

## Oxidative cracking of oil sand bitumen with iron oxide catalyst in a steam atmosphere

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Production of light oil from oil sand bitumen is strongly demanded. There are several methods such as thermal cracking, catalytic cracking, and hydrocracking, for upgrading of bitumen. Coke formation was reduced in a hydrogen atmosphere, although hydrogen is expensive. Accordingly, upgrading of bitumen with steam as a hydrogen source might be a promising method. In the previous paper, we reported that petroleum residual oil was effectively decomposed with zirconia-alumina-iron oxide catalyst in a steam atmosphere [1]. The heavy oil fraction of bitumen reacted with the active oxygen species, which are generated from steam, on the iron oxide catalyst. Zirconia promoted the generation of these species. The addition of alumina reduced the phase change of iron oxide and enhances the durability of the catalyst. The objective of this study was production of light oil from oil sand bitumen. We examined reaction conditions of catalytic cracking of bitumen with zirconia-alumina-iron oxide catalyst in a steam atmosphere.

The zirconia-alumina-iron oxide catalyst was prepared by a coprecipitation method using aqueous iron (III) chloride, aluminium sulphate and zirconium oxychloride. Athabasca oil sand bitumen was diluted with 1-methylnaphthalene to reduce the viscosity of bitumen. The 10 wt% solution of bitumen thus obtained was used as feedstock. Catalytic cracking of bitumen with steam was carried out using a fixed-bed reactor at 450–500 °C under atmospheric pressure. Time factor  $W/F$  was 0.4 to 4.7 h, where  $W$  is weight of the catalyst and  $F$  is flow rate of feedstock. The liquid samples were analyzed by gas chromatographic distillation and the boiling range distribution was determined. The gas samples were analyzed by gas chromatographs. The spent catalyst was calcined at 700 °C using a thermogravimeter and the weight of coke was measured.

Figure 1 shows the relationship between the conversion of heavy oil and time factor. The conversion was defined as the amount of heavy oil fraction (boiling point > 350 °C) converted to light oil (boiling point < 350 °C) and gas ( $\text{CO}_2 + \text{C}_1\text{--C}_4$  hydrocarbons). The conversion increased with an increase in time factor and reached the constant value. The heavy oil fraction effectively reacts with active oxygen species generated from steam on the catalyst and coke was not formed at higher time factor. When the sufficient amounts of active oxygen

species were not generated at lower time factor, some coke was formed.

Figure 2 shows the yield of light oil, carbon dioxide, and gaseous hydrocarbons ( $\text{C}_1\text{--C}_4$ ). Light oil yield monotonically increased with an increase in conversion and the largest amounts of light oil was about 50 mol%-C. The carbon dioxide yield sharply increased. On the other hand, the yield of gaseous hydrocarbons hardly increased. When the large amounts of active oxygen species were generated from steam at higher time factor, these species react with heavy oil, producing light oil and carbon dioxide.

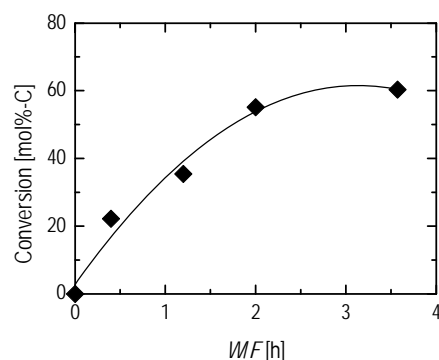


Fig. 1. Relationship between the conversion of heavy oil and time factor. Catalytic cracking of bitumen was carried out at 500 °C in a steam atmosphere.

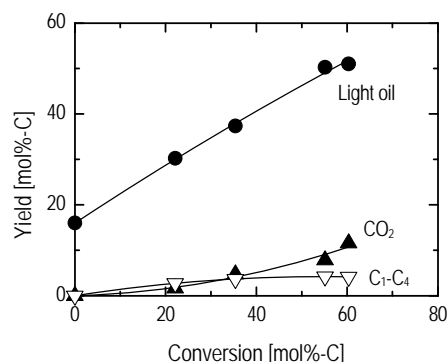


Fig. 2. The product yield of light oil, carbon dioxide, and gaseous hydrocarbons after the reaction of bitumen with the catalyst at 500 °C in a steam atmosphere.

### References

- [1] Fumoto, E. et al. (2009) Energy Fuels 23, 1338-1341.