Prediction of Solid Fat Index (SFI) Values of Food Fats Using DSC

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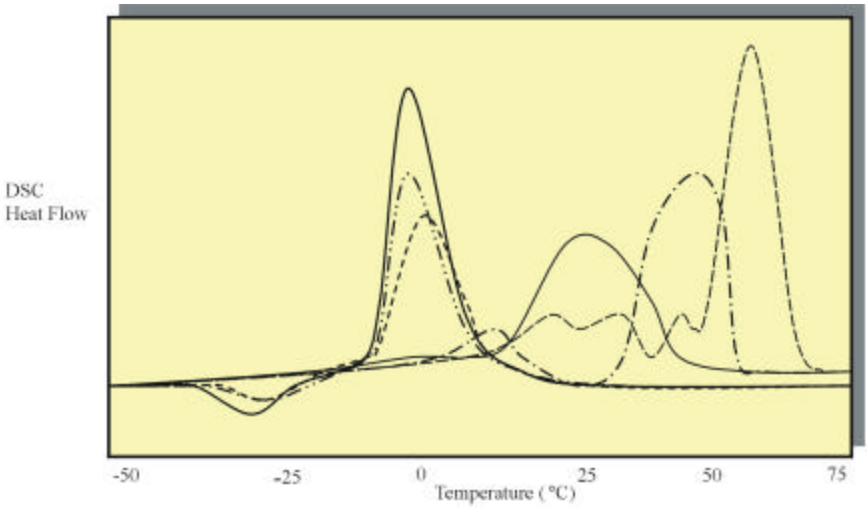
Introduction

Differential scanning calorimetry (DSC) is useful technique for the characterization of food products, including: the gelantinization behavior of starches, the polymorphism of cocoa butters and chocolate, effects of moisture content or absorbed moisture, aging effects, protein denaturation, and the determination of fat content. The processing and handling behavior of food fats has been found to depend upon the solid-to-liquid fat ratio in the food sample. Many rheological or flow properties, and their resultant effect on the texture of the final product, stem from this fat ratio index.

The percent of solid fat in a sample is traditionally measured using the Solid Fat Index (SFI) value, a dilatometric (volumetric) technique that takes about 5 hours. Food samples are loaded into a calibrated dilatometer and are first immersed in successive baths at 60, 40, 27 and 0 C to temper the samples. Tempering places a specific thermal history into the sample and allows the fats to crystallize under controlled conditions for comparative purposes. The samples are then immersed for 30 minutes in baths at various increasing temperatures and the volumes measured. The volume versus temperature response of the fats gives the SFI values at the different temperatures.

Figure 1. DSC results on the melting of hydrogenated sunflower oils.



Because of the time consuming nature of the dilatometric SFI test, the use of faster techniques, including DSC and NMR, has been investigated. DSC represents a fast and convenient way to control processing and blending of fats by predicting the SFI values.

DSC

DSC measures the heat flow into or from a sample as it is heated, cooled and/or held isothermally. For thermosetting resins, the technique provides valuable information on glass transition temperatures (Tg), onset of cure, heat of cure, maximum rate of cure, completion of cure and degree of cure.

PerkinElmer offers several high performance DSC systems, with different technologies, to accommodate a wide variety of applications, needs and budgetary conditions. Autosampler capability is available for unattended operation. The PerkinElmer systems use the Windows NT based Pyris Manager software for outstanding ease of use and flexibility.

Experimental Conditions

A series of sunflower oil samples was hydrogenated to generate various SFI values. Six hydrogenated oils

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Figure 2. Measurement of DSC partial areas of melting.

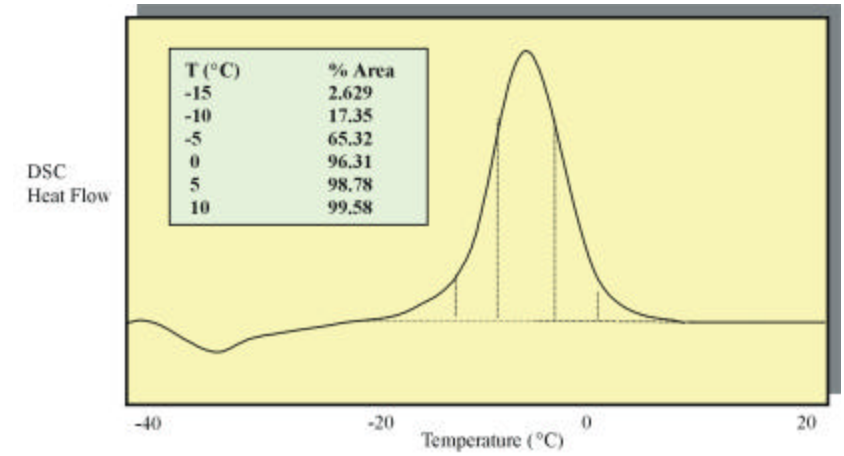
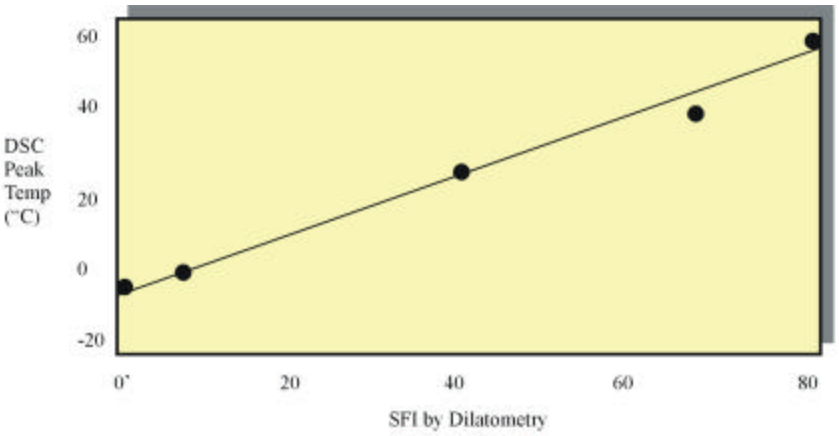


