Ebatco Nano
A Bimonthly Newsletter

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Ebatco

We will be participating and exhibiting at a few conferences this year. The tradeshows and conferences we have decided to participate are as follows:

- April 29th, Minnesota Microscopy Society Spring Symposium, The Science Museum of Minnesota, Saint Paul, MN
- May 11th-12th , **Booth # 629**, Society of Vacuum Coaters 2016, Indiana Convention Center, Indianapolis, IN
- October 3rd -5th, 2016 BioInterfaces Workshop and Symposium, The Commons Hotel, Minneapolis, MN

As always, please stop by and visit us if you are attending any of the above tradeshows. We hope to see you there!

Nano Brief

Dr. Dehua Yang of Ebatco, and Mr. Takashi Sekine of Kyowa Interface Science Co. Ltd. had presented at the 39th Annual Adhesion Society Meeting in San Antonio this February. The topic of their poster presentation was "Evaluation of pressure sensitive adhesives using contact angle and adhesion tension relaxation".

Surface free energy analysis using static contact angle has often been used as a method to evaluate adhesives. The general assumption is that the greater the surface free energy is the stronger the adhesiveness should be. However, the surface free energy of the acrylic adhesive, a Pressure Sensitive Adhesive (PSA), is as low as that of Teflon and silicone rubber. It is obvious here that it is not proper to evaluate the adhesiveness of PSA only using surface free energy analysis and conventional sessile drop contact angle measurements.

When evaluating PSAs using contact angle techniques, it is important to consider the mechanism of multicomponent polymeric systems that re-orient their segments in response to the testing medium. It is worthy of note that measurements of contact angle

hysteresis and adhesion tension relaxation are very useful approaches in comparison to static contact angle measurement.

Case Study

With their low cost and ease of manufacture, structural polymer components have become increasingly common in consumer products. While switching from metal to polymeric components can decrease the material cost of a product, there are additional design considerations to take into account. One of those considerations is the viscoelastic nature of polymeric materials.

The time and temperature dependent behavior of polymers is due to their molecular structures. As a polymer is stressed, it undergoes molecular rearrangement in an attempt to relieve the stress. This results in an apparent decrease in stiffness (or storage modulus) over time. This would seem to imply that polymers must be evaluated for specific applications by testing under the conditions they will be subjected during use. Fortunately, there is a demonstrated relationship between the time (frequency) and temperature at which a material is tested. In other words, it is possible to determine very low (or high) frequency properties by simply testing the material at a higher (or lower) temperature. This relation is known as 'time-temperature superposition' (TTS).

Dynamic mechanical analysis (DMA) characterizes the viscoelastic behavior of materials by applying a sinusoidal force to a specimen and measuring the material response. It is one of the most sensitive and accurate techniques for applying the time-temperature superposition principle.

