Untangling the Details of North Sea Crude Oil

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Reservoir Fluid Characterization

A detailed knowledge of the molecular composition of crude oil and reservoir fluids is fundamental to understanding its formation, physical properties and macroscopic behavior. Our objective is to study compositional changes that occur during recovery processes, and gain a better understanding of the underlying mechanisms on a molecular level. Additionally, parameters that correlate to maturity, biodegradation and oil genetics are employed to understand migration patterns. The results will provide input for computational models that link laboratory-scale enhanced oil recovery (EOR) experiments to theory, and ultimately field applications.

Sample Set

Geochemical parameters were determined for a sample set consisting of 5 oils and 2 condensates from different fields and wells in the Danish North Sea. The condensates are visually distinguishable based on colour, and are lighter than the crude which also is evident in the data.

Group-type Analysis

The crude oil samples show typical distributions of saturates and aromatics, with OilS4 having slightly higher content of polar components than the others. The two condensates show a high concentration of light hydrocarbons and monoaromatics, however furfural distribution was not determined due to lack of method specificity for this type of samples. The oils have low asphaltene content, and due to the high uncertainty associated with asphaltene precipitation at these levels, values are reported as <0.5% without further specificity. The percentage of n-alkanes is back-calculated.

Maturity and Biodegradation

Semi-quantitative parameters used for maturity, biodegradation and oil source correlation are based upon peak area ratios and should be used with care. Issues such as co-elution, and integration parameters affect the data and interpretation the values must be used in relation with others and as indications, not absolute truths. Compounds were identified by a combination of deconvolution of mid-resolution mass spectra and comparison of retention using a reference sample (NIST NGS-1) of known composition.

C-19 bisphenanthrene (m/z 312) is the diagnostic marker for the biodegradation process in the sample set. OilS4 shows the highest levels of degradation and OilS2 the least. The biodegradation process is also evident in the relative increase in the ratio of 4-hydroxy and 4-hydroxy bisphenanthrene in OilS4.

Experimental Details

Solid Phase Extraction

Crude oil and condensates were transferred into acetone and saturated hydrocarbons using Parametric Thermo solid-phase extraction columns. The SPE columns were conditioned with MeOH and n-hexane. Afterwards aliquots of crude or condensate were combined with internal standards and loaded onto the column. Samples were dried with a vacuum following drying of analytes using DIH2O. Extracted samples were eluted once per quartet of compounds, avoiding evaporation to decrease in losses in toluene. Each sample was processed and analyzed in two runs under.

GC/MS

Mass spectrometry analysis was carried out using an Agilent 6890 gas chromatograph coupled to an Agilent 5973 Mass Selective Detector. Compounds were separated on a 30 m x 0.25 mm x 0.25 μm film, HP-5 column. The oven temperature was programmed as follows: 1 min at 60 °C and 5 °C/min to 280 °C. MeOH was introduced at the start of the run. Retention times were determined using a mixture of saturates and polar compounds isolated from the crude oil.

GC/MS analysis was carried out on a 3800DX (Agilent) gas chromatograph and using a Thermo Scientific Trace (Qtrap) and a NIST mass scale. Separation and integration were carried out using a 15 metres column at 1°C per minute. Components were identified by matching to NIST mass spectra.