The Effects of Physical Aging on Tensile Behavior of Polyphenylquinoxaline Films

Wan Jun LIU, Yue WANG, Jing Shu SHEN*, Feng Cai LU , Mao XU

Polymer Physics Lab, Institute of Chemistry, Chinese Academy of Sciences, Beijing 100080

Abstract: The effects of physical aging on the tensile property of notched samples and the endothermic peak at glass transition region of polyphenylquinoxaline films were studied.

Keywords: Physical aging, tensile property, cohesional entanglement, DSC, PPQ-E.

The mechanical properties are affected by physical aging [1]. Polyphenylquinoxaline (PPQ-E), an aromatic heterocyclic polymer, has many uses due to its high performance [2,3]. The aim of the paper is to study the effects of physical aging on tensile property for PPQ-E films. To avoid new physical aging effect during stretching [1,4], tensile test method for notched specimens and DSC measurement are used in the experiments.

Experimental

The PPQ-E synthesized in the laboratory was cast into a film 0.05 mm in thickness, which was then cut into rectangular specimen of 35 mm long and 1.7 mm wide. The notch was made on the middle of one edge along the length of specimen with sharp razor and approximately 0.2 mm in depth. These specimens were quenched to room temperature after annealed at 320°C for 1.5 hr. Then the specimens were classified into two sets, one set of specimens was denoted as sample 1. The other set was annealed at 280°C for 1.5 hr. again and then slowly cooled to room temperature, denoted as sample 2. The tensile property and T_g of the two kinds of samples were tested.

Results and Discussion

The DSC curves of these samples are shown in **Figure 1**. It can be seen that there is a obvious endothermic peak at the glass transition region on curve **b** and no obvious endothermic on curve **a**. All the results are related to physical aging of samples. According to the view point of cohesional entanglement [5], the difference in condensed structure of the two kinds of samples focuses on cohesional structure of the polymer chains. Molecular segments of sample 2 have chance to repack and to form more quantity and stronger cohesional entanglement points than that of sample 1. Thus, in the heating process of DSC, sample 2 will absorb more energy to disentangle. As a result, the endothermic peak at the glass transition is obvious.

Figure 1. The DSC curves for a. sample 1 and b. sample 2

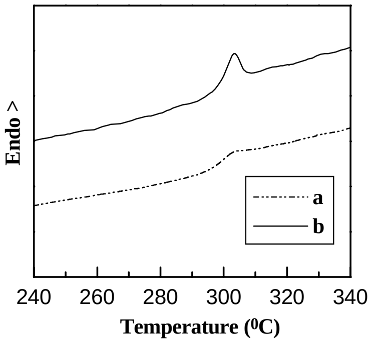
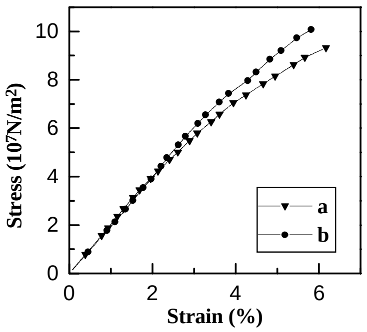


Figure 2. The nominal stress-strain curves for a. sample 1 and b. sample 2.



The nominal stress-strain curves of the two kind of notched specimens are shown in **Figure 2**. The values of fracture strain ε_b, fracture stress σ_b and fracture energy E_b which was attained through integration on the nominal stress-strain curve are shown in **Table 1**.

Table 1. Fracture stress, strain and fracture energy for two kinds of samples.

Samples	1	2
ε_b, %	6.16	5.77
σ_b, 10^7N/m^2	9.31	10.08
E_b, 10^5J/m^3	33.21	31.98

Though both samples fractured in macroscopical brittle manner, sample 2 has higher value of fracture stress, lower value of fracture strain and lower fracture energy than those of sample 1. The difference of ε_b, σ_b and E_b between samples 1 and 2 are real response of physical aging on tensile behavior. Also the difference of E_b between samples 1 and 2 is a response of cohesional entanglements on toughness. Because sample 2 will form more cohesional entanglements points than sample 1, its molecular mobility decreases, so, in the tensile process, brittleness increases and toughness decreases.

Acknowledgment

This work was supported by the National Key Projects for Fundamental Research--"Macromolecular Condensed State" the State Science and Technology Commission of China and by the foundation of PPLAS.

References

1. L.C.E.Struik, *"Physical Aging of Amorphous Polymers and Other Materials"*, Elsevier, Amsterdam, **1978** .
2. F.Lu, *J. Macromol. Sci.- Rev. Macromol. Chem.Phys.*,**1998**, *C38*(2), 143.
3. F.Lu, *Chin. Polym.Bull.*, **1996**, (1),1.
4. S.Strenstein, *J. Appl. Polym. Phys.*, **1972**, *43*(11), 4370.
5. R. Qian, *Macromol. Symp.*, **1997**, *124*, 15.

Received 3 February 1999