

## CHAPTER V

### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

This research can be divided into two main sections. In the first section, the nature of the acid attacker on analcime particles was studied. The concept of a critical breaking time was defined to characterize the effectiveness of each condition on the dissolution of analcime.

The other section is the study of the reaction kinetics of the dissolution of analcime by citric acid. The effect of the external diffusion on the dissolution reaction was investigated by using analcime particles in different initial sizes.

The conclusions drawn from the experimental results are as follows:

- 1) The exist of the critical breaking time indicates that the reaction does not occur following the shrinking core model. This phenomenon also suggests the idea that acid may diffuse through the pores on the surface of analcime into its internal surface where dissolution reaction occurs simultaneously with the reaction on the external surface and then leads to breaking of the particles.
- 2) The critical breaking time decreases as the size of the particles decreases and the acid concentration increases.
- 3) There is no significant difference between hydrochloric and citric acid in term of the critical breaking time which may be because there is only hydrogen diffused into the internal structure of analcime instead of acid molecule.
- 4) The breaking of particles appears to be occurred through the diffusion of  $H^+$  into and attack the internal structure.
- 5) The dissolution occurred at different patterns on the surface with different composition.
- 6) The order with respect to HCl is approximately 1st order.
- 7) Si, Al and Na are leached out of analcime structure during the dissolution reaction with citric acid but at different rates.

- 8) Final concentration of Al is found to be lowest which may be due to Al precipitation.
- 9) The decrease in particle size results in the higher reaction rate due to the increase in the surface area in other word the increase in the reactive site.
- 10) Not only the external diffusion but the internal diffusion also has the influence on the contribution to the dissolution reaction.

## 5.2 Recommendations

To achieve a better understanding of the reaction kinetics, more batch experiments should be carried out at various citric acid concentration and temperature. However, smaller particle size of analcime should be used instead in order to eliminate the effect of mass transfer.

In addition, since in the actual conditions in oilfield reservoirs it is not possible to eliminate the effect from mechanical force, more experiments should be carried out to investigate this effect. The ratio of acid to analcime is the parameter that one should consider to understand the shear effect on the dissolution reaction.

The use of other acid or a mixture of two or more acid should be methodically examined especially the mixture of inorganic and organic acid to obtain innovative results.

For the study of the nature of acid attack, the experimental method should be modified into the process that can measure the size of the particles and run the reaction simultaneously in order to decrease the error resulted from filtration. Different method of size distribution analysis should also be employed to obtain more accurate results.