Thermal Upgrading of Oil Sand Bitumen

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With the projected increase in bitumen production from Canada's oil sands and the expected shortage of diluents, thermal upgrading is a potential option to reduce the viscosity and density of Canadian bitumen to meet pipeline specifications. This work investigates changes in flow properties and characteristics of visbroken oil sand bitumen and establishes a multi-lump kinetic model to predict conversion and product distribution from bitumen visbreaking. Experiments were carried out in a soaker type visbreaker at mild cracking temperatures between 390 and 430°C. Bitumen flow rates were selected at 2 and 3 kg/h, giving a residence time of about 30 and 20 min, respectively. Under these conditions, the severity index (SI) ranged from 500 to 1900 seconds. Changes in bitumen characteristics in terms of density, viscosity, and composition were observed. Increases in naphtha and light gas oil fractions and decreases in heavy gas oil and pitch fractions were apparent at higher severities. The pitch was further separated into two fractions, $R_1$ (524–650°C) and $R_2$ (650°C+), and it was observed that, while $R_1$ is easily crackable, a significant amount of $R_2$ cannot be converted even under highest visbreaking severity. While improvements in both density and viscosity were observed as the severity increased, issues of total liquid product (TLP) stability arise at higher severities due to the presence of more paraffinic molecules coupled with the increase in aromaticity of TLPs. A 4-lump kinetic model for the mild cracking of bitumen is proposed and kinetic constants and activation energies associated with the cracking of the various lumps of bitumen are calculated.