Application Brief

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Dynamic Viscoelastic Measurements of Polyethylene Film

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1. Introduction

Polyethylene is used widely in the various field as one of the major industrial materials. Most of the mechanical properties of Polyethylene is determined by formation and process conditions.

Dynamic viscoelasticity measurement plays the important role in the development of new materials as well as it is used in the mechanical property evaluation of various materials with Polyethylene.

In this brief, we measure Polyethylene dynamic viscoelasticity by tensile mode[1].

2. Experiment Conditions

The samples are Polyethylene film which has the thickness 12-15μm formed by roll stretch. DMS200 Dynamic Mechanical Spectrometer (Tension Module) connected to a SDM5600H Rheol. Station is used for the measurements.

3. Measurement results

Figure1 and Figure2 show the measurement result of drawing direction and vertical direction of Polyethylene film. These are the storage modulus (*E*'), the loss modulus (*E*") and tanδ curve at measurement frequency 1Hz. All results shows α-dispersion in the vicinity of 100°C, α'-dispersion in the vicinity of 20°C, γ-dispersion in the vicinity of -125°C. Attribution of each dispersions are, α-dispersion to crystal relaxation, α' to grain boundary relaxation, and γ to local mode relaxation[2]. Also β-dispersion (glass transition) is rarely observed. The reason why the beta dispersion by glass transition of amorphous area is nearly seen is likely because Polyethylene film formed by the stretch has high crystallinity and high orientation of amorphous chain.

Figure 3 shows the comparison result of tanδ curve on Figure 1 and 2. This result shows the remarkable difference in α-dispersion between drawing direction and vertical direction.

On the other hand the direction of the hold surface is changed vertical to the drawing direction. When the strain is applied to the vertical direction, the slide can be seen easily at the hold surface of crystal lamellas, which causes crystal relaxation in the wider area. Therefore, the larger peak is likely shown at vertical direction than drawing direction at α-dispersion area in Figure 3.

Figure 4 shows the simultaneous measurement result of temperature dispersion and frequency dispersion regarding vertical direction of Polyethylene film. They are *E*', *E*", and tanδ curves at the measurement frequency of 0.5, 1, 2, 5, and 10Hz. From the result of the measurement, frequency dependence are observed at all dispersion of α-, α'-, and γ-dispersion.

Figure 5 shows the calculation results of apparent activation energy ΔE[3] of α'- and γ-dispersion. Apparent activation energy are 103kJ/mol for α'-dispersion and 64kJ/mol for γ-dispersion.

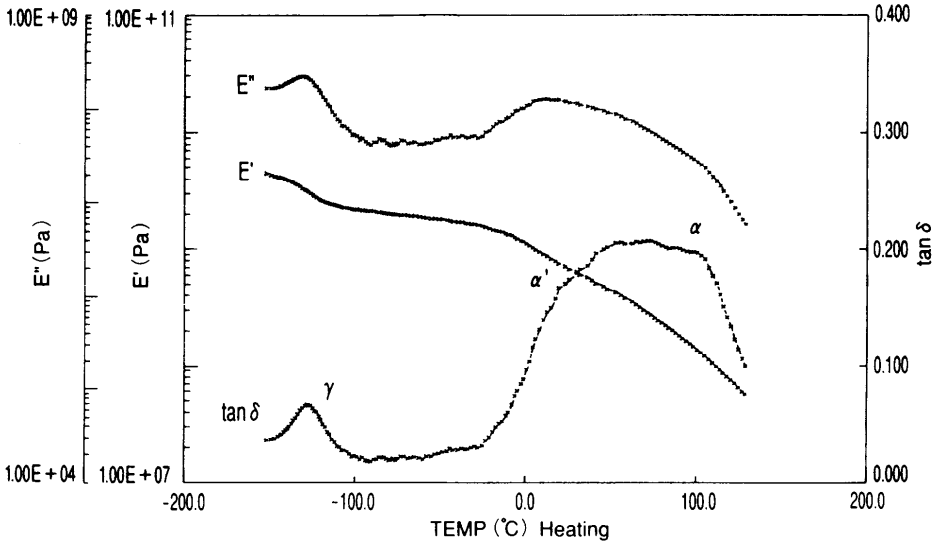

Figure 1 Dynamic viscoelasticity spectrum of Polyethylene film (drawing direction)

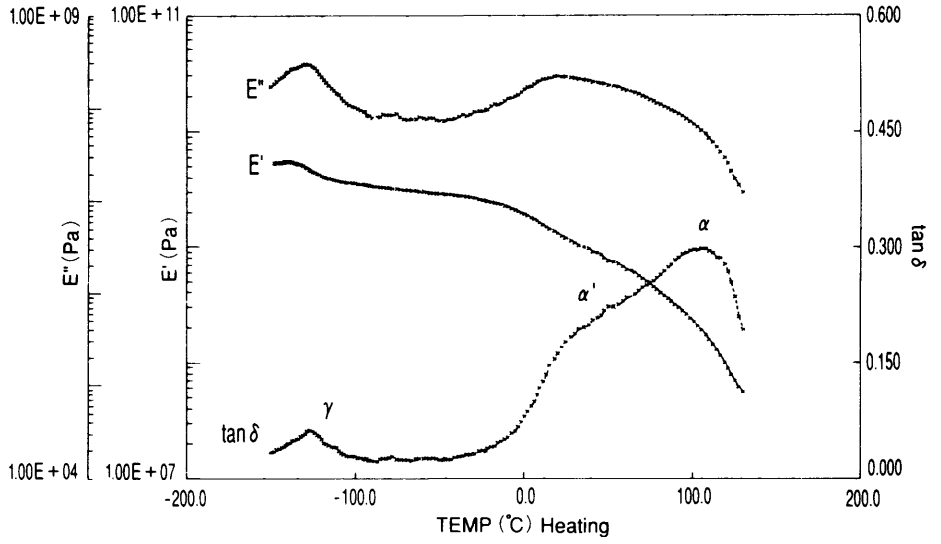

Figure 2 Dynamic viscoelasticity spectrum of Polyethylene film (vertical direction)