Figure 3. Correlation of DSC peak temperature versus SFI values (dilatometric).



were selected to determine the dilatometric and DSC SFI values.

The DSC studies were conducted using the PerkinElmer power compensated DSC. The fats were completely melted in a hot water bath and mixed to assure uniformity and loaded both as molten and solid samples. The samples were cycled through a heat-cool-reheat cycle, where they were heated to 80 C at a rate of 10 C/min, cooled to –50 at 10 C/min, and then reheated at 10 C/min back to 80 C. The melting endotherms of the fats during the second heating segment were analyzed to determine the SFI values.

Results

Displayed in Figure 1 are the DSC results generated during the second heating segment for the six hydrogenated sunflower oils samples?

The DSC melting curves show that the melting transition shifts to increasingly higher temperatures as the degree of hydrogenation (and SFI) increases. This is expected as both traditional SFI and DSC are measuring the thermal dependent properties of the fats.

DSC can be used to predict the SFI values by using the partial areas of melting rather than the peak temperatures. The partial area refers to the measurement of the area contained under the melting curve (in units of J/g) at a certain temperature. The PerkinElmer software does provide for this measurement of the partial area. Figure 2 shows the partial area calculations on the melting transition of an oil sample.

There is a reasonable correlation between the DSC melting temperature, as defined by the peak temperature, with the dilatometric SFI value. This is shown in Figure 3.

A better correlation can be obtained between DSC and the traditional SFI dilatometry test by using the percent partial areas of melting. Figure 4 shows the values and the calculated SFI values at temperature of 37.8 C for the six hydrogenated sunflower oil samples.

The use of DSC partial areas of melting gives good correlation with the standard SFI values as obtained from dilatometry.

Summary

DSC is a useful technique for the characterization of foods. One important test is the measurement of Solid Fat Index (SFI) values for hydrogenated food oils. The SFI value is related to the solid fat content

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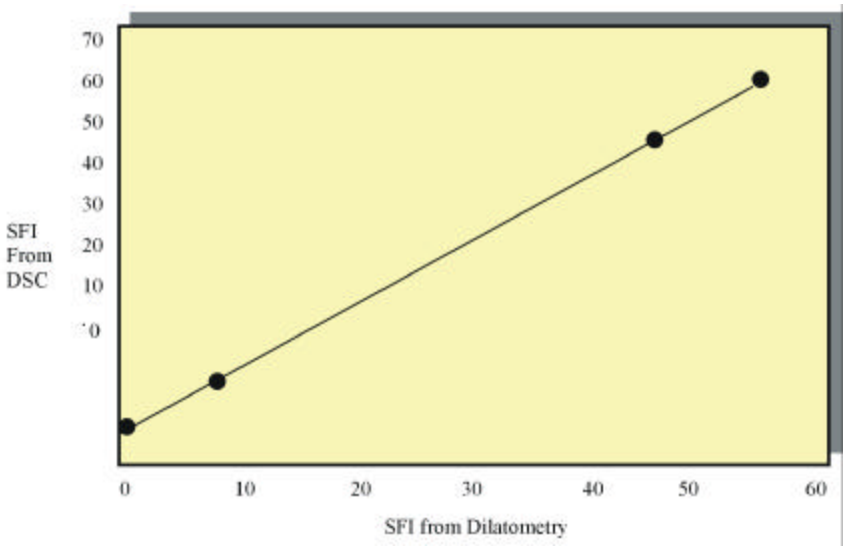
Figure 4. Correlation of DSC partial area of melting versus SFI value (dilatometry).



and to the textural and rheological properties of the oils. Additionally, since SFI measures the degree of hydrogenation of oils, this is useful for dietary purposes with the increasing importance of trans fats in foods and its relationship to 'bad' cholesterol levels.

There is a fair correlation between the DSC melting peak temperatures with the dilatometric SFI values. It was found that an even better correlation exists between the DSC partial area of melting versus the SFI values. The DSC approach can provide a fast and convenient means of determining SFI values of food oils. The SFI test by DSC takes less than 1 hour to perform and analyze versus 5 hours or more using the standard, dilatometric SFI test. PerkinElmer offers a wide range of high performance DSC instruments for various applications and needs.

References

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