APPLICATION**NOTE**

Honey – Differential Scanning Calorimetry

Why Thermal Analysis of Honey Matters

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Introduction

Honey is a natural sweetener characterized not only by its unique taste, but also by its nutritional and medicinal properties.

All gourmets know that honey may crystallize over time, depending on its composition and the storage conditions. This process affects its texture and appearance as glucose separates from the water phase and forms solid crystals. The stability of honey against crystallization is related, amongst other factors, to its thermal properties. In the following, we show how the form of the glass transition step of honey contains information about its stability.

Experimental

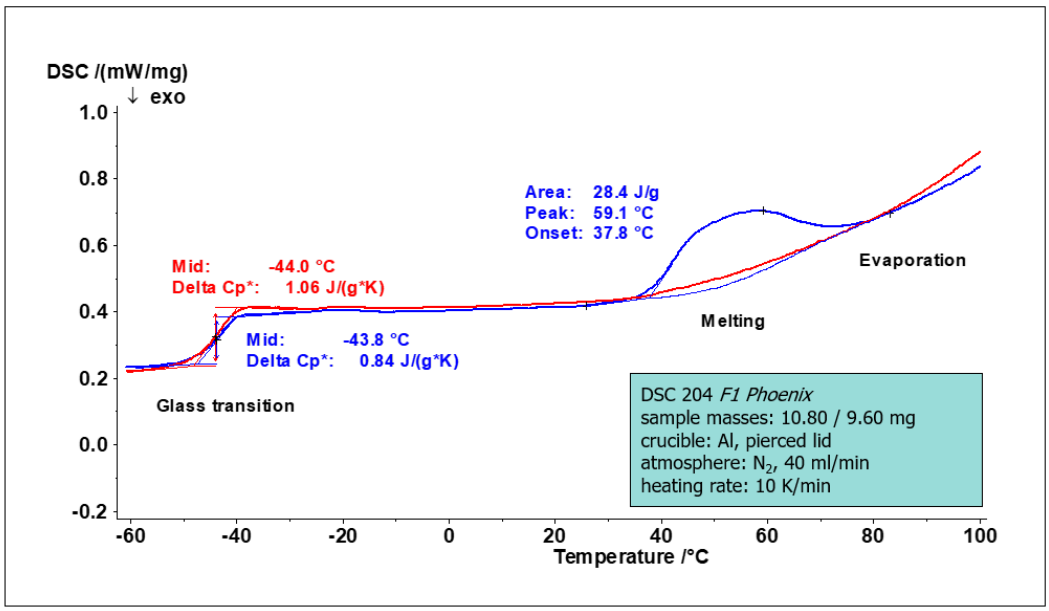
DSC (Differential Scanning Calorimetry) is a typical technique for determining the thermal properties of honey like melting point and glass transition temperature.

A DSC measurement was performed on two honey samples of the same brand with different age and appearance. The first one (OLD) was in a crystallized (or partially crystallized) state, the second one (NEW) was clear and in a liquid state.

For the tests, 10.8 mg and 9.6 mg of crystallized and liquid honey were prepared in an aluminum crucible closed with a pierced lid. Each crucible was placed in the DSC cell, cooled down and then subjected to a heating between -80°C and 100°C at a controlled heating rate of 10 K/min^{-1}. During the experiment, the DSC cell was purged with a dynamic flow of nitrogen (40 ml/min).

Measurement Results

Figure 1 depicts the resulting DSC thermogram for both measurements. The endothermal step detected at -44°C (midpoint) in both curves is due to the glass transition of the honey samples. It was found at the same temperature, but related to different heat capacity step heights.



1 DSC curves of partly crystallized (old product) and completely amorphous (new product) honey; measurements performed with crucibles with pierced lid.

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The step height is connected with the amount of the amorphous phase. The higher the crystallization degree of honey, the lower the amount of amorphous phase and the smaller the heat capacity step. This explains the Delta c_p of 0.84 J/(g·K) for the crystallized honey in comparison with the higher value of 1.06 J/(g·K) for the liquid one.

