1. Introduction

Dynamic mechanical testing measures the strain response of the material when changing the stress periodically. Delay (tan\(\delta\)) of the strain against the stress is used as a factor acquires the change of molecular motion of the material.

In this brief, TMA/SS periodic loading mode is used. The tan\(\delta\) of Styrene-Butadiene-Styrene (SBS) is measured by phase difference of stress and strain.

2. Measurements

2-1 Stress-Strain measurement

The sample is SBS Block copolymer. The film sample of 910\(\mu\)m thickness from the benzene solution is used. Average molecular weigh is \(1.2\times10^4\) for styrene unit, \(5.6\times10^4\) for butadiene unit. Sample size is length 15.6mm \(\times\) width 3mm and measured between -120 to 100°C at the heating rate of 2°C/min.

Figure 1 shows the TMA/SS measurement result in the vicinity of 50 to 70°C. Measurement condition is frequency 0.01Hz and load (F) 20±10g. From the amplitude ratio of the load and strain, the value proportional to the complex modulus is obtained. The tan\(\delta\) is calculated from the phase difference of the load and strain.

Figure 1  TMA/SS results for Styrene-Butadiene-Styrene film

F(g): load (frequency 0.01Hz, 20±10g.)
L(\(\mu\)m): displacement
dL/dt: time-derivative of displacement
Figure 2 shows the result of $\tan \delta$ calculated from Figure 1. The peak in the vicinity of 90°C shows the main dispersion of butadiene and the peak in the vicinity of 80°C shows the main dispersion of styrene. Considering the molecular weight and frequency dependence, it shows almost the same that of measurement result by the dynamic mechanical analysis\(^1\).

![Figure 2](image)

Figure 2  $\tan \delta$ curve for Styrene-Butadiene-Styrene film

2-2  DSC measurement

Figure 3 shows the DSC measurement result of the same SBS sample. Glass transitions in the vicinity of -100 to -90°C and 65 to 80°C are observed. From the result of Figure 2, even the method of the dynamic mechanical testing, the result similar to the one by the DSC measurement is obtained.

![Figure 3](image)

Figure 3  DSC curve for Styrene-Butadiene-Styrene film

Reference