PVC/Gypsum 복합체에서 Gypsum 의 영향

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Effect of gypsum content on the properties of PVC/Gypsum polymer blend material

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Key Words : morphology, physico-mechanical

ABSTRACT

Polyvinyl chloride (PVC)/gypsum polymer blend materials were prepared by melt blending of PVC with gypsum and additives. Effect of gypsum content on the properties of PVC/gypsum polymer blend material was studied by investigating physico-mechanical properties, thermal properties and morphology development. It was found that the replacement of gypsum for methylene-butadiene-styrene (MBS) component in PVC/gypsum polymer blend material enhanced the tensile strength, but gradually decreased its impact strength. Besides, with the increase of gypsum content, the elongation at break of material gradually decreased. The presence of the different gypsum contents made a shift of glass transition temperature and increased the thermal stability as well as the processing temperature range of polymer blends. The observation of morphology, the results of the physico-mechanical properties and thermal properties proved simultaneously that PVC/gypsum polymer blend material with the gypsum content of 22.56 wt.% reached the optimum results among five kinds of PVC/gypsum polymer blend materials investigated.

1. Introduction

The research that has continuously conducted in the history of macromolecules is to reinforce the properties of the polymer materials, in which, they are generally plastic by adding additives, or the methods of copolymer and blend etc. are used [1]. It has been found by Kato that the superior dynamic property of macromolecules exists in the two-phase form with more than two mixed macromolecules in them and they are scattered, so they have the highly-improved shock resistance and toughness in comparison with the mono-phase macromolecules [2]. However, in order to have the superior dynamic characteristics in the polymer blend material, each ingredient should be soluble enough, so that in the bulk of the polymer blend, the interaction between the phases is highest and the distribution is perfectly regular in each other.

Polyvinyl chloride (PVC), as an important commercial polymer, has been studied and used widely in industrial fields for many years. However, due to its inherent disadvantages, such as low thermal stability and brittleness, PVC and its blend are subjected to some limitations in certain applications [4]. Consequently, it is necessary to develop new PVC products with high quality and good properties in order to yield high added values and enlarged PVC applications.

Therefore, in this paper, we mainly investigated the effect of gypsum content with and without the presence of MBS content on the physico-mechanical properties, thermal properties of the PVC/gypsum polymer blend. Five kinds of rigid PVC/gypsum polymer blend with different gypsum contents were prepared by melt blending method. The morphology development of the PVC/gypsum polymer blend samples is also discussed in this paper.

2. Experiment and materials

Suspension polymerization PVC (PVC LS-100, DP = 1000) was provided by Lucky Co. LTD, Korea. Gypsum was produced with particle size less than 200 nm by Namhae Chemical Co, Korea, the composition of gypsum was shown in Table 1. Methylene-butadiene-styrene (MBS), lead oxide (PbO) were provided by LG Chemical Co, Korea.

PVC/gypsum polymer blend samples were prepared by melt mixing PVC, gypsum, and processing additives in the roll-mill (Nishimura, KR-250, Japan) at 175°C for 5 minutes. After that, the polymer blend samples were quickly molded into sheets of 3mm in thickness by hot pressing machine (Wabash, G302-BCLX, USA) at 175°C and 20 MPa for 5 minutes, followed by cooling to room temperature at 5 Mpa. The sheets were prepared for the structure characterization and the property measurements.

The tensile strength and the elongation at break were performed using an Universal Tensile Tester (Instron, series IX automated materials testing system, USA) according to ASTM D638M-93/89 standard. The tensile test was conducted and obtained the average value by measuring each sample piece five times at a crosshead speed of 10mm/min while applying tensile strength to the manufactured sample pieces.

In order to measure the impact strength of the sample pieces, the impact strength test (Izod impact, tinus 01 sen willow, Grove, PA, USA) was conducted according to ASTM D256-97 standard. For impact strength, the results also obtained the average value by measuring each sample piece five times with a hammer speed of 3.5 m/s and pendulum weight of 0.818 kg at room temperature.

