APPLICATION NOTE

Thermal Analysis

Dynamic Mechanical Analysis of Coffee

Summary

This application note demonstrates the ability of DMA to investigate a complex powder formulation. Both granulated instant coffee and granulated filter coffee were analyzed by DMA. A multi-frequency experiment clearly shows complex relaxation processes and other phase transitions. When run over a large temperature range, relaxations were observed as well as reproducible events below -150 °C. As the coffee is in powdered form, the Material Pockets were used to hold the sample in the PerkinElmer® DMA 8000.

Introduction

Dynamic Mechanical Analysis (DMA) is one of the most appropriate methods to study amorphous materials. The glass transition (Tg) is a key process in any material, and can be observed with ease by DMA. This technique provides very revealing information about these relaxations through the tan δ vs. temperature data. Coffee, when in the final marketed state, is often in a powdered or granular form. This applies to both instant and filter coffee. Powders can be easily investigated in the DMA 8000 by using Material Pockets which sandwich the powder in a stainless steel prior to measurement.

DMA works by applying an oscillating force to the material and the resultant displacement of the sample is measured. From this, the stiffness can be determined and the modulus and tan δ can be calculated. Tan δ is the ratio of the loss modulus to the storage modulus. By measuring the phase lag in the displacement compared to the applied force it is possible to determine the damping properties of the material. Tan δ is plotted against temperature and glass transitions are normally observed as a peak.

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Coffee is a very complex formulation of various components. Even the simple coffee bean has multiple molecules, some of which are polymeric in nature, that make up the structure. In addition, the oils and other materials also affect the flavor.

Experimental

1. Multi-frequency scan of instant coffee. five frequencies from -80 °C to 250 °C at 5 °C/min.

2. Dual-frequency scan of instant and filter coffee. 1 Hz and 10 Hz from -190 °C to 220 °C at 3 °C/min.

About 10 mg of each sample was weighed into a Material Pocket before being mounted into the DMA 8000 in Single Cantilever Bending geometry.

Equipment	Experimental Conditions	
DMA 8000 1L Dewar	Sample:	Tesco® medium blend filter coffee Nescafe® instant coffee granules
	Geometry:	Single Cantilever Bending
	Support:	Material Pocket
	Frequency:	Multi-frequency and, 1 and 10 Hz

Results and conclusion

Figure 1 shows tan δ data from the multi-frequency scan of instant coffee. A very large and broad relaxation is seen which is almost certainly made up from several glass transitions. The peak position is frequency dependant proving this event, or series of events, is a relaxation.

The storage modulus data from the multi-frequency scan of instant coffee is shown in Figure 2. The conclusions from the tan δ plot are confirmed as this data also shows frequency dependence at the same temperature range. In addition, the material is seen to get less stiff as the temperature increases indicating a softening over the glass transition area.

Figure 3 shows data starting at a lower temperature for both filter and instant coffee. Both tan δ and modulus are superimposed on the same plot. This data was run at a lower scan rate than the previous examples and it shows a good separation of two glass transition peaks for the instant coffee. Again, a phase separation is observed. There are also clear transitions in the filter coffee sample. Although nothing is seen in the tan δ data, both filter and instant coffee show a small drop in modulus at about -165 °C which is as yet unexplained. This very low transition temperature can only be seen using the DMA 8000 as most DMA cannot reach this low a temperature. Since the DMA 8000 can reach -190 °C it is ideal ofr low temperature work.

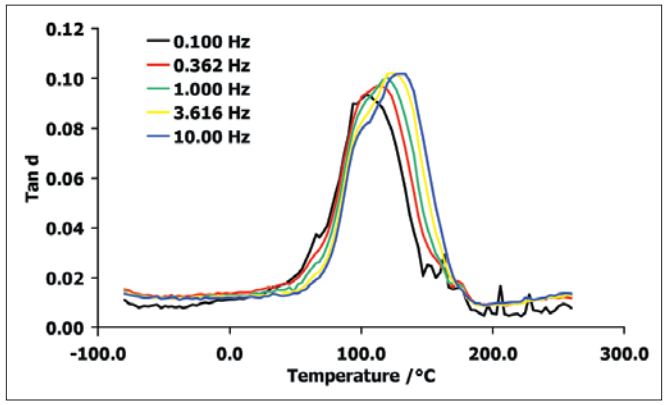

Figure 1. Tan δ data from scan of instant coffee.

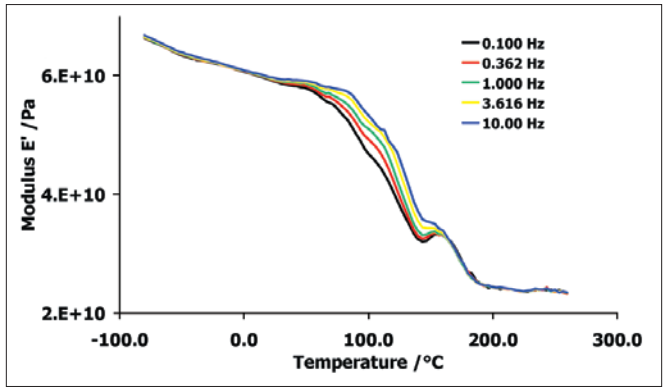

Figure 2. Storage modulus data from scan of instant coffee.

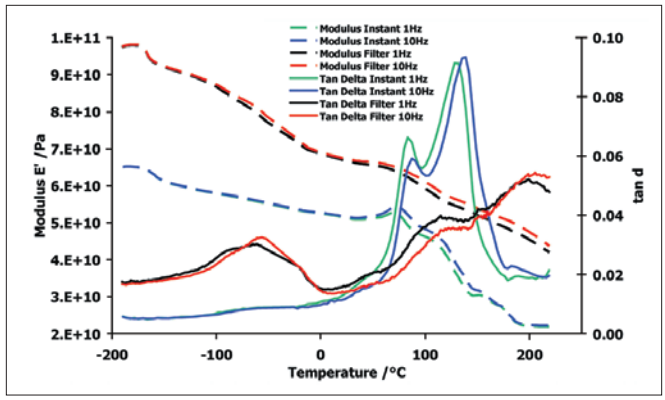

Figure 3. Scan data of both filtered and instant coffee.

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