Wax and fatty compounds: various applications about crystallization

Introduction

Waxes are group of solids at room temperature, which are composed of different types of compounds, such as fatty esters (beewax), fatty alcohols and triglycerides, long chain hydrocarbons (paraffin wax). They are lipids and share some characteristics with them: they are not soluble in water, but well soluble in organic solvents. Moreover, crystallization of waxes is similar to fat crystallization as observed in chocolate or butter.
Waxes are used in cosmetics, food and pharmaceutical industry to texturize and thicken creams, to form water-resistant films and to form so-called oleogels. However, in some application, the presence of waxes can be a disadvantage, such as the crystallization of paraffin waxes in mineral oil as it can plug the filters in engines (low temperature diesel).
This document gives a rapid overview of different applications related to waxes.

A) Food application

Genarally speaking, natural waxes are used for film formation (glazing on chocolated peanuts or chewing gums). Waxes can also be used for gelation of olive oil or other vegetable oils to give edible oleogels. Carnauba, sunflower or candelilla wax may be used in substitutes of margarines and give new & healthier alternatives for butter. The melting point of these products depends on the wax concentration. Especially candelilla wax shows an excellent oil retention capacity.
Palm oil is also used in various food applications. Palm oil quality can differ significantly due to different triglyceride compositions (particularly tristearine and trioleine, this last one increasing the fusion temperature), which have an impact on crystallization points of the palm oil.

The figure below shows a heating and cooling cycle of two different palm oils. Palm oil I (red) crystallizes at 30°C, whereas Palm oil II (dark blue) crystallizes at 27.3°C. During heating, the Palm oil II (clear blue) melts at 48°C and Palm oil I (orange) at 51.5°C. This behavior seems to indicate that Palm oil I contains more trioleine than Palm oil II.

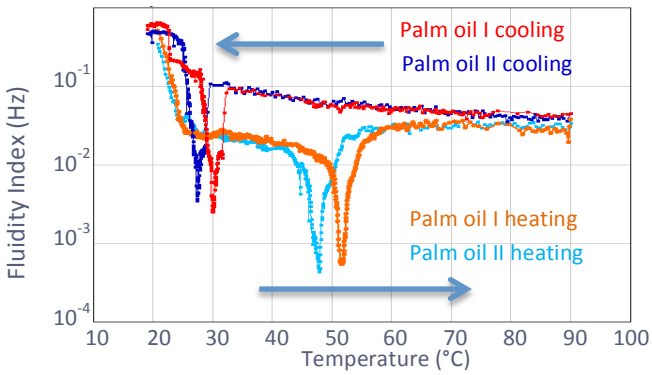

Figure 1. Schematical signatures of MSD curves.

Fat crystallization is similar to wax crystallization. It is also important for butter and butter-like products. Butter is a water-in-oil emulsions stabilized by milk proteins. According to the triglyceride composition, different butters melt at different temperatures.

In the example below, a standard butter shows a peak at higher temperatures (22°C), which is consistent with a hard aspect of the butter at room temperature, whereas an easy spreadable butter shows an important melting peak at 19°C and a smaller one at 22°C, indicating a lower mass fraction of high melting triglycerides. At room temperature, this butter can then be spread easily.

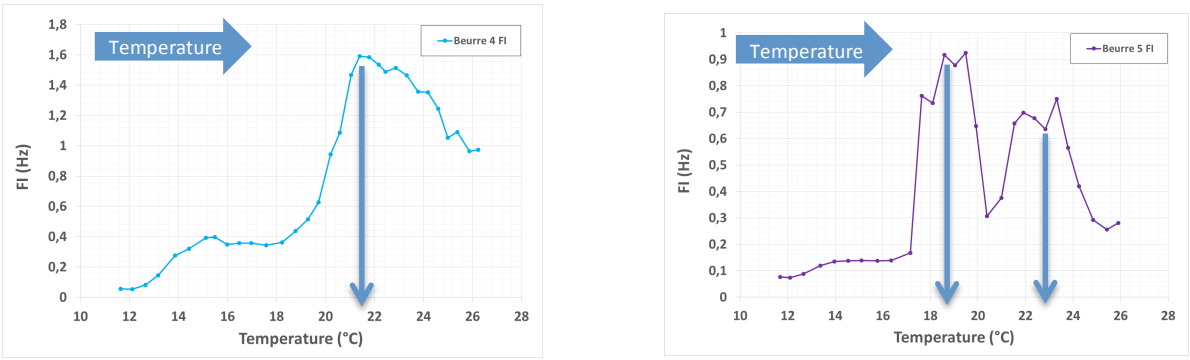

Figure 2. Heating ramp of two butters. Top: Conventional butter with high saturated fatty acid content; Bottom: Easy spreading butter with increased unsaturated fatty acid content.

B) Cosmetics application

Lipsticks and glosses often contain waxes to solidify the formulation. The study with Rheolaser can offer several advantages as the measurements are performed in hermetically closed glass cells and therefore preventing evaporation.
The example below shows **lipsticks** with the same base, but different color pigments and nacres. The crystallization point is the same for all samples.

