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# Reaction behavior of oil sand in fluidized-bed pyrolysis

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**Abstract:** The reaction behavior of oil sand from Inner Mongolia (China) were studied in a fluidized-bed pyrolysis process, and a comparative study was conducted on the properties of the liquid products obtained through fluidized-bed pyrolysis of oil sand and the native bitumen obtained by solvent extraction. The results indicated that the fluidized-bed pyrolysis, a feasible carbon rejection process, can be used to upgrade oil sand. The reaction temperature and time were found to be the key operating parameters affecting the product distribution and yields in fluidized-bed pyrolysis of oil sand. The optimal temperature was 490 $^{o}$C and the most suitable reaction time was 5 min. Under these operation conditions, the maximum yield of liquid product was 80wt%. In addition, the pyrolysis kinetics of oil sand at different heating rates of 5, 10, 20 and 30 $^{o}$C/min was investigated using a thermogravimetric analyzer (TGA).

**Key word:** Oil sand, bitumen, fluidized-bed pyrolysis, fluidized bed, thermogravimetric analyzer, Kinetics

## 1 Introduction

The depletion of conventional oil reserves and the increasing price of crude oil are leading to the use of unconventional oil resources. Oil sands, an alternative fossil fuel (Söderbergh et al, 2007), will play an important role in the future. The worldwide recoverable oil sands are approximately $6.5\times10^{11}$ bbl (Zhai, 2008), about 32% of the total recoverable oil and gas resources. In China, there are plenty of undeveloped oil sands located in Inner Mongolia, Xinjiang, Qinghai and Sichuan (Niu and Hu, 1999). The shallowly buried oil sands located in the Songliao Basin of Inner Mongolia (China) are of great value for development and utilization because of their large volume as well as high bitumen contents (Jia, 2007).

Oil sand is mainly used for extracting bitumen. The bitumen from oil sand can be recovered through open-pit mining and in-situ thermal processes (Bhargava et al, 2005; Yan et al, 2009). The open-pit mining process includes the mining of oil sand and the subsequent surface processing to recover bitumen from the sand matrix. The hot water separation method was most widely used for separating and recovering bitumen (Speight, 2006; Subramanian and Hanson, 1998). However, the biggest disadvantage of the hot water separation method is that it was limited by the types of oil sands: high bitumen recovery yields can only be achieved for water-wet oil sands (Meng, 2007). Solvent extraction can increase the bitumen recovery of the oil-wet oil sands, but it requires a large amount of organic solvent, resulting in high treatment costs and potential environmental pollution. To overcome this problem, a more feasible alternative way is to process oil sands by a direct pyrolysis process to obtain bitumen-derived liquid products.

A lot of research has been conducted on the pyrolysis of oil sands. Most studies have been focused on obtaining liquid products in fixed beds (Meng, 2007; Meng et al, 2007), rotary kilns (Berg, 1959; Kraemer and Meresz, 1978; Taciuk, 1977; Hanson et al, 1995; 1992a; Cha et al, 1991) or fluidized-bed reactors (Cha et al, 1991; Hanson et al, 1992b; Fletcher et al, 1995; Gishler and Peterson, 1956; Nathan et al, 1969; Nathan and Grubb, 1969). Thermogravimetry is employed to investigate the effects of heating rate on pyrolysis and reaction kinetics to optimize the pyrolysis process (Li et al, 1995; Khraisha, 1999; Sonibare et al, 2003; Ma and Li, 2010). Lu et al (2008) has patented a process and apparatus for direct fluidized-bed coking of oil sands, as shown in Fig. 1. This process may improve the bitumen recovery of oil-wet oil sands with continuously feeding and good operating flexibility. Fluidized-bed pyrolysis of oil sands has a potential of producing bitumen-derived liquid products, although research on pyrolysis of oil sand is still at a laboratory scale. Therefore, the pyrolysis of oil sand from Inner Mongolia is worthy of investigation in order to widen the feedstock resources for fluidized-bed pyrolysis.

In this work, fluidized-bed pyrolysis of Inner Mongolian oil sand was investigated under different operating conditions, such as reaction temperature,

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