Fouling Mechanisms of Bitumen Containing Unsataturated Hydrocarbons

1Z. Fon, 1P. Rahimi, 1T. Alem and 2A. Eisenhaver
1NCUT, CarmentENERGY, Natural Resources Canada, Devon, AE, Canada
2Nalco Canada Company, Fort McMurray, AB, Canada

Background
- Cracked naphtha as a solvent in the froth treatment process, the resulting bitumen contains olefins and di-olefins, which cause fouling in processing units:
  - Condensed deposits: locations of high temperatures;
  - Gums: areas of lower temperatures;
  - Mixture of the above deposits in preheat exchangers;
  - For hydrotreater bed, mostly polymers formed from oxygen exposure in intermediate tankage
- Fouling mechanisms are complex, and may be different at different environments.

Fouling Rates of CGO at Different Surface Temperatures
- At low temperature (~250°C), fouling rate caused by chemical reactions is very low.
- At the temperature ca. ~300°C, the polymerization of olefins and di-olefins lead to an observed high fouling rates.
- At the temperature ca. ~400°C, the bonds formed by polymerization of olefins and di-olefins could be broken faster than they are formed, and caused an observed lower fouling rate.

Concluding Remarks
- The bench scale fouling tests indicate that fouling rates of CGO followed a bimodal distribution as a function of temp. As the surface temp. increased up to 300°C, the fouling rate increased. Further increase of temp. resulted in a decline of the fouling rate, and then an increase again at temp. above 400°C. The phenomena are consistent with the industrial observations, i.e. different kinds of deposits were noticed at different temperature locations.
- At the temp. of 270°C, the bromine and diene values of CGO declined with the time, but viscosity, molecular weight, density increase with the times. These suggest that polymerization of unsaturated hydrocarbons in CGO was taking place, and led to the formation of fouling precursors.

Objectives
- Investigate the fouling mechanisms of CGO by using a bench scale hot liquid process simulator (HLPS) Alchor units, and autoclave treatment.
- Mitigate the fouling problems for the bitumen crudes containing olefins and di-olefins.

Autoclave treatment
- CGO was treated at the temperature of 270°C, under either inert atmosphere up to over 20 days.
  - Analyze olefin and diene contents (bromine and diene value, respectively), viscosity, molecular weight, density at different reaction times.

Concluding Remarks
- Based on the fouling rate observation, either minimize the residence time or the concentration of conjugated olefins in the temperature range of greatest polymerization rate could mitigate the fouling problems, but increase the operation temperature above the range of the greatest fouling rate also could mitigate the fouling problems caused by polymerization of olefins and dienes. This concept was verified in the industrial practice by Wahn (2003).
- More detailed fouling mechanisms of CGO still need further investigation, and large scale lab or commercial tests are encouraged.

Experimental Apparatus

CGO properties change with the time at 270°C

On-Going Work
- CGO treated under other temperatures (i.e., 350 and 400°C) is on going.
- A finger fouling probe is under design and to be put into autoclave to test the fouling at different surface temperatures.
- Different fouling deposits is going to collected at different surface temperature and characterized with SEM, TG&A, ATR-IR, elemental analysis, etc.
- More detailed CGO fouling mechanisms will be provided.