ELSEVIER

Materials Science and Engineering A 457 (2007) 231–235

MATERIALS SCIENCE & ENGINEERING A

www.elsevier.com/locate/msea

Structure and properties of polyurethane elastomer cured in graded temperature field

Zhao Peizhong [a], Hua Xingyan [a], Wang Yuansheng [b,*], Zhu Jinhua [a], Wen Qingzhen [a]

[a] *Department of Chemistry and Materials, College of Science, Naval University of Engineering, Wuhan 430033, China*
[b] *Administrative Office of Training, Naval University of Engineering, Wuhan 430033, China*

Received 1 June 2006; received in revised form 5 December 2006; accepted 8 December 2006

Abstract

Polyurethane elastomer with graded structure was prepared via changing traditional curing processing. Curing reaction of polyurethane was performed in graded temperature field.

The sample prepared was characterized using FTIR, WAXD, tensile testing and other methods. The results show that the degree of microphase separation in the sample decreases with the decrease of the curing temperature. The Young's modulus and tensile strength also exhibit the same changing trend. In the contrast, transparency increases with the decreasing temperature. According to the study, the graded properties of polyurethane prepared are related to microdomains structure in the material, changing with the curing temperature.

Keywords: Functionally graded materials; Polyurethane; Graded; Transparence; FTIR; Microphase separation

1. Introduction

Polyurethanes (PUs) are an important class of thermoplastic elastomers with excellent properties and wide applications [1–4]. Typical PU elastomers are (AB)n type multi-block copolymers comprised of alternating "soft" poly-ether or polyester segments and "hard" polyurethane or polyurea segments [5]. Thermodynamic incompatibility of these segments drives their microphase separation into hard and soft domains. This microphase separation is responsible for the excellent properties of polyurethane elastomers. The degree of microphase separation is affected by the chemical composition, method of synthesis and thermal history, etc. [6,7].

Functionally graded materials (FGM) are a new type of functional materials whose properties change gradually along a direction. The change of the properties is caused by a position-dependent chemical composition and microstructure [8]. In the past years, many studies have been done in this field. However, most of the studies focused in metal system, and studies about polymer materials are relatively few [9]. Moreover, as far as the graded polymer materials are concerned, the more usual preparing way is sequential curing and the major studied systems are blends and IPNs [10–13]. Studies about graded polymer materials prepared from homogeneous system are few. Furukawa et al. [14] and Doupovec et al. [15] prepared graded materials using temperature gradient, and Bunel and co-workers [16] using the intensity gradient of UV light.

The aim of this paper is to prepare polyurethane elastomer whose degree of microphase separation changes along the length direction gradually. Accordingly, the properties of the polyurethane also change gradually. The method to obtain the graded polyurethane is curing the PU prepolymer in the graded temperature field, analogous to the methods of Furukawa and Doupovec's. However, studies in the present work are different with those of the two literatures.

2. Experimental

2.1. Materials

Tolylene diisocyanate (TDI) is supplied by Bayer. Poly(oxypropylene) glycol (PPG: Mn = 2000) is supplied by the third plastic plant of Nanjing. 3,3-Dichloro-4,4-dianilino methane (MOCA), used as chain extender, is produced by Xiangyuan refined chemical industry limited company, Jiangsu provenience. *N*,*N*-dimethylformamide (DMF), analysis reagent,

* Corresponding author. Fax: +86 2783620304.
E-mail address: zpzgraduate@163.com (P. Zhao).

0921-5093/$ – see front matter © 2006 Elsevier B.V. All rights reserved.
doi:10.1016/j.msea.2006.12.053

