

**EVALUATING H₂S GENERATED BY A STEAM TREATED OIL SAND:
AN EXPERIMENTAL INVESTIGATION LEADING TO A KINETIC MODEL
BASED ON SULPHUR EVOLUTION**

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Oil sands are loose sand reservoirs impregnated by heavy oils or bitumen. Due to the high viscosity and the high density of these fluids, oil sands are often produced by steam assisted recovery methods. Steam is injected at a temperature in the range from 180°C to 300°C; the time of steam-crude contact in the reservoir can reach months or years. In these conditions, physicochemical interactions between crude, steam and mineral matrix lead significantly to chemical modifications of the crude and to gas generation. As bitumen and heavy oils are generally sulphur-rich, there is a risk that H₂S is formed within the reservoir during the production time, as a result of the aquathermolysis of organo-sulphur compounds. In order to evaluate this risk, steam treatment of an oil sand was carried out in laboratory conditions and a kinetic model for H₂S generation was derived from the experimental data thus gathered. This paper reports the experimental conditions, the results and the kinetic model obtained with an oil sand core sample coming from the Fisher Field in Athabasca-Canada.

Steam treatment was undertaken at laboratory-scale, despite no fluid displacement was taken into account, by means of static closed hydrous pyrolysis experiments. Experiments were conducted in batch reactors, in an inert atmosphere under 10MPa of pressure, at five temperatures from 240°C to 320°C and at two residence times: 24 hours and 203 hours. For each condition, the most relevant pyrolysis products were recovered and quantified in order to set up a mass balance: the gas phase, the C₁₄⁺ SARA fractions and the insoluble residue in nC₅ and CH₂Cl₂ (organic + mineral). In a first approximation, the light organic fraction C₆-C₁₄ was not recovered, since it was not present in the native bitumen and was estimated to represent less than 3wt% after laboratory-treatment. Finally, H₂S and the sulphur content of each fraction were quantified in order to set up the sulphur mass balance.

Results showed that the laboratory steam treatment induced a lightening of the bitumen: resins and asphaltenes decreased with time and temperature, giving rise to saturates, aromatics, an organic insoluble residue and gas. Sulphur contents in different fractions revealed that resins and asphaltenes were depleted in sulphur, while aromatics, residue and gas were enriched in sulphur. The sulphur mass balance showed that, while this element was

initially mainly concentrated in resins and in asphaltenes, part of this "resinic" and "asphaltenic" sulphur was progressively resettled into the insoluble residue, the aromatics and H₂S, as the temperature increased (Cf. Figure 1). This suggested that organo-sulphur compounds (OSC) in resins and in asphaltenes were converted into lighter aromatic sulphur compounds, into heavier insoluble OSC and into H₂S. The OSC that were transformed might correspond to mercaptans, sulphides and di-sulphides, as these latter compounds are the most labile OSC under such aquathermal stress conditions.

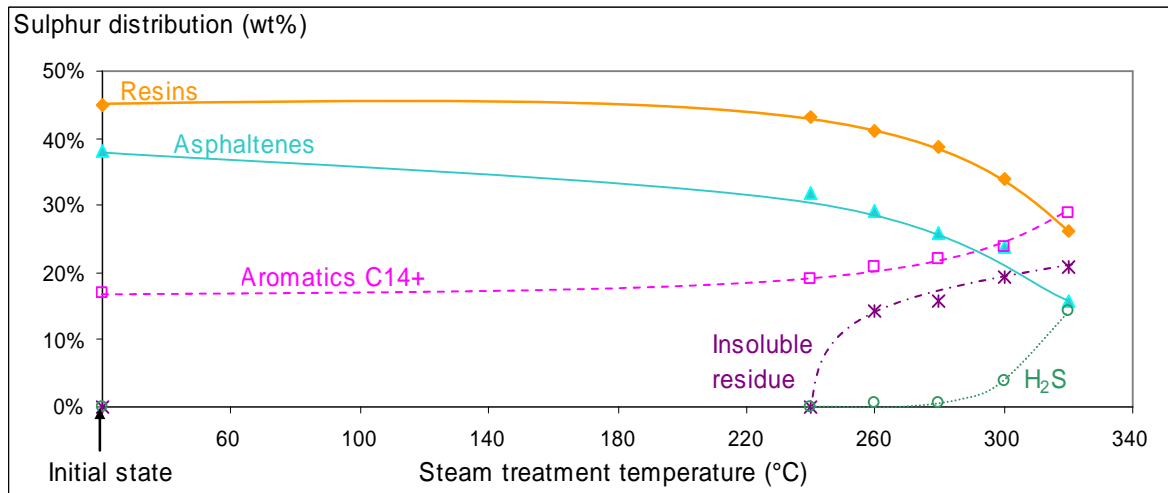
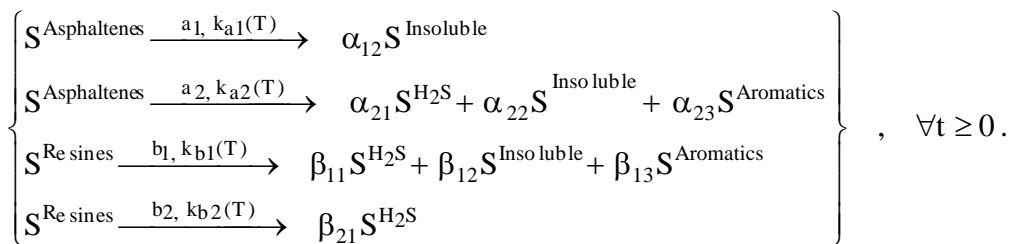


Figure 1. Sulphur distribution over asphaltenes, resins, aromatics C₁₄⁺, insoluble residue and generated H₂S, as a function of steam treatment temperature, after 203h under 10MPa, on an oil sand core sample for the Fisher Field, Athabasca.

Experimental data were used to derive a first-order kinetic model. Four parallel reactions describe the conversion of sulphur contained in the asphaltenes and the resins into sulphur contained in aromatics, insoluble residue and gas:



Consistently, an equation describing the H₂S yield as a function of time, temperature and sulphur distribution in oil sand was calibrated. This equation can be used at temperatures and contact times prevailing during steam assisted recovery processes, in order to evaluate H₂S generation in the reservoir.