On the stability of bitumen-in-water emulsions

Thomas Czubak*, Alexander Böker

DWI an der RWTH Aachen e.V., Lehrstuhl für Makromolekulare Materialien und Oberflächen, RWTH Aachen University, Germany
(corresponding author: czubak@dwi.rwth-aachen.de)*

Bitumens of various origins are known to display different emulsification behaviour, which is related to the bitumen composition. Aim of the presented work is to identify the key parameters governing the emulsion formation and establishing a relation between emulsion stability and the ingredients of the different bitumens, namely the asphaltenes.

First the bitumens were analyzed in bulk by Differential Scanning Calorimetry (DSC), rheology (plate to plate geometry) and scanning force microscopy (SFM). Here, SFM revealed differences in the dispersion of the hard components in a honey-like matrix (Fig. 1). The dispersion respectively phase separation is induced by Asphaltenes [1]. Bitumen **1** shows a finely dispersed phase and Bitumen **2** exhibits several phases, roughly dispersed.

In the following, bitumens from various sources were emulsified in an aqueous medium (bitumen/water ratio of 60:40) with ultrasound or an Ultra-Turrax. The Bitumen was heated up to 130°C and the temperature of the aqueous phase was 65°C.

The prepared emulsions were characterized with respect to the droplet sizes and size distribution as well as the interfacial tension between the water and the bitumen phase. Here, the asphaltenes showed strong interfacial activity as described earlier by Kilpatrick et al. [2]. SEM images revealed that the emulsions are stabilized by an Interfacial layer mainly consisting of asphaltenes (Figs. 2).

TEM pictures of the interfacial layer formed during pendant drop measurements show finely dispersed particles in the case of bitumen **1** and separation of the asphaltenes for bitumen **2.** Here asphaltenes separate from the rest of the material at the interface and aggregate in an asphaltene flock (Fig. 3, white frame) like precipitated from a bad solvent like heptane [3]. The arrangement of Bitumen particles on the surface plays a crucial role for the mechanical properties of the interfacial layer as dilational rheology measurements reveal. Bitumen **1** exhibits lower elastic moduli than bitumen **2**.

In summary it can be seen that the dispersion of the different phases in bitumen strongly influences the emulsification behavior.

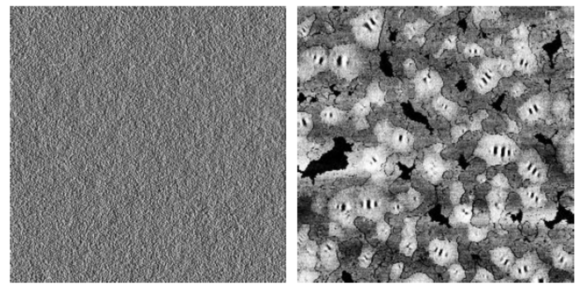

Fig. 1. Phase images with SFM-Tapping Mode (scan size 15 µm) of two different Bitumens with same penetration grade (70/100). Left picture: Bitumen **1**, z-range 2°. Right picture: Bitumen **2**, z-range 9,5°

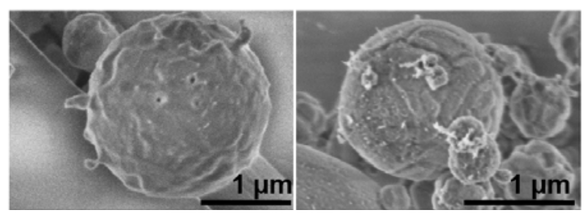

Fig. 2. Left picture emulsified bitumen droplet of **1**: Smooth surface. Right picture: emulsified bitumen droplet of **2**: rough surface.

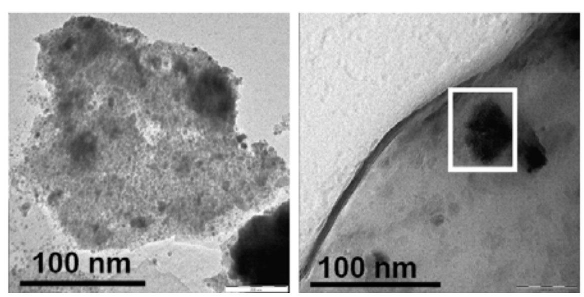

Fig. 3. TEM pictures of droplet skins of Bitumens **1** and **2**. Bitumens were diluted in Toluene at a concentration of 0.1 mg/ml. A small water droplet was brought into that solution for 2 h. The interfacial layer was measured with TEM. Pictures show the interfacial layers. Left: **1**, right **2**.

References

[1] Masson, J. F.; Leblond, V.; Margeson, J. (2006) Journal of Microscopy (Oxford, United Kingdom), 221, (1), 17-29.
[2] Yang, X., Verruto,V.J., Kilpatrick, P.K. (2007) Energy & Fuels, 21, 1343-1349
[3] Sharma, A.; Groenzin, H.; Tomita, A.; Mullins, O. C. (2002) Energy & Fuels, 16, (2), 490-496.