Compositional Description of Brazilian Type-I Kerogen Using Hydrous Pyrolysis Products

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Introduction

Oil and gas formation and accumulation result from the evolution of petroleum systems during geological time. Basin modelling use kinetics of description of primary and secondary cracking reactions, obtained by artificial maturation of source rock samples, to reproduce, besides the migration paths and accumulations, the compositional aspects of oil trapped.

The possibility of modeling petroleum composition during generation, as well as, the PVT behavior of the fluids during migration has only become available recently in modern basin modelling software packages.

It is noticeable the great similarity between the hydrous pyrolysis products and the natural petroleum fluids, even into the physical and chemical properties.

The aim of this work is to get new insights into petroleum composition phases and PVT parameters, such as gas-to-oil ratio (GOR) and API gravities, along an artificial maturation trend of a type I source rock submitted to hydrous pyrolysis experiments.

Sampling and Methods

Hydrous pyrolysis (HP) was applied to assess the products of petroleum generation in samples from the Tremembé Formation, outcropping in São Paulo State (Brazil), in Taubaté Basin. The Oligocene lacustrine sediments were deposited in a tertiary onshore rift in southeastern Brazil and can be considered a representative of a Type-I kerogen (TOC=10.1 weight %; S2=74 mg/g rock; HI=730 mg/g TOC and Ro= 0.32%).

Each maturation experiments consisted in 275g of crushed source-rock chips ranging in size from 0.5 to 2 cm, heated isothermally in 1 L reaction vessels at temperatures between 280 and 360°C for 36 to 144 hr in the presence of liquid water, based on the methodology presented by Lewan (1997).

Total organic carbon (TOC) contents in source-rock aliquots, before and after the HP experiments, were determined by combustion in a Leco carbon analyzer and the organic parameters were obtained by Rock-Eval pyrolysis.

Generated gases and oils were collected and quantified. Molecular compositions of the gases were obtained by gas chromatography (GC) with a Flame Ionization Detector (FID) for hydrocarbons, and a Thermal Conductivity Detector (TCD) for non-hydrocarbons (O2, N2, CO, CO2, H2S, NO, etc.). Quantitative GC analyses were carried out on the expelled oil samples. API gravities were measured only in some samples because low-maturity experimental conditions did not yield enough oil for further analyses.

Results and Discussion

Cumulative generation curves are presented in Figure 1. The fluid description consists of individual compounds as C1, C2 and C3, and composite classes of compounds grouped by carbon number: C4, C5, C6-C15, C16-C25, C26-C35, C36-C45, C46-C55 and C56.

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The mass-balance of products indicates recovery factor over 90%. Non-hydrocarbon gases such as N2, H2S and CO2 are part of the compositional description of the gases, although they were not taken into account in GOR calculations.

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increase in GOR (up to 80 m³/m³) was observed only at TR > 60%, when gas production appears to overcome oil generation (Figure 2b).

Conclusions
A compositional model for hydrocarbon generation and maturation of a type-I kerogen was developed based on cumulative data from hydrous pyrolysis experiments.

Gas and liquid phases increase systematically with transformation ratio (TR), and do not present evidence of oil to gas cracking up to a TR of 90%.

API gravity values are almost constant (around 30°) with TR, a feature that replicates the distribution of API gravities of natural non-biodegraded petroleums derived from type-I kerogens, in Campos and Santos basins.

GOR presents the highest values at low TR's because of the contribution of early gas, then decreases during the main oil-generating phase, and increases again at TR > 60%.

The compositional description presented in this work gives reliable knowledge about the modification of the petroleum classes as a function of increasing thermal stress. These data will be used to develop a compositional kinetic model to be applied in basin modeling software to predict natural petroleum composition and phase behavior.

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References