CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The packed-bed of large spheres flow-loop apparatus was validated to be a good system with high reproducibility to investigate asphaltene deposition from adhesion and attachment of asphaltenes onto the surface. The deposit can be inspected visually through the glass column and mass of collected material was sufficient for further characterizations. Only the unstable asphaltenes in the solution were attributed to deposit formation on surface. The deposition rate can be measured as a function of superficial velocity. It initially increases then decreases as the superficial velocity increases for both studied crude oil and diluted bitumen. The regime where deposition rate increases with superficial velocity was suggested to be controlled by the mass-transfer of asphaltenes toward the surface with the diffusion coefficient of 3×10^{-12} m^2/s. While the regime where deposition rate decreases with increasing superficial velocity was possibly controlled by the effect of shear from flow imposed to the surface.

5.2 Recommendations

From the visual inspection of the deposit, most of the deposit formed on stainless steel spheres and a little bit on glass column. The baseline experiment should be conducted with empty glass column in order to probe the ratio of deposit on glass column and deposit on stainless steel spheres. Once the ratio is obtained, the deposition rate measured before in the previous experiments can be normalized using this ratio to get the more precise asphaltene deposition rate.

The crude oil-heptane solution feeding system can be changed from batch system to co-continuous feeding system of fresh crude oil and heptane. The continuous feeding system has a better control of asphaltene size in the solution than the batch system. The size of the asphaltenes can be controlled by changing the size of mixing chamber before the inlet of the packed-bed column. Moreover, the depletion of asphaltenes in solution will be drastically minimized by the continuous feeding system.

The deposition in mass-transfer limited at low superficial velocity regime should be investigated with other crude oil for determining the universality of the deposition behaviour of asphaltenes in this regime. Moreover, to determine if the dependency of the deposition rate and superficial velocity of a power of 0.5 holds true for crude oil from different origins.

The deposition rate and mechanism in a regime where the asphaltene adhesion and attachment control the deposition rate can possibly be assessed in the intermediate superficial velocity regime. This regime can be observed by the departure of the experimental deposition rate from the deposition rate calculated by the mass transfer coefficient for packed-bed correlation proposed by Thoenes and Kramers (Thoenes et al., 1957). Once this regime is assessed, the effect of surface properties on deposition rate and mechanism can be investigated. The interesting surface properties that should be investigated are the surface materials, surface roughness, and surface morphology.

The deposition in shear limited regime at high superficial velocity regime should be investigated further in order to know exactly the mechanism of how shear imposed on the surface affects the asphaltene deposition.

In addition, the deposit asphaltenes should be characterized in order to distinguish the specific characteristic of deposit asphaltenes from the asphaltenes that do not deposit. The difference between those two types of asphaltenes (e.g., deposit asphaltenes and bulk asphaltenes) could be the different in heteroatoms, polarity, and aromaticity. The techniques that could be conducted in order to probe those characteristics are XPS, elemental analysis, and dielectric constant measurement.