RHEOLOGICAL PROPERTIES AND FOAMING OF NEW HIGH HEAT RESISTANT STYRENIC COPOLYMER

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ABSTRACT

We investigated rheological properties and foamability of our new styrenic copolymer in order to produce favorable foamed products in industry. The styrene-methyl methacrylate-maleic anhydride copolymer R-2 was synthesized by free radical polymerization. R-2 showed high VST and enhanced the heat resistance of PMMA by extrusion blending without losing significant characteristics of PMMA such as transparency and surface hardeness. The foaming behavior was examined under the identical CO_2 adsorption condition. We found that R-2 showed very fine cell morphology with higher cell number density comparing with neat PMMA. It should be noted that blending R-2 with PMMA increased expansion ratio drastically despite of the similar cell size to neat PMMA foam, comparing with those of neat R-2 and PMMA.

1. INTRODUCTION

Polystyrene (PS) has been widely used for making polymeric foams, because of its good foamability [1]. One of the disadvantages of PS foams is , low heat resistance. Therefore, styrene-acrylonitrile copolymer (SAN), modified poly-(phenylene ether) (PPE) [2], poly-(carbonate) (PC), and poly-(methyl methacrylate) (PMMA) have been used for specific applications such as automobiles and home electrical appliances, which require the higher heat resistance. Recently , there has been growing demand for materials with higher heat resistance and more excellent foamability in the market.

In this work , we investigated the rheological properties and foamabilities of our new styrenic copolymer that was made of styrene, maleic anhydride , and methacrylic monomer for providing the higher heat resistance.

2. EXPERIMENTAL

2.1 Materials

We used styrene-methyl methacrylate-maleic anhydride copolymer synthesized by free radical polymerization as a new high heat resistant styrenic polymer (Coded as R-2, Mw 160,000 g/mol, Tg 132 °C). We also used the commercial PMMA (Mw 100,000 g/mol, Tg 108 °C). R-2/PMMA (50/50 wt-%) blend was extruded by a single screw extruder (ϕ=40mm) at 240 °C and screw rotation speed of 100rpm. The blend is transparent and considered to be compatible (Mw 140,000 g/mol, Tg 120 °C).

2.2 Foam process and evaluation

R-2, PMMA, and R-2/PMMA blend were press molded to sheets (radius of 20 mm and thickness of 1 mm) at a temperature of 200 °C. CO_2 was used as a foaming agent. CO_2 was absorbined to the sheet specimens in the pressure vessel of 25 °C for 8hr. Adsorption pressure was controlled so that CO_2 concentration of each specimen was to be 14 wt%. After the saturation, specimens were heated in the oil bath for 1 min to foam. Oil temperature was set to be Tg + 10 °C for each specimen (R-2 : 142 ℃, R-2/PMMA blend : 130 °C, PMMA : 118 °C). After the heating, specimens were cooled in the water bath of 15 °C for 1min. Melt flow rate (MFR) and vicat softening temperature (VST) of R-2, PMMA, and R-2/PMMA blend before the foaming were evaluated according to ISO 1133 (220 °C 98N), ISO 306 (50 N). Cell size was measured by scanning electron microscope (SEM), and expansion ratio was calculated by density of foams.

3. RESULTS AND DISCUSSION

MFR, cell size, and expansion ratio are shown in Table -1. SEM images are shown in Fig. 1. The uniform closed cell structure was observed in all foams. The cell size of R-2 (7.4 μm) is very fine compared to PMMA (56.8 μm) and R-2/PMMA blend (26.1 μm). The cell size of R-2/PMMA blend is intermediate between R-2 and PMMA. However, we should note that the expansion ratio of R-2/PMMA blend is significantly high in comparison with those of PMMA and R-2/PMMA blend under the same adsorbed CO_2 concentration. At present this is open question for us. Further study is needed to clarify this intriguing issue.

We can say that R-2 or R-2/PMMA blend have a great potential of using as a starting material for foaming application since fine cells and the higher expansion ratio can be achieved and thermal-insulating properties of foams can be improved.

We also studied rheological behaviors, such as melt tension, extensional viscosity and dynamic viscoelasticity, to discuss the foamabilities of R-2 and R-2/PMMA blend. This will be presented at the conference.

4. CONCLUSION

We found that our new high heat resistant styrenic polymer (R-2) and R-2/PMMA blend have good foamabilities to lead to fine cell morphology with high cell number density, high thermal-insulating properties and the heat resistant properties. foam industrially. We are investigating other rheological properties such as melt tension, extensional viscosity, and dynamic viscoelasticity to reveal the foamabilities of R-2 and R-2/PMMA blend.

Table-1 Cell size and Expansion ratio
((a) R-2 (b) R-2/PMMA blend (C) PMMA)

	(a)	(b)	(c)
MFR (g/10min)	7.1	4.0	3.0
VST (°C)	129	119	108
Averaged cell size (μm)	7.4	26.1	56.8
Expansion ratio (-)	8.5	14.2	5.0

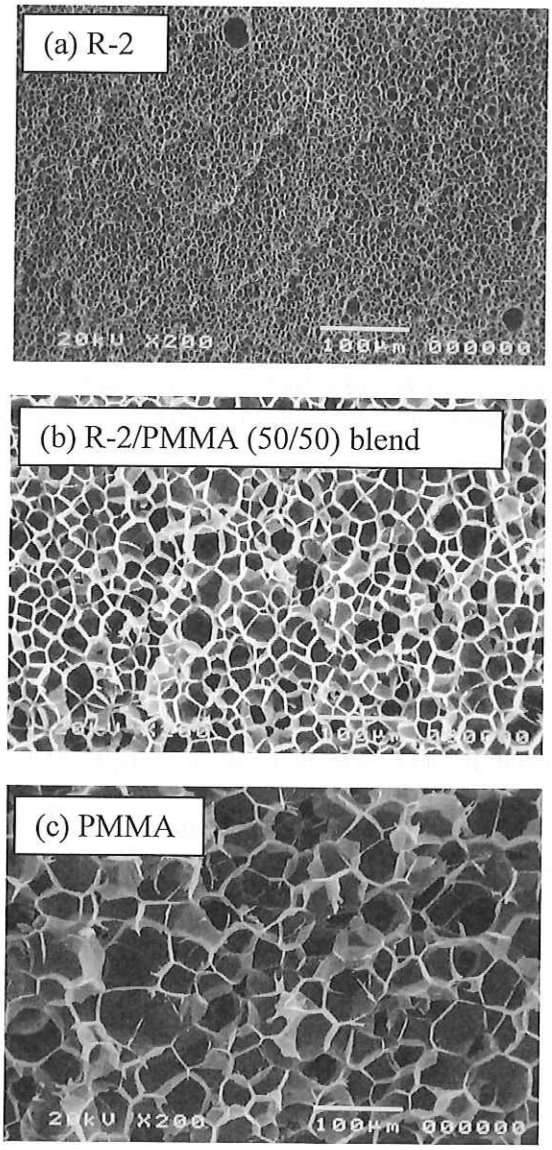

Fig.1 SEM images of foams of (a) R-2, (b) R-2/PMMA blend and (c) PMMA.

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