

Chocolate hysteresis

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1. Purpose

In chocolate we can observe the phenomenon of thermal hysteresis what means that once it is molten, it will not solidify again in the same temperature but it will remain in a state of liquid even if overcooled to much lower temperature than the first melting temperature. In my experiments I was trying to determine what factors and conditions the hysteresis depends on and what is the inner structure of chocolate.

2. Experiments

2.1 Practical part

The experiments were carried using differential scanning calorimeter (DSC). (Nearly) All the experiments were carried in same conditions in cycle in which the chocolate sample was melted, solidified and melted another time. Results are presented on plots generated by DSC. The peaks on these plots represent in this case phase transitions.

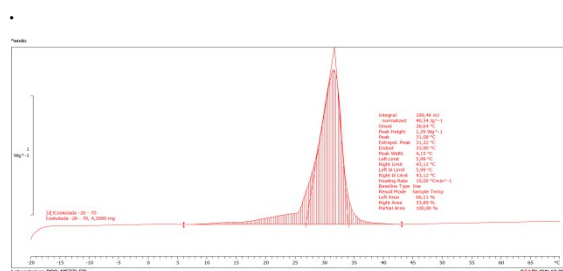


Fig. 1 Melting

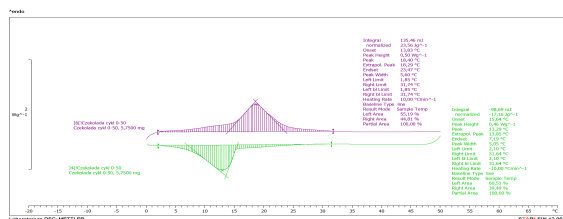


Fig. 2 Solidification and second melting

Beside confirming hysteresis occurrence in chocolate, in my experiments I also proved that none of chocolate ingredients degrade during the experiment and that the main ingredient responsible for hysteresis is cocoa butter. I also tempered the chocolate and checked if hysteresis depends on heating/cooling speed.

2.2 Theoretical explanation

On the base of my experiments and other resources. I managed to draw some conclusions about chocolate's structure. One of the most import is that inner structure of leaving factory chocolate is metastable. In melting process chocolate's structure is destroyed and when it solidifies it endeavours to reach fully stable structure. As the ingredient responsible for hysteresis is cocoa butter, the way in which its molecules are arranged mainly decides about type of chocolate's inner structure and also on its physical properties. Cocoa butter contains triglycerides which can take different configurations. In case of chocolate they take so called tuning fork configuration. Stability of inner structure and some of chocolate properties will vary depending on the way cocoa butter's molecules are packed, and even on their gradient.

3. Conclusion

Hysteresis occurs in chocolate and in cocoa butter. There also is change is lipid molecules arrangement and in physical properties of sample. Cooling and heating rate have significant influence on the process. Also ingredients of chocolate have great influence on the phenomenon but because of their great diversity it is hard to state which ingredient in what way affects hysteresis.

Resources

- H. Szydłowski „Pracownia Fizyki”
- http://www.courses.psu.edu/fd_sc/fd_sc400_jnc3/lipids/Tempering.ppt
- http://luluschocolate.com/raw_chocolate_physics.html