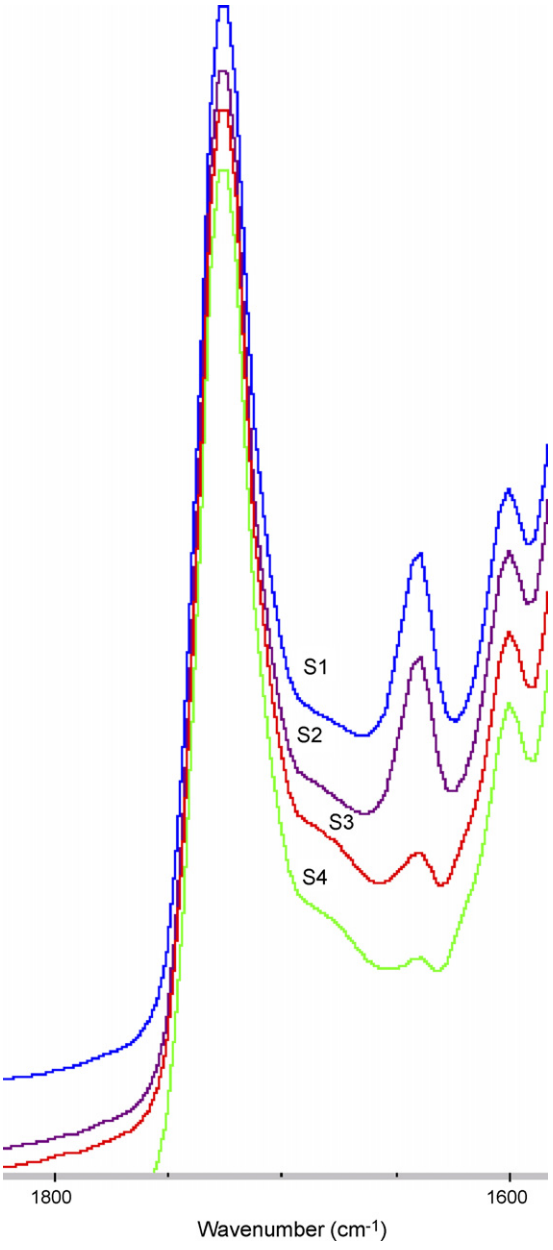

Fig. 1. FTIR of graded polyurethane in C═O region.

is supplied by Tianjin Kaitong chemical reagent limited company. PU prepolymer was prepared in our laboratory [17].

2.2. Preparation of graded polyurethane

The mold with the thickness of 2 mm was placed horizontally, and the temperature of the two ends was controlled at 120 and 60 °C, respectively. The prepolymer and chain extender were mixed well with a ratio of $[NH_2]/[NCO] = 0.85$. The mixture was poured into the mold after eliminating the air bubbles for about 8 min. After curing in the mold with temperature gradient for 3 h, the mold including the reactants was put into the air oven with the temperature of 110 °C for 4 h. And then the oven was powered off and the sample was demolded untill the temperature decreased to the room temperature.

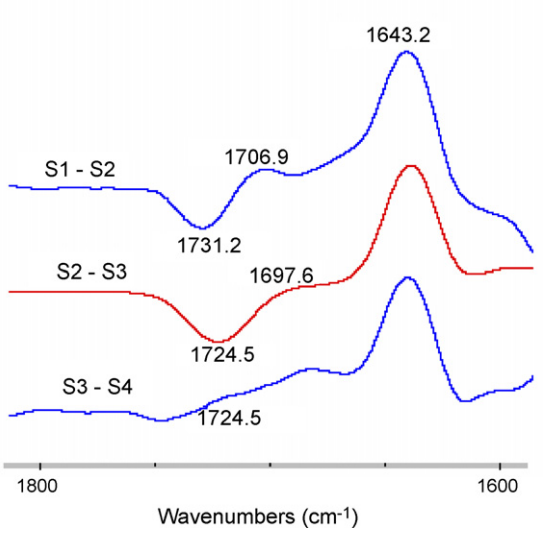

Fig. 2. The difference spectra of samples.

2.3. Characterization

The polyurethane prepared was cut into four samples in the length direction averagely. The samples were characterized under the same conditions. From the higher temperature end to the lower, samples were marked as S1–S4, respectively.

FTIR testing was performed using NICOLET 5700 FTIR apparatus. The omni-sampler accessory was selected to test reflection spectra. The resolution is 4.0 cm^{-1}. The number of sample scan is 32.

Tensile measurement was performed on MTS tester at room temperature with the tensile rate of 40 mm/min. The samples were cut into dumbbell shape.

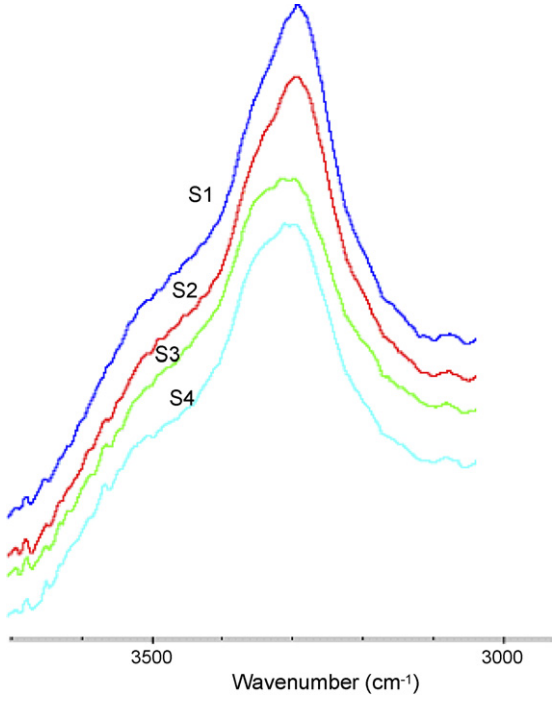

Fig. 3. FTIR of graded polyurethane in NH region.