3. Results

The results of the physico-mechanical properties are presented in terms of the tensile strength, elongation at break, and impact strength by comparing the gypsum content to the PVC compound samples and are given in Figure 1 (a) to (c) respectively. As shown in Table 2 and Figure 1(a), upon adding of gypsum to the PVC compound replacing the MBS on PVC2 sample with the content of gypsum of 16.26 wt%., the tensile strength of PVC compound was increased from 43.8 MPa up to 49.6 MPa. The highest tensile strength among five samples was measured on PVC3 sample with the gypsum content of 22.56 wt%, reached a value of 51.3 MPa, then which gradually decreases to 48.5 MPa and 40.9 MPa as the amount of gypsum phase increases at PVC4 and PVC5 samples, respectively. This expected that the content of gypsum phase had a critical value on which the gypsum phase was regularly distributed in the bulk polymer, and a good compatible with PVC compound system made a peak of tensile strength value as shown in Figure 1(a). If the content of gypsum phase is added over this value, the polymer compound system may be taken the consequence of the coalescence effect due to the increase of gypsum content, this may cause the decrease of the tensile strength of those samples [8]. On observation of the elongation at break of PVC compound samples in Figure 1(b), when MBS, as a reinforcement

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agent, was rejected from PVC compound, the elongation at break drop drastically from 42.9 % (PVC1, 15.38 wt% gypsum) to 32.7 % (PVC2, 16.26 wt% gypsum) , then 16.5 % (PVC3, 22.56 wt% gypsum), and then gradually decrease to 12.7 % (PVC4, 27.97 wt% gypsum), to 10.85 % (PVC5, 32.67 wt% gypsum). It was revealed that the gypsum phase plays a role as an inorganic distributed phase, which causes a decrease of the flexibility of PVC matrix phase because of the small particle side of gypsum (around 200 nm), which easily intercalated into the vacancy of the bulk polymer [9].

From the impact strength observed, Figure 1(c), comparing between the samples with and without of the presence of the MBS phase the impact strength of PVC compound sample dramatically decreases from 6.61 Kgf.m/m to 4.17 kgf.m/m. However, after that the impact strength of PVC 3, PVC4, PVC5 samples gradually increases with increasing of gypsum content. Thus, it was clearly that the content of the gypsum phase distributed in PVC matrix phase has actively affected the impact strength of samples. It revealed that the gypsum phase not only plays a role as a good filler, but also is a good interactive inorganic material with PVC matrix phase, which was well dispersed in the polymer system, and hence good impact strength. Although PVC5 sample had highest impact strength, the difference of the impact strength between PVC3 and PVC5 samples is not much and so it may propose that PVC3 sample had sufficiently gypsum content (22.56 wt%) on which physico-mechanical properties have been optimal values among of the five PVC compound samples.

4. Conclusions

The PVC/gypsum blend material was obtained via a melt blending process. The physico-mechanical properties was investigated base on the different gypsum content of the blend samples to establish the mechanical strength of this material. The elimination of MBS content from PVC/gypsum polymer blend increased its tensile strength though the impact strength significantly decreased. The highest tensile strength of this material was measured at PVC 3 with the content of gypsum component of 22.56 wt.%. The elongation at break continuously decreased while increasing of the gypsum content, however the rate of decrease is not the same among five samples. Inversely, the impact strength of blend material gradually enhanced with increasing of the gypsum content. phase and it had a good interaction between two initial phases. TGA curves also indicated the presence of gypsum contents increased the thermal stability and expended the processing temperature range of the polymer blend material.

On observation of SEM micrographs simultaneously indicated that PVC/gypsum blend material had a good distribution of gypsum phase on the case of the gypsum content of 22.56 wt.%.

Finally, as a result of adding the gypsum buried in the sea to PVC resin, we cannot only get the polymer blend material that has such superior physico-mechanical properties and thermal stability, but also solves the environmental problems by using waste matters.

Table 2. Sample code and composition of blend.

	PVC (g)	Lubricant (g)	Stabilizer (g)	MBS (g)	Gypsum (g/wt.%)
PVC0	100	0.5	3.0	-	-
PVC1	100	0.5	3.0	7.0	20.0/15.38
PVC2	100	0.5	3.0	-	20.0/16.26
PVC3	100	0.5	3.0	-	30.0/22.56
PVC4	100	0.5	3.0	-	40.0/27.97
PVC5	100	0.5	3.0	-	50.0/32.67

Referances

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