Meso-scale organization in physically separated vacuum residue: comparison to asphaltenes in simple solvent

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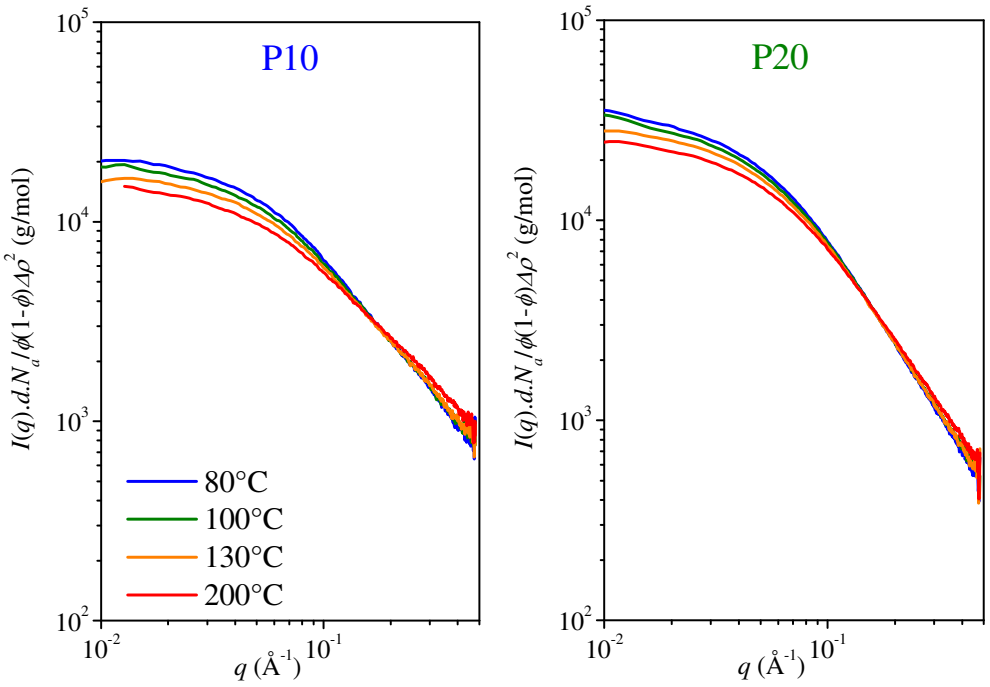
SUPPORTING INFORMATION

A. Effect of temperature on Permeates and Safaniya Vacuum residue: SAXS data



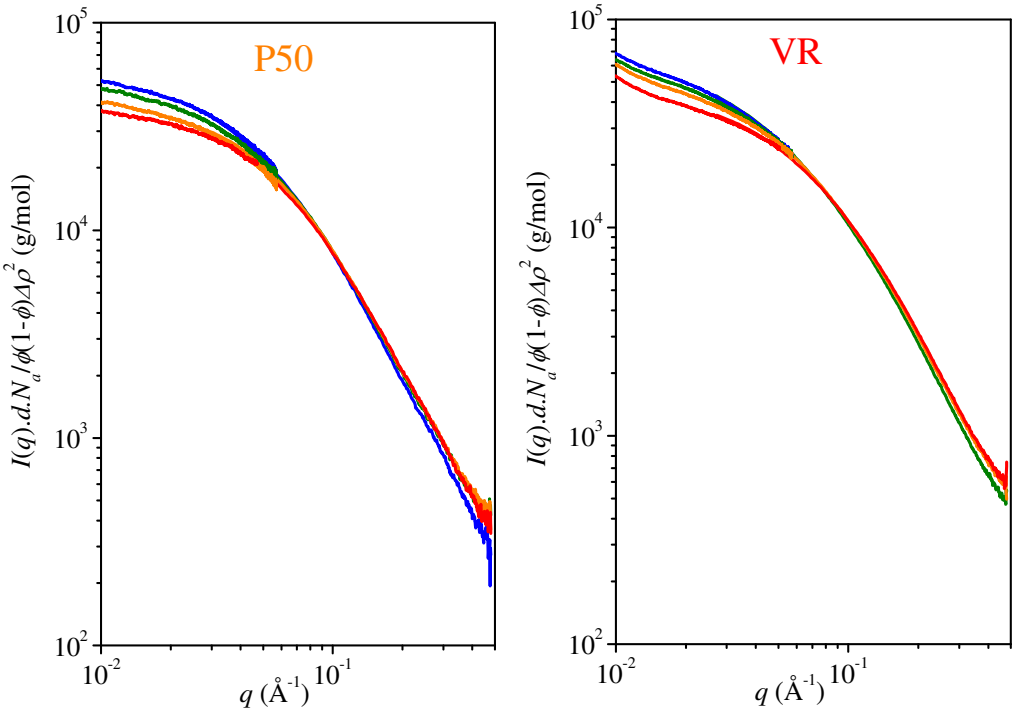


Figure A. SAXS spectra for the permeates P10, P20 and P50 and for the VR, in the 80 °C-200 °C temperature range, normalized by the contrast term and the volume fraction (eqs. 6-8 in the main document).

B. Large scale fluctuations: USAXS analysis

Along with SAXS and WAXS analyses, ultra small angle X ray scattering was performed and is shown in Figures B1 and B2. The spectra cover more than 4 orders of magnitude in q which enables relating the submicronic length scale, the colloidal length scale and finally the atomic length scale.

