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Microwave induced solid-state interactions for the synthesis of Fischer-Tropsch catalysts

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CHAPTER 7

CONCLUSIONS

The major aim of this work was to investigate the microwave effect on catalytic activity and selectivity in Fischer-Tropsch synthesis.

7.1 CATALYST CHARACTERIZATION

Characterization techniques for bulk analysis such as TEM, PXRD and BET revealed that there is a significant increase in the particle size of iron catalysts due to the microwave pre-treatment for unsupported iron oxide samples. TPR, SEM showed no significant change in the reducibility and morphology after microwave pre-treatment of the iron oxide samples. When iron catalysts were supported on silica, PXRD results investigated changes taking place on the crystal structure of these materials. This was shown by the presence of silica components (quartz) after microwave pre-treatment. The crystallinity was shown to increase too after microwave heating. The BET surface area measurements revealed a dramatic decrease in surface area of the support (SiO_2) after microwave pre-treatment due to sintering. PXRD and BET results therefore investigated that the microwave pre-treatment of the supported iron catalysts resulted in changes on the catalyst surface. In addition, high surface sensitive techniques such as: temperature programmed surface reactions (TPSR) and Secondary ion mass spectroscopy (SIMS) experiments are more revealing the changes which take place on the catalyst surface of the supported iron catalysts. SIMS measurements showed that the ratio of Fe:K increases from 0.055 to 0.095 after the microwave pre-treatment. This shows that the microwave pre-treatment alters the surface of the iron FT catalysts. Temperature-programmed surface reactions investigated that the microwave pre-treatment increases the number and type of active sites present on the catalyst surface. The amount of the desorbing

components from the catalyst surface was found to increase with the microwave pre-treatment also.

Effect of the power level was studied, TPSR investigated that 270 W is the optimum power to be used in the microwave pre-treatment of the Fe/SiO_2 catalysts in order to obtain significant microwave effect.

7.2 FISCHER-TROPSCH REACTIONS

Fe/SiO_2 catalyst activity was tested in Fischer-Tropsch synthesis and the results showed 21 % CO conversion. Upon microwave pre-treatment (540 W in 8 s) the catalytic activity of Fe/SiO_2 catalyst dropped to 17 %. The decline in activity was found to be due to crystal growth due to microwave heating. On potassium promotion the catalytic activity dropped from 21% to ~ 9% due to high potassium loading. Upon microwave pre-treatment of the potassium promoted catalyst, the CO conversion improved due to promotional effect.

Positive effects on product selectivity such as: decrease in methane selectivity, enhanced carbon dioxide selectivity and improvement in the formation of olefins were observed after microwave pre-treatment. The formation of methane dropped due to the crystal growth which takes place after microwave heating. An increase in carbon dioxide selectivity was claimed to be due to high conversion level obtained after microwave pre-treatment of a potassium promoted iron catalysts. Enhancement in the formation of olefins was found to be due to the presence of potassium. The microwave pre-treatment affects the way in which iron and potassium interact.

Effect of bed size and shape was investigated and the experimental data revealed that the catalytic activity improved after the catalyst was uniformly placed on a Petri dish. Olefin selectivity was found to improve on uniform arrangement of the catalyst. This signifies effective absorption of the microwaves after the catalyst is uniformly spread.

7.3 FUTURE WORK

For future work the following aspects can be explored:

- Microwave effect on cobalt oxide samples.
- Optimize potassium on iron oxide samples and examine the microwave effect.
- Focus on temperature programmed surface reactions (TPSR) and SIMS measurements, since these seem to be the most revealing methods of microwave induced changes in the surface chemistry.
- More microwave studies to be done on unsupported iron oxide samples.