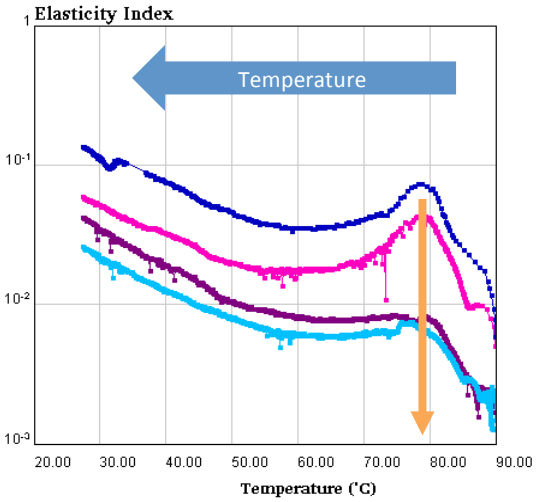

Figure 3. Elasticity Index of Lip stick formulations with the same base, but different colors & pigments, during cooling.

Glosses can also contain waxes. The example below (Figure 4) shows two glosses, with and without wax as thickener. When wax is used, typical peaks are observed in the Fluidity Index during heating from room temperature to 90°C (melting of the crystals).
In Gloss I, actually, two waxes are used with characteristic peaks at 48°C and 65°C. Gloss II with different polymeric thickeners only shows a continuous increase of Fluidity Index without characteristic peaks.

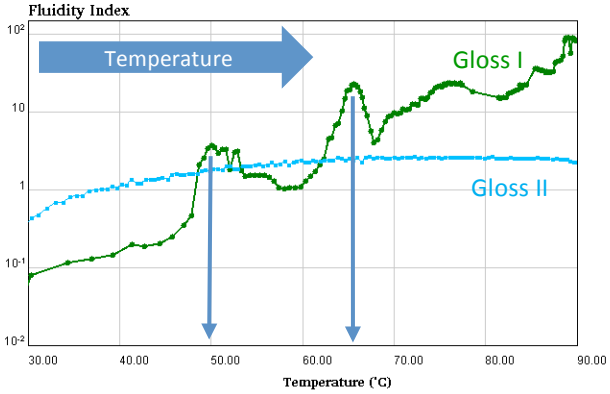

Figure 4: Heating ramp of glosses with wax (Gloss I) and without wax (Gloss II).

C) Petroleum applications

Paraffin waxes (long chain hydrocarbons) are common compounds in crude oil, especially in heavy crude oil (HCO). The higher is their concentration, the lower is the solidification point, which can induce problems for the transportation of HCO through pipelines in cold regions.

The example below shows a model product using mineral oil and paraffin wax (long chain alkanes) to study wax crystallization in crude oil. 2.5 to 25% of paraffin waxes were dissolved at 60°C in mineral oil.
When cooling down the samples, the paraffin wax crystallizes and forms an oleogel. The crystallization temperature increases with increasing paraffin concentration.

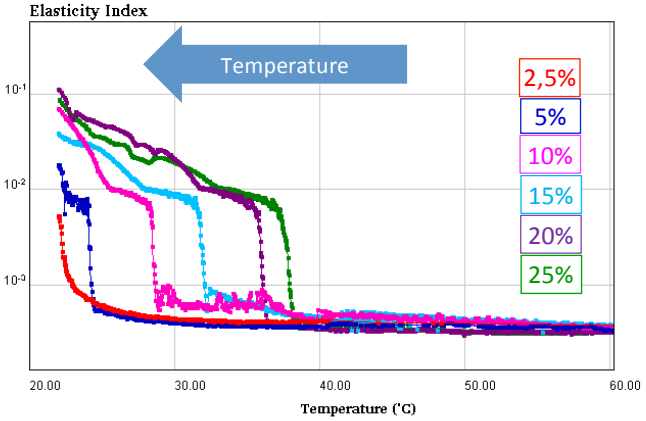

Figure 5. Cooling ramp of a mineral oil with different concentrations of paraffin wax.

The following table lists the crystallization points (EI passes over 10^{-3} nm^{-2}).

WAX CONTENT (WT. %)	CRISTALLIZATION POINT (EI = 10^{-3} NM^{-2})
2.5%	**23.0 °C**
5%	**24.3 °C**
10%	**28.7 °C**
15%	**32.1 °C**
20%	**36.1 °C**
25%	**37.9 °C**

Possible applications

FOOD (margarines, butter, chocolate, oleogels, …)
COSMETICS (lipsticks, glosses, deodorant, foundation, …)
OIL & PETROLEUM (diesel, heavy crude oils, engine oils, …)

Benefits

FAST - 6 measurement positions & automatic data treatment
ACCURATE - nano-scale measurement
EASY - Disposable measurement cells, closed environment, 1-click computation