Crystals of paraffin. Figure B1 points out the melting of crystals of paraffin between 25 °C and 80 °C, through an extinction of the sharp peaks at high q (see inset in Figure B1), and an intensity decrease at low q. Intermediate q-range remains unchanged. However, this experiment shows that the intensity increase at low q is not solely assigned to paraffins, because high intensities are observed down to low q values and up to 300 °C. Large particles, larger than 1 µm, are present in the residue, probably at a very low mass fractions.

Presence of large particles. Figure B2 highlights the intensity increase at low q for various samples at 130 °C. The comparison of VR and P100 samples shows that the 100-nm filter membrane did not remove these large particles, or at least only a few, because about the same intensity increase is observed a low q. Intermediate q-range, not shown here, behaves the same for the two samples. On the other hand, USAXS performed on P50 shows that the 50-nm filter membrane did remove these particles because no significant scattering signal is recorded. Chemically separated maltenes, unlike P50, show a sharp intensity increase, just as VR. During the chemical separation, asphaltenes were filtered from the maltenes with a 450-nm pore size filter.

The slope at low q remains unchanged with temperature elevation up to 300 °C (not shown here). Therefore these particles are believed to be mineral particles.[1] However, the presence of low contents of these large particles does not affect the colloidal properties of vacuum residue samples.

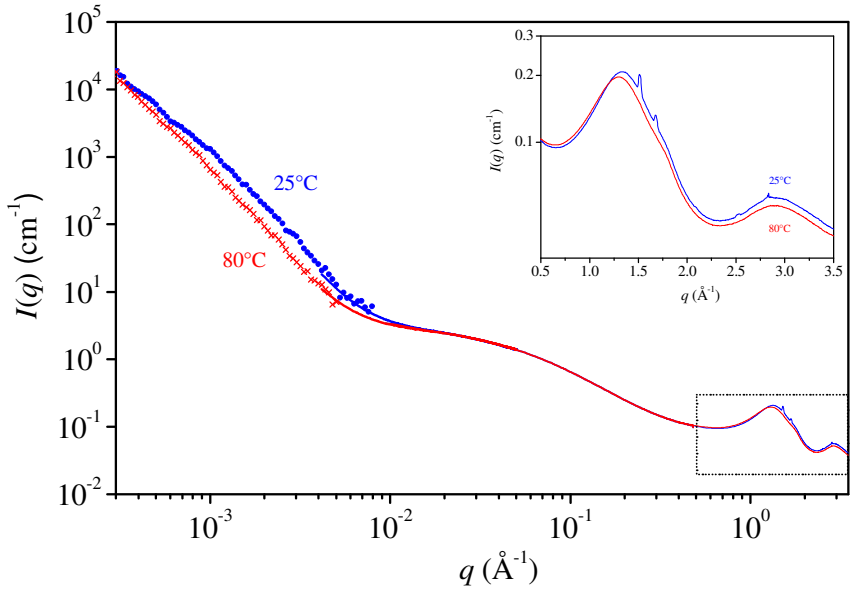


Figure B1. USAXS, SAXS and WAXS spectra of vacuum residue at 25 °C and 80 °C. Inset: zoom on the WAXS part of the spectra.

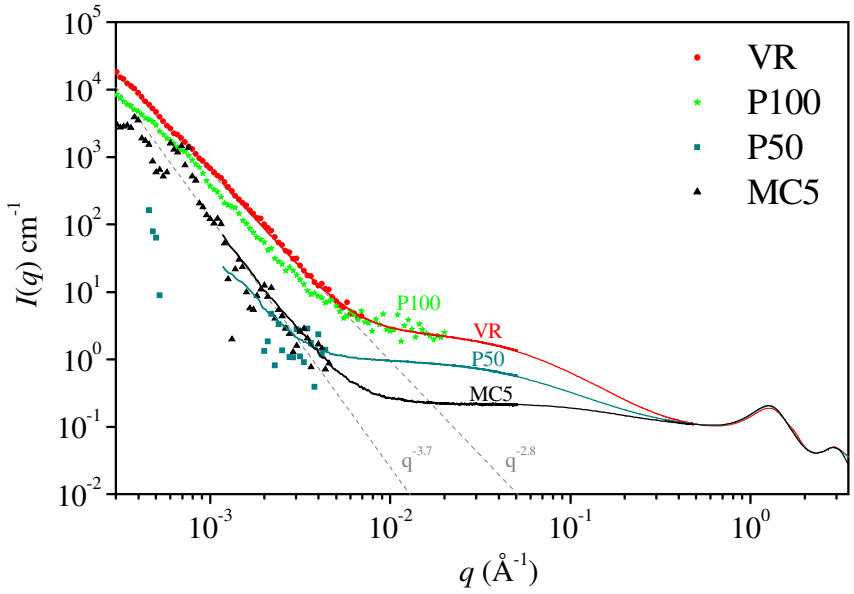


Figure B2. USAXS, SAXS and WAXS spectra of vacuum residue, P100 and P50 permeates and *n*-pentane maltenes at 130 °C.

REFERENCES

(1) Zhao, B.; Shaw, J. M. Composition and size distribution of coherent nanostructures in Athabasca bitumen and Maya crude oil *Energy Fuels* **2007,** *21*, 2795-2804.