Untangling the Details of North Sea Crude Oil

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Publication date: 2018

Document Version
Publisher's PDF, also known as Version of record

Link back to DTU Orbit

Citation (APA):
Reservoir Fluid Characterization
A detailed knowledge of the molecular composition of crude oil and reservoir fluids is fundamental to understand 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 links 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 crudes which also is evident in the data.

Group-type Analysis
The crude oil samples show typical distributions of saturates and aromatics, with OIS4 having slightly higher content of polar components than the others. The two condensates show a high concentration of light hydrocarbons and monoaromatics, however full SARA-distribution was not determined due to lack of method specificity for this type of samples. The oils have low asphaltene content, and to the high uncertainty associated with asphaltene precipitation at these levels, values are reported as >0.5% without further specificity. The percentage of resin 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 affects the data and interpretation and the values must be used in relation with others and as indications, not absolute values. Compounds were identified by a combination of decomposition of high-resolution mass spectra and comparison of retention using a reference sample (NIST NSD-1) of known composition.

The alkane distribution is noticeable different between OIS1 and the other samples. Maturity parameters indicate that these oils are of similar thermal maturity, and the difference is likely due to slight biodegradation. Ratios of Pr+Ph to C17+Pr+C27+Ph reflect further evidence, as biodegradation affects linear hydrocarbons before branched. OIS2 and OIS3 are the most affected samples. For the condensates, the distribution is shifted towards lighter hydrocarbons as expected. Only very low levels of saturated biomarkers were detected in the condensates, which indicates that evaporative fractionation / gas-condensate migration in the source has taken place.

Geochemical Parameters

<table>
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<th>Parameter</th>
<th>OIS1</th>
<th>OIS2</th>
<th>OIS3</th>
<th>CondS1</th>
<th>CondS2</th>
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<tr>
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<tr>
<td>n-C20/C15</td>
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</table>

Experimental Details
Solid Phase Extraction
Crude oils and condensates were fractionated into saturates and aromatic hydrocarbons using Parametric Strata-P and solid-phase extraction columns. The API volumes were conditioned with CHCl₃, and n-hexane, although individual crude or condensates were conditioned with internal standards and tested before the column. Samples were stored with their corresponding fraction of saturates, aromatic hydrocarbons, and the remaining volume response. Each sample was processed and analyzed in two two replicates.

GC/MS
More specifically, analysis was carried out on a Varian 3900 gas chromatograph coupled to a Varian 3900-5975 MSD (MSD) mass spectrometer. Compounds were separated on a 50 m × 0.25 mm ID, 0.25 μm film thickness capillary column using a temperature program from 50 °C (1 min) to 300 °C (20 min) at 5 °C/min. Compounds were then quantified using a 4-point calibration curve prepared from reference standards measured in 50 μl vials. Concentrations of alkylated heteroaromatics were indicated using response factors of the parent unsubstituted aromatic. Chromatographic separation was optimized using a 4-point calibration curve prepared from a reference mixture containing 25. Identification of the compounds were monitored at m/z 171, 188, 205, 217, 231 and 248, with emphasis on compounds of natural occurrence and those that consist of saturated hydrocarbons and polynuclear aromatic hydrocarbons. 100 sample is no internal standard and received.

Sample, Solvent, Chemistry, Fraction & Analysis
MSD Analysis was carried out on an Agilent 6890N/GC and preparation was carried out on a Varian 3900-GC and a Supelco Pentafluorobenzyl methyl-ether. Separation of saturated and aromatic hydrocarbons were carried out on a Phenomenex Supelco-1500 using a 15 m × 0.25 mm ID, 0.5 μm film thickness capillary column using a temperature program from 50 °C (1 min) to 300 °C (20 min) at 5 °C/min. Compounds were then quantified using a 4-point calibration curve prepared from reference standards measured in 50 μl vials. Concentrations of alkylated heteroaromatics were indicated using response factors of the parent unsubstituted aromatic. Chromatographic separation was optimized using a 4-point calibration curve prepared from a reference mixture containing 25. Identification of the compounds were monitored at m/z 177, 188, 205, 217, 231 and 248, with emphasis on compounds of natural occurrence and those that consist of saturated hydrocarbons and polynuclear aromatic hydrocarbons. 100 sample is no internal standard and received.

Quality Control
Two runs of internal standard (DB-5MS 1 and DB-1 1.5m × 0.1mm × 3.0 μm) were used as internal quality control during extraction and analysis.

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