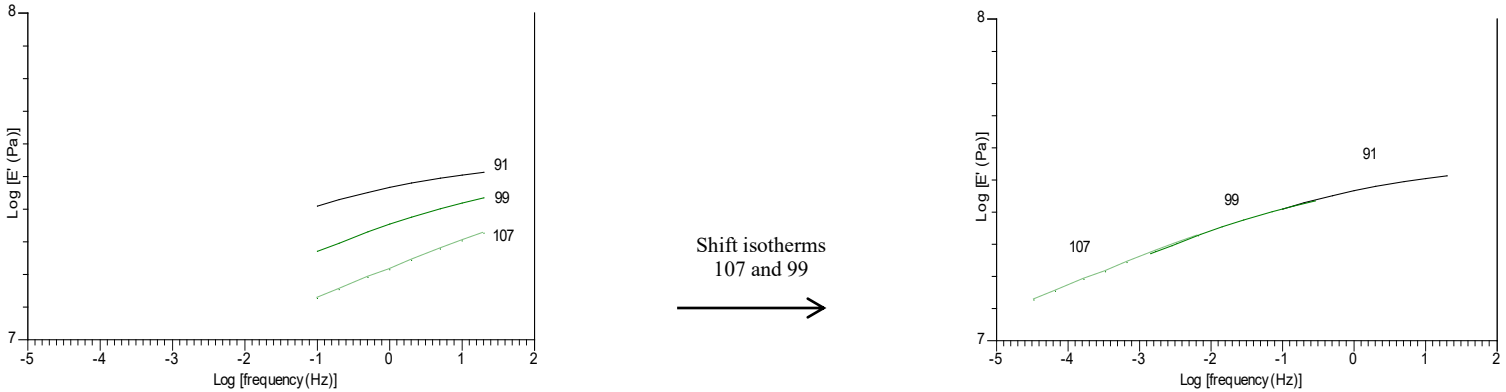

Figure 1. Demonstration of time-temperature superposition. The isotherms for 107°C and 99°C are shifted to predict low frequency properties at 91°C.

With TTS, it has been demonstrated that it is possible to determine material properties for very low or high frequencies by performing creep, stress relaxation, or multiple frequency tests at a variety of different temperatures. By shifting the isothermal data along the time (frequency) axis, it is possible to obtain a single isotherm, typically referred to as the 'master curve,' of the modulus for a much broader range of frequencies than was tested. This is illustrated in Figure 1.

The amount of shifting required to obtain the master curve can be mathematically described by the Williams-Landel-Ferry equation, shown in Equation 1.

Equation 1: $$log(a_T) = -C_1^o \frac{T-T_0}{C_2^0+T-T_0}$$

In this equation, T_0 is the reference temperature, i.e. the temperature to which all the isotherms are shifted. T_0 is typically defined as the glass transition temperature, Tg. C_1^o and C_2^0 are empirical constants (17.4 and 51.6, respectively, for many amorphous polymers), T is the temperature of the isotherm to be shifted, and a_T is the shift factor

To illustrate the principle of TTS, Ebatco's NAT Lab tested poly(ethylene terapthalate) (PET) ribbon at a variety of temperatures and frequencies. By applying the WLF model, the isotherms are shifted to create a master curve for the storage (E') and loss (E") moduli at 91°C, the glass transition temperature of the material, presented in Figure 2.

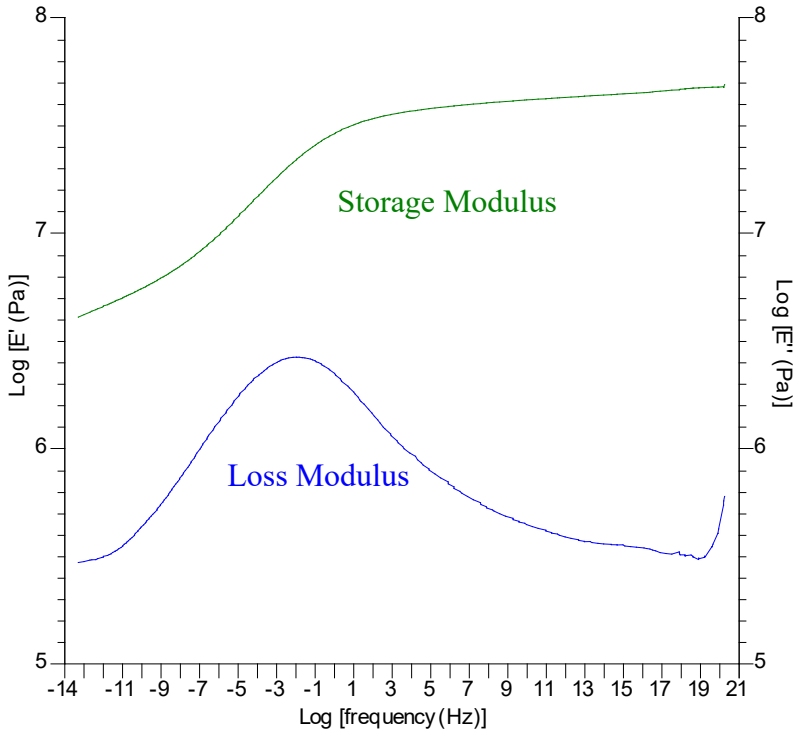

Figure 2. Master curve for PET at 91°C.

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