An endothermal peak was detected between 30°C and 80°C only in the DSC curve of the crystallized honey. It comes from the transition from the solid to the liquid state and takes place only for honeys that are in the partly or completely crystallized state [1]. The melting peak is superimposed with an endothermal increase in the baseline. This results from the evaporation of the water contained in honey.

The use of closed crucibles allows for the prevention of moisture evaporation, as shown in figure 2. Here, measurements were performed under the same conditions as before, except for one: closed aluminum crucibles instead of crucibles with pierced lid were used. The change in crucible doesn't influence the glass transition step. The melting peak can be evaluated more accurately because it is no longer superimposed on evaporation effects. The measurements show that the melting process is connected to an increase in specific heat.

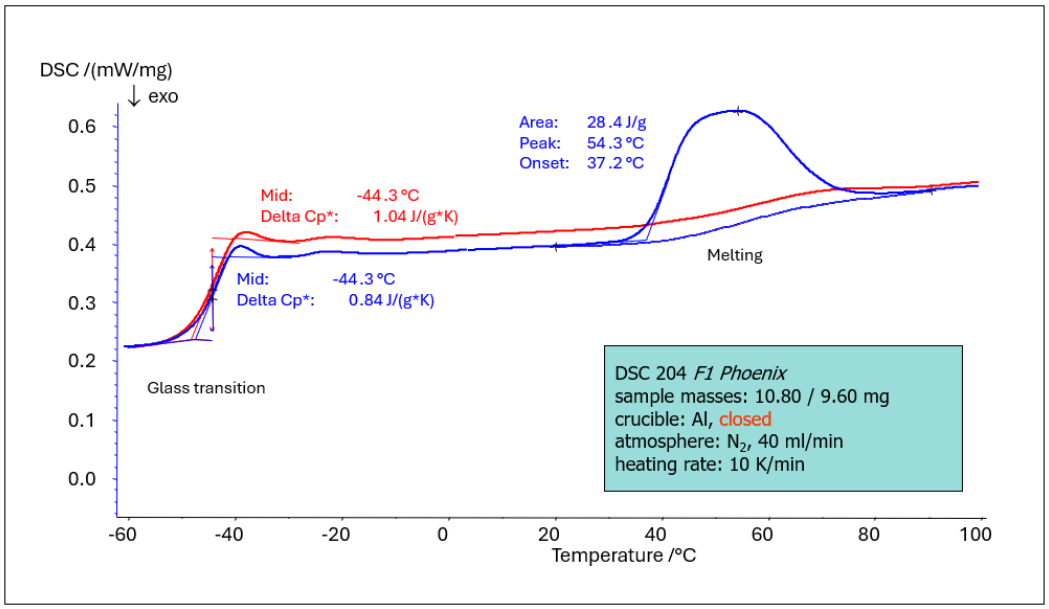
Conclusion

The thermal properties of two honey samples were determined with differential scanning calorimetry. The first one was translucid and liquid, and the second one partly crystallized. The two products differed in their age, the crystallized one being older than the clear one. The glass transition temperature of both honeys was detected at -44°C. When honey is stored at a temperature below its glass transition temperature, T_g, it will be stable. On the other hand, above the T_g, it is susceptible to crystallization. If the product contains a crystallized part, a melting peak is detected in the DSC curve. The higher the crystallinity, the higher the melting enthalpy.

Thus, DSC analysis can be used to visualize the crystallinity state of honey and even to predict its stability.

Sources

[1] Differential scanning calorimetry for determining the thermodynamic properties of selected honey, J. Tomaszewska-Gras, S. Bakier, K. Goderska and K. Mansfeld, Journal of Apicultural Science, June 2015



2 DSC curves of partly crystallized (old product) and completely amorphous (new product) honey; measurements performed in crucibles with closed lid.

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