

INTERACTION BETWEEN ISOTACTIC POLYPROPYLENE AND ITS NON-SOLVENTS

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ABSTRACT

Polypropylene (PP) microporous film prepared by biaxial stretching of isotactic PP is treated with non-solvent liquid at room temperature. The dimension of the film may change after the treatment. The degree of area contraction of PP film is dependent on the match between PP and liquid in solubility parameter and polarity. The fact indicates that some interactions do exist between liquid and isotactic PP, and a shrinkable porous film is a sensitive probe to detect the weak interactions.

INTRODUCTION

The interaction between polymers and liquids^[1] including solvents and monomers is an important topic in the studies of polymer solutions and blends. When a polymer is not dissolved or swollen by a liquid, the interaction between them becomes difficult to be detected and studied. However, these weak interactions may have their influence on polymer processing and application in some cases^[2,3]. Isotactic polypropylene is known as a semi-crystalline polymer which has only a few solvents at higher temperatures. The interactions between isotactic PP and ordinary liquids can be characterized only at temperatures above T_m ^[4], about 170°C, a rather high temperature, according to the inverse gas chromatography (IGC) method. Moreover at room temperature the interactions of isotactic PP with other liquid materials are usually not considered or just ignored in practice. In this work a convenient method for detecting the weak interaction between isotactic PP and its non-solvent liquids at room temperature is reported.

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EXPERIMENTAL

An isotactic polypropylene microporous film^[5] of thickness around 30 microns was used as a probe to detect the weak interaction between isotactic polypropylene and liquids. The film has a porosity of 36% and an average pore size around 50nm. It was prepared by biaxial stretching method, and exhibit thermal shrinkage of about 10% in their two stretching directions during heating up to 130°C.

Square porous film specimens were dipped in the liquids for 24h at room temperature and then placed in air. The dimension of the specimens was measured after the evaporation of the liquids involved in the porous specimens. It was found that the dimensions of the film specimens may change after the treatment. The contraction of the specimens in the film plane is usually very clear and can be determined without difficulty, while the thickness change of specimens is very small and is not easy to be measured exactly. So the area contraction ratio of the specimen, $(A_0 - A)/A_0$, is used to characterize the interaction between isotactic polypropylene and the liquid, where A_0 and A are areas of the square film specimens before and after the liquid treatment respectively.

RESULTS AND DISCUSSION

Results for some liquids including two monomers, styrene and butyl acrylate, are given in Table 1. The behavior of microporous polypropylene film is quite different in these liquids. Acetone and ethanol show very little influence on polypropylene samples. The others all results in an obvious area contraction, being as high as 14.5% and 15% for carbon tetrachloride and toluene respectively. Some film samples were treated with acetone (or ethanol) and toluene in turn. The final contraction degrees were the same as those treated with toluene only.

It can be supposed that the interaction between isotactic polypropylene and the liquids may influence the molecular motion of polypropylene and then lower the shrinkage temperature. So the degree of area contraction of film specimen after liquid treatment described above may reflect the interaction between the polymer and the liquid. Also given in the Table are the solubility parameter and the fractional polarity of the liquids^[6]. Polypropylene is a typical nonpolar polymer and the solubility parameter of polypropylene^[7] is 8.2—9.2 (cal/cm³)^{1/2}. It seems reasonably that the area contraction of polypropylene films is positively dependent on the match between polypropylene and the liquids in their solubility parameter and polarities.

The contraction of stretched dense polymer films has been observed for some polymers, including polypropylene under the influence of the solvents. However, no detectable effect of these non-solvents on stretched dense polypropylene films was observed in our experiments. It can be supposed that the advantage of microporous films is their high specific surface area, which makes the film quite sensitive in detecting weak interactions. The microporous film was biaxial stretched. Although heat-annealed, polypropylene was still oriented in a certain degree. When contacted with non-solvents a slight permeation was supposed occurring in polypropylene, especially in the amorphous phase. The orientation was relieved in some degree and the stress led to the film contraction.

Table 1 Comparison of properties of various liquids* and their induced area contraction ratio [$ACR = (A_0 - A)/A_0$] of microporous PP film

Liquid	$SP^{**} (\text{cal}/\text{cm}^3)^{1/2}$	FP^{***}	$ACR(\%)$
Styrene	8.66	0	10.6
Butyl acrylate	8.9		8.7
Ethanol	12.7	0.268	1.8
Acetone	10.0	0.695	0.7
Toluene	8.9	0.001	15.0
Tetrachloroethylene	9.35	0.000	12.8
Carbon tetrachloride	8.6	0	14.5

* Data from reference [5] ** SP: Solubility parameter *** FP: Fractional polarity

For a linear polymer, the polymer-liquid interactions may be characterized by measuring the interaction parameter above glass transition temperature for a glassy polymer or melting point for a semi-crystalline polymer with an inverse gas chromatography^[4]. The melting point of crystalline isotactic PP phase is about 170°C. So for isotactic PP the parameters can be obtained only at rather high temperatures and the measurement are relatively complicated to conduct in IGC. At lower temperatures the interactions of isotactic PP with other liquids are so weak that they are usually not considered or just ignored in practice. Our results given here indicate that these interactions do exist at room temperature and seem to be common even for many conventional liquids. It is also clear that a shrinkable porous film is a suitable probe for detecting these weak interactions and this method or its principle idea might be useful for other polymers.

Keywords:

Polypropylene; Non-solvents; Interaction

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