Application Brief

Hitachi High-Tech HITACHI

Hitachi High-Tech Science Corporation
RBM Tsukiji Bldg., 15-5, Shintomi 2-chome, Chuo-ku, Tokyo 104-0041
TEL:+81-3-6280-0068 FAX:+81-3-6280-0075
http://www.hitachi-hitec-science.com

DMA NO. 18 OCT.1992

Dynamic Mechanical Characterization of Oriented Polypropylene films

1. Introduction

Polypropylene is a widely utilized polymer for various applications because of its relatively high strength and resistance to solvents. The mechanical properties exhibited by polypropylene films are slrong1y dependent upon the processing conditions utilized in the generation of the films. Because of the crystalline nature of polypropylene, varying the processing conditions can affect the crystalline structure of the bulk polymer which can, in turn, affect the mechanical properties exhibited by the final product. For these reasons, it is important to characterize the structure, or morphology, of polypropylene materials using thermal analysis, and, in particular, using dynamic mechanical spectroscopy (DMS).

DMS provides a very sensitive means of characterizing the physical and mechanical properties of various polymeric materials such as plastics, films, fibers, elastomers, thermosets and composites. The technique provides a wealth of information on the molecular motions associated with a given material and on the particular morphology of a polymer. This information is critical in the development of new, high performance polymers. The mechanical characteristics of feedstock po1ymers and the final products produced from these polymers provide important data for both manufacturing process control and evaluation testing.

2. Experimental

In this particular study, a linear polypropylene film (with a thickness of 1mil) was characterized using the DMS200 with the combination tension mode. The film was analyzed to determine differences in the machine and transverse orientations. Strips of the film were cut parallel to the machine direction and then at 90º to generate the transverse specimen.

The following conditions were used to character･

The following conditions were used to characterize the film samples:

Heating rate: 2℃/min
Initial temperature: -20°C
Deformation mode: combination auto-tension
Sample length: 10 mm
Sample width: 9 mm
Sample thickness: 0.025 mm
Frequencies: 1, 2, 5, 10 and 20 Hz
Strain amplitude: 30μm
Base force: 30 grams
Initial force: 200 grams
Tension proportional coefficient: 1.3

3. Example of Analysis

The polypropylene film specimen was analyzed in two different orientations: machine and transverse directions. Displayed in Figure 1 are the results obtained on the 1mil polypropylene film specimen that was oriented in the machine direction (MD). The f1gure shows the tensile storage modulus (E') and the tanδ data as a function of sample temperature. The MD oriented specimen exhibits a beta transition as reflected by the series of small peaks in the tanδ data at 14°C. The modulus of the machine direction specimen at 20°C is 2.6GPa. The alpha transition is observed as a broad peak from 25 t0 170°C with a peak temperature of 128°C. This alpha transition may actually consist of two alpha events (α1 and α11) which are associated with the movements of molecules in the crystalline phase. The peak value of tanδ is 0.13 for the MD specimen.

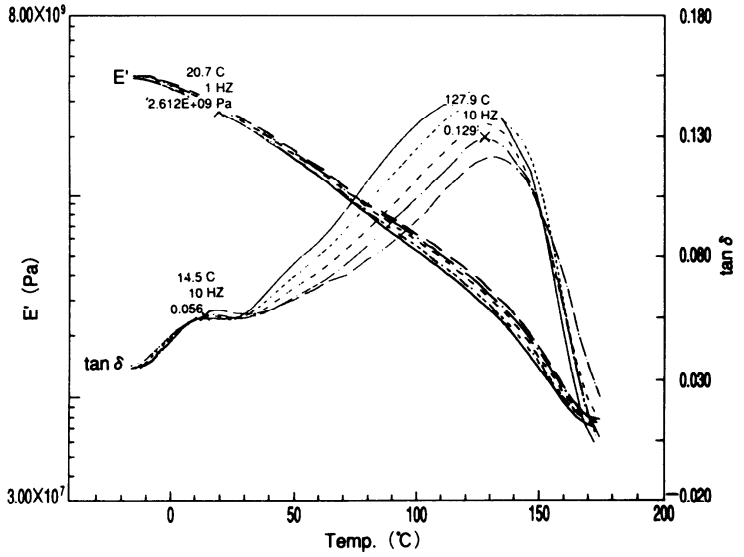

Figure 1 Dynamic viscoelasticity spectrum of polypropylene film (MD)

