CHAPTER V

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Asphaltenes precipitated at different times exhibit *minor*, if any, differences in their properties as can be seen from the characterization results. However, due to the highly polydispersed nature of asphaltenes, the aggregation behavior of the asphaltene fractions is significantly different. The fraction that precipitates earlier is more unstable than the fraction that precipitate later. From microscopy results, it can be concluded that the asphaltenes precipitated at different times have different aggregation rate in model oil system and the fraction that precipitate first is the most unstable with higher aggregation tendency. Nevertheless, the properties that influence the difference in the aggregation rate are still unknown. Further investigation on other characterization techniques need to be done to better assess the information and understand the difference in their aggregation behavior.

5.2 Recommendation

In order to better understand asphaltene precipitation kinetics, another type of crude oil can be used to extract asphaltenes. The asphaltenes can be fractioned at different times and onset experiments can be performed on the fractionated asphaltenes to investigate the universality of the aggregation behavior of different type of asphaltenes. Furthermore, the unified model for aggregation of asphaltene (Haji Akbari Balou et al., 2012) can be used to predict the collision efficiency of the time-based asphaltene fractions to investigate the collision efficiency distribution among the asphaltene fractions.

The population balance model developed by Maqbool et al., 2011 can also be used to calculate the collision efficiency of different asphaltene fractions and compare with the values obtained from the unified model. The main goal is to identify the main factor that influence the difference in the aggregation behavior of the time-based asphaltene fraction.

One of the future plans of the experiment was to fractionate another type of asphaltene (K1) using a different type of crude oil and to characterize them using Small Angle X-Ray Scattering (SAXS). However, the SAXS equipment at the University of Michigan was down for three months period. The problem was due to the burn in the detector caused by the X-ray source. The scattering data obtained were inaccurate and not representable.

Various samples were prepared. These samples include solubility-based fractionation (fractionation of asphaltenes based on their solubility when precipitant was added) of K1 asphaltenes dissolved in solvents, namely, toluene, tetrahydrofuran (THF) and 1-methyl naphthalene. The solubility based fractions were at 50 vol%, 60 vol% and 80 vol% heptanes. The reason for choosing K1 crude oil was because it has higher asphaltene content and the collision efficiency changes greatly when the concentration of precipitant was increased (Maqbool, Ph. D. Dissertation, 2011).

The goal of this experiment was to investigate the size of asphaltene nanoaggregate of a different type of asphaltene to confirm the universality of the asphaltene aggregation behavior. This would have been done as a preliminary characterization step before moving towards other characterization techniques which require larger amount of asphaltenes in the sample preparation, if there were large differences in the size of nanoaggregate for K1 asphaltene fractions.

In addition, other characterization techniques can be explored to investigate on the major contributing factor for the difference in asphaltene aggregation behavior of the time-based fraction. One possible factor that could be looked at is molecular weight measurements. However, as asphaltenes exist as nanoaggregate, it is impossible to measure the molecular weight of a single asphaltene molecule and there are very few techniques that can fully ionize the nanoaggregate. One of the techniques that could possibly be used without the ionization limitation is the High Resolution Mass Spectroscopy.