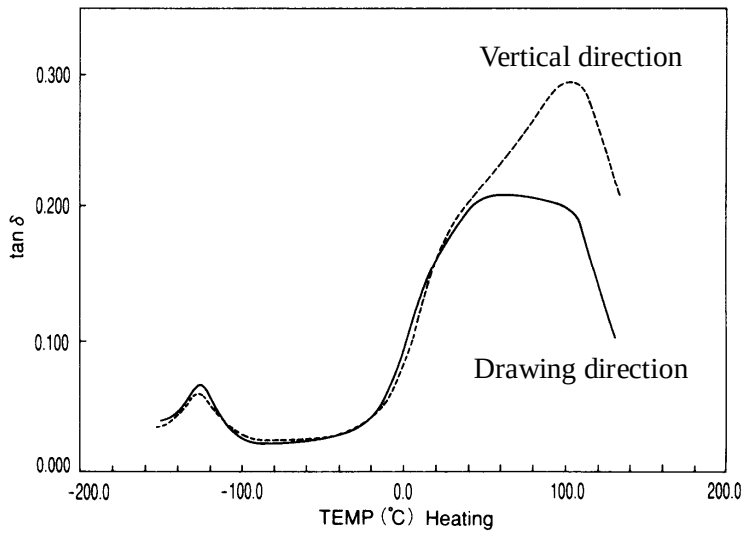

Figure 3 tanδ curves comparison of Polyethylene film (drawing & vertical direction)

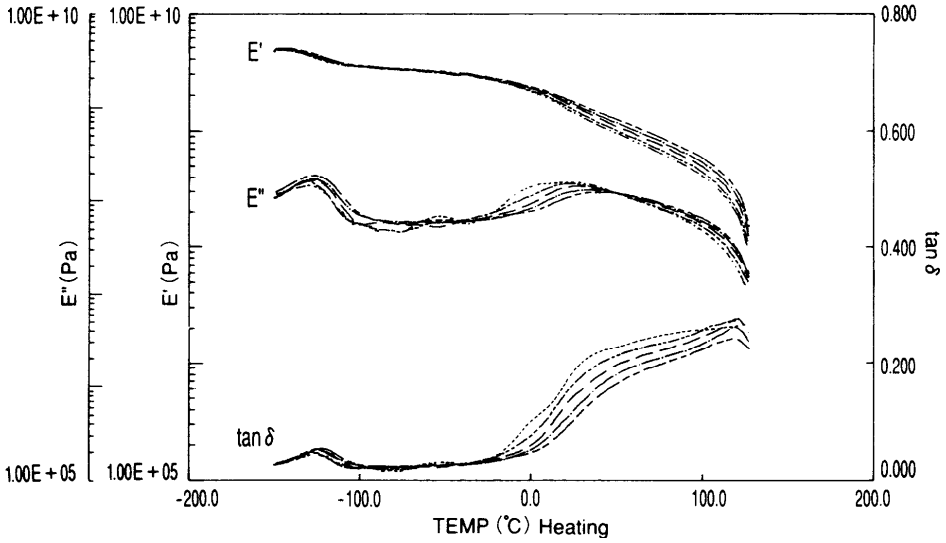

Figure 4 Dynamic viscoelasticity spectrum of Polyethylene film (vertical direction)

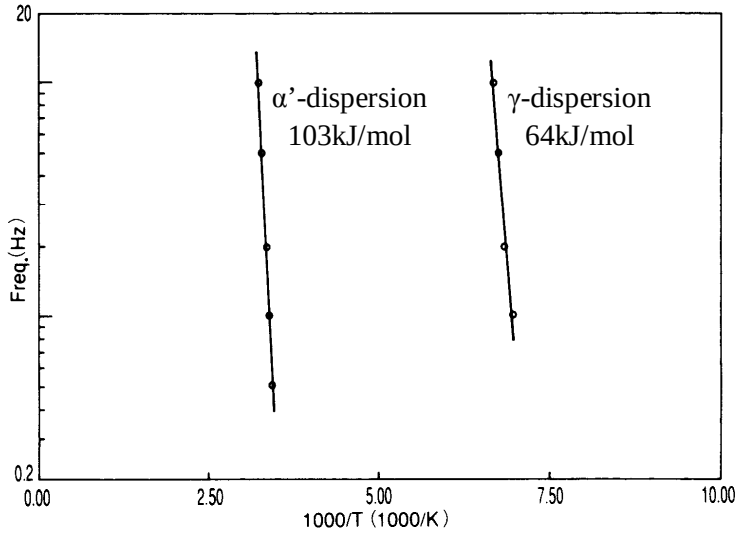

Figure 5 Apparent activation energy of α'- and γ-dispersion of Polyethylene film (vertical direction)

4. Conclusion

In this brief, Polyethylene film at tensile mode is measured. The sample formed by the stretch makes the difference in the measurement result in drawing and vertical direction. Depending on the sample material and forming method, there may be anisotropy. Dynamic viscoelasticity measurement is effective for this kind of anisotropy evaluation.

References

1) Y. Sugano, N. Okubo, Y. N. Nakamura and Y. Teramoto, The 26th Japanese Conference on Calorimetry and Thermal Analysis, p12 (1990)
2) Yasaku. Wada, "Solid Properties of Polymers", Baihukan (1971)
3) Nobuaki Okubo, Application Brief DMS No.7, Hitachi High-Tech Science Corporation (1990)