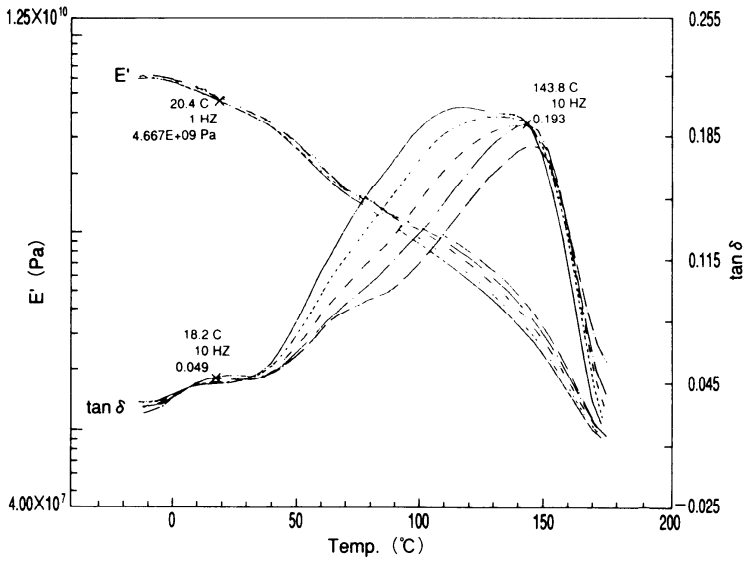

Figure 2 Dynamic viscoelasticity spectrum of polypropylene film (TD)

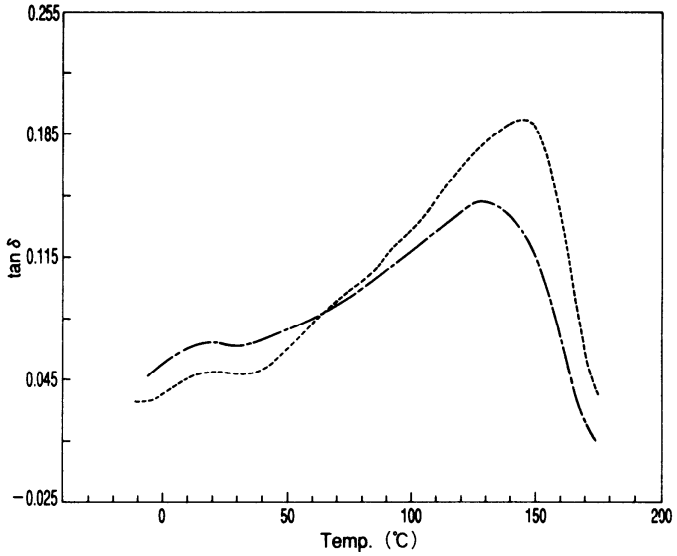

Figure 3 Comparison of the tanδ for MD and TD of polypropylene film
— · — MD
····· TD

Displayed in Figure 3 are the results obtained on the transverse direction (TD) polypropylene film specimen. This sample yields a beta relaxation event at 18°C. The value of E' at room temperature for the TD sample is 4.7GPa which is significantly higher than that obtained for the MD sample (E' = 2.6GPa). The TD specimen has a broad alpha transition between 30 and 180°C with a tanδ peak temperature of 144°C. The value tan δ at the peak maximum is 0.195 (at a frequency of 10Hz). Both the tan δ peak temperature and magnitude are higher for the TD specimen (TD: 144°C, 0.195; MD: 128°C, 0.13).

A direct comparison of the tanδ behavior associated with the machine and transverse oriented samples is displayed in Figure 4 (10Hz data). The observed differences between the machine and transverse directions are reflective of differences in the morphology (especially in the crystalline phase) between the two orientations.

4. Summary

An oriented polypropylene film (thickness of 1mil) was characterized using the Seiko Instruments DMS200 in both the machine and transverse directions. The films specimens were analyzed using the combination tension mode which permits data to be obtained completely through the alpha transition event where the sample becomes very soft. The film specimen oriented in the transverse direction had a higher value for the tensile modulus, E', (TD E' = 4.7GPa, MD E' =2,6GPa). The tan δ peak temperature and magnitude were significantly higher for the TD specimen: TD, 144°C, 0.195; MD, 128°C, 0.13). These differences demonstrate that the polypropylene film specimen exhibits significantly different mechanical properties in the transverse and machine directions due to differences in the morphologies.