefficients of equation 4 are derived from non-linear fitting of experimental values of hardness in composites including 0 to 15 W% calcium carbonate or talc. These coefficients are given in TABLE 3:

Amplifier	α_1	α_2	α_3	α_4
Talc	0.0008	-0.0201	0.1528	3.792
calcium carbonate	0.0004	-0.0101	0.0727	3.792

CONCLUSIONS

In this study, the effect of stiffeners such as calcium carbonate and talc on hardness of polypropylene was investigated. The results indicate that in the same weight percentages, the polypropylene hardness with talc is more than that with calcium carbonate. Also, in composition of polypropylene with talc and calcium carbonate, to achieve the highest possible hardness, the W% of the stiffeners should be 5%. In composition of polypropylene with calcium carbonate, hardness is decreased with increase of stiffener W% while for talc composition; the lowest hardness is obtained when the weight percentage of stiffener is 10W%. Finally, an experimental formula was proposed to calculate the hardness of polypropylene composited with talc and calcium carbonate.

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