CHAPTER V
CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

A capillary technique has been used for investigating the possible mechanisms of barium sulfate deposition in the pipeline. According to Hagen-Poiseuille equation, changing in radius of a capillary leads to significantly change in pressure drop. Initially, barium sulfate experiments were conducted by using a reused capillary. However, when a capillary was reused, the deposition occurred faster and can cause erroneous results. Therefore, a new capillary was used in every experiment.

In this work, two possible mechanisms were proposed for barium sulfate deposition. First, since barium sulfate has nucleated and before growth has completed, barium sulfate can deposit in pipelines. Second, after barium sulfate has completed their growth, barium sulfate can deposit in pipelines.

Barium sulfate deposition experiments show that before barium sulfate has completed their growth, it will deposit in a stainless steel capillary at almost the same deposition rate in smooth and rough surfaces. Dissolution experiments were conducted in order to investigate the uniformity and deposit location of deposited barium sulfate. A comparison between the uniform mass which is calculated from Hagen-Poiseuille equation and deposited mass from the dissolution experiment indicate that barium sulfate deposition is non-uniform and preferentially deposit at the beginning of the capillary.

The second mechanism was investigated by flowing precipitated barium sulfate solution through a capillary. In addition, three types of inner surface capillary were used in order to investigate the effect of surface heterogeneity on the deposition of barium sulfate. Results show that after barium sulfate has completed their growth, they will not deposit either in smooth or rough surfaces. Higher salt concentration, 40 mM, was used to confirm results. However, the same deposition trend is observed. According to the morphology and particle size of barium sulfate particles, the amount of particles, particle size and particle shape may not affect to the deposition.

On the other hand, when precipitated barium sulfate solution were flowed through a pre-scaled capillary, barium sulfate particles deposited on the pre-scaled layer because pre-scaled layer acts as preferential sites for subsequent barium sulfate deposition.

5.2 Recommendations

5.2.1 Experimental System

- Due to the formation of barium sulfate is instantaneous, once barium sulfate is formed, it will deposit at any places in the system. For example, in a mixing tee and/or plastic tubing. Thus, after an experiment is finished, cleaning all the system or changing the plastic tube is required.

- Normally an experimental system has to be taken apart either to connect a capillary or clean the system. These actions lead to have an air bubbles come into the system and pass to the differential pressure transducer. Consequently, causes a changing in pressure drop. Therefore, the air bubbles have to be removed before start off the experiment.

- Pump is one of the main issues for studying the deposition of barium sulfate. HPLC pumps which were used in the experiments are very sensitive to an air bubble and may cause changes in flow rate. Thus, before running the experiments, flow rate has to be measured. If the flow rate is found to be inaccurate, pumps need to be primed in order to remove the air bubbles out from the pumps and the flow rate has to be double-checked again. In addition, flow rate has to be measured during the entire experiment.

5.2.2 Further Investigation

- In order to understand more about the deposition mechanism, a new experimental technique has to be developed.

- To further understand the effect of surface heterogeneity on the deposition, hydrochloric acid has to be flowed through a capillary in order to have more corrosion on the surface. Moreover, inner surface of the capillary before and after corrode by hydrochloric acid have to be examined.

- Additionally, other parameters which affect to the deposition needs to be investigated. For instance, residence time in a capillary, capillary inner diameter, flow rate, temperature, pressure and other material types of the capillary.

- When the deposition mechanism is well understood, deposition model has to be developed in order to predict the barium sulfate deposition. Moreover, effective prevention method can be developed, for example, creating an efficient inhibitor to prevent barium sulfate deposition at the specific state.

- Other alternative method to prevent the deposition is coating inner surface of a capillary.