Rheological characterization of two petroleum waxes

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ABSTRACT

Two petroleum waxes were characterized rheologically in a strain-controlled mode during oscillation. Three different strains were used to investigate the structure formation in the materials during cooling. The two waxes showed very different behaviour during solidification which indicates different mechanisms for crystallization.

INTRODUCTION

Materials made of hydrophobic waxes can be used to retard water vapour permeation. These materials can be used either as coatings on moisture sensitive mediums, but they can also be used as carriers of moisture sensitive substances that are intended to be released in a controlled way from the coating to another medium. In such applications the water vapour barrier properties as well as the mechanical properties of the material are important parameters.

The microstructure of the material is of great significance for the barrier properties of the coating. The rheological properties and the microstructure of the material are of course closely related. To be able to improve and finally also control the water vapour permeability properties of a material, a deeper understanding must be gained on the mechanisms of water vapour transport through a film and also what properties of the material that affects the barrier properties the most.

The aim of this study was to evaluate the rheological properties of two petroleum waxes intended for use as water vapour barriers. The two waxes have comparable composition, but different oil content and permeability properties.

MATERIALS AND METHODS

Two petroleum waxes were evaluated in this study. The first wax was a white vaseline with a high content of mineral oil (ACO Vaselin, ACO Hud AB, Sweden) and the other wax was a microcrystalline wax (Microwax 1847, Kahl&Co, Germany) with a much lower oil content than ACO Vaselin. ACO Vaselin showed a creamy consistency while Microwax 1847 was a solid wax.

Both waxes were characterized during a temperature scan in the strain-controlled mode with the Stresstech HR Rheometer (Reologica Instruments, Lund, Sweden). The experiments were performed in oscillation in a parallel plate geometry. The diameter of the plates were 30mm for ACO Vaselin and 20mm for Microwax 1847 and the gap was 1mm for both waxes in the beginning of the sweep. Three different strains, low, intermediate and high (5×10^{-4}, 1×10^{-3} and 1×10^{-2}) were used in order to evaluate the shear sensitivity of the two waxes. ACO Vaselin was cooled between 70 and -15°C and Microwax 1847 was cooled between 90 and 0°C. The cooling rate for both waxes was 2°C/min. During the Microwax 1847 experiments, an axial load of 0.01N was used, since the wax shrank during cooling. This autotension was applied when 75°C was reached.

RESULTS

During cooling of ACO Vaselin an ordinary congealing behaviour was seen for low and intermediate strain, see Fig. 1. The storage modulus G’ increased somewhat more rapidly when a low strain was applied than with an intermediate strain. However, when a high strain was applied, the storage modulus increased less than the loss modulus, thus indicating that ACO Vaselin was still in its viscous region even at low temperatures, see Fig. 1.

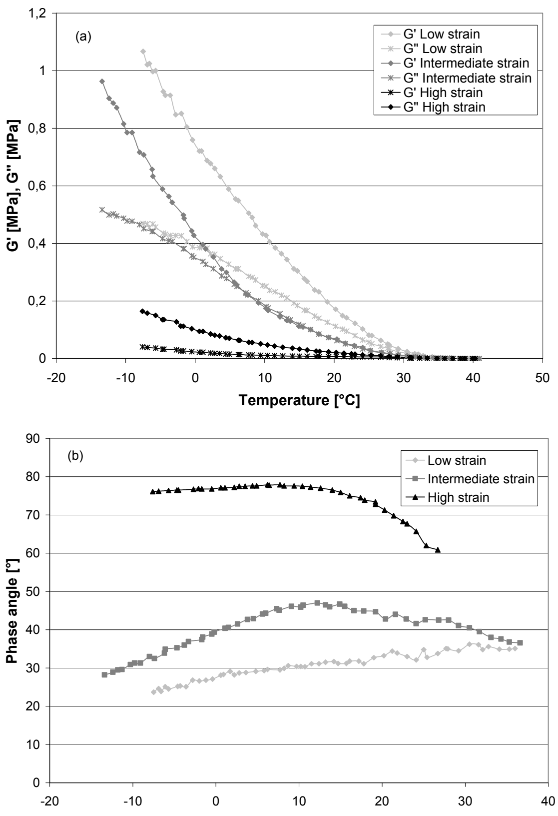

Figure 1. Rheological behaviour of ACO Vaselin, (a) shows G’, G’’ and (b) shows the phase angle. Low strain is represented by light grey, intermediate strain by dark grey and high strain by black curves.

Microwax 1847 showed a more complicated behaviour. A clear break in G’ could be seen when low or intermediate strain was applied, thus indicating that two processes took place during congealing, see Fig. 2. This behaviour indicates that the crystallization of the wax took place through two distinct steps. When a high strain was applied only one process was seen during congealing, see Fig. 2. The solidification started at a lower temperature when a high strain was applied, but proceeded more rapidly than with lower strains.

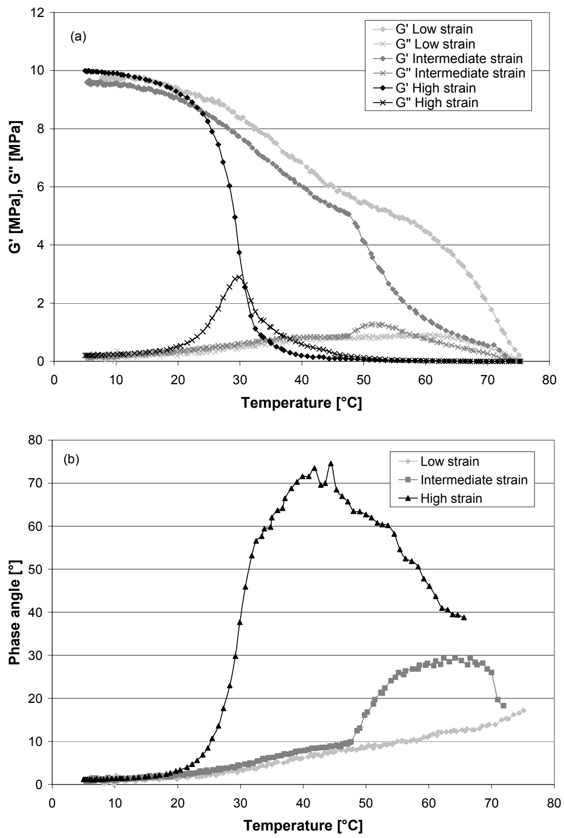

Figure 2. Rheological behaviour of Microwax 1847, (a) shows G’, G’’ and (b) shows the phase angle. Low strain is represented by light grey, intermediate strain by dark grey and high strain by black curves.

An explanation of these results is that at lower strains two structural networks or structures were formed in the wax, of which the first formed was more shear sensitive.

When a high strain was applied this weaker structural network could not be formed. This indicates that the crystallization took place through two separate steps. Further work is in progress to validate these theories.

CONCLUSIONS

ACO Vaselin showed an ordinary congealing behaviour, except for the high strain experiments where it remained in the viscous region even at low temperatures. During the low and intermediate strain experiments with Microwax 1847 it was seen that two processes were taking place, thus indicating that the crystallization took place through two distinct steps. During high strain experiments only one solidification process could be noticed, thus indicating that the first formed structure when lower strains were applied was more shear sensitive.

ACKNOWLEDGMENTS

We wish to thank the Knowledge Foundation through its graduate school YPK for financial support.