Declaration

I declare that this dissertation is my own, unaided work. It is being submitted for the Degree of Master of Science in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in any other University.

...........................................
Signature of candidate

....................... day of ......................... 2012
Abstract

Microwave-assisted pre-treatment is a fast, selective and volumetric method used to activate catalysts. The advantages of using microwave radiation emanate from its ability to transfer energy directly to the reactive species (called molecular heating), thereby promoting transformations that are not possible using conventional heating. In this work the unique microwave heating properties have been used for the modification of iron-based Fischer-Tropsch catalysts in the solid state. The effect of the potassium loading on the microwave effect is presented.

A series of unsupported and silica supported iron FT catalysts were prepared using the continuous precipitation and the incipient wetness impregnation techniques. The amount of the potassium promoter was varied from 0.2 to 1.5 wt. % in the catalysts. Microwave pre-treatment (10 seconds, 450 W) was then done prior to catalyst characterization and evaluation. The bulk properties of the catalysts were characterized using XRF, BET, TPR, XRD, TEM and EDS techniques and the surface properties were determined by temperature programmed surface reaction-mass spectrometry (TPSR-MS). The results showed that microwave pre-treatment modified the surface but not the bulk properties of the K/Fe and the K/Fe/SiO$_2$ catalysts. Catalytic properties of the catalysts were evaluated using FTS and increases in the olefin selectivity and the $\alpha$ value were found with the microwaved catalysts. Differences in the data recorded for the microwaved and the non-microwaved samples were taken to be induced by microwave pre-treatment since all other parameters were kept constant in all reactions.

TPSR profiles (methane profiles) were used to study the carbon chemisorption behaviour of the catalyst surface. Peak areas were used to determine the type and amount of carbon species deposited on the catalyst. Microwave pre-treatment was seen to increase the amount of methane produced in the TPSR experiments, indicative of an increase in the number of active sites. The increase was observed to be dependant on the potassium loading in the catalyst. It is suggested that microwave modification promotes the migration of potassium ions to the surface of the catalyst. The effects of the microwave irradiation time and the catalyst preparation method were also investigated.
To my parents Eve Dzelewe Dlamini

And

the late Morris Mehlwengane Dlamini

And the rest of my family members

I love you all
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University of the Witwatersrand

University of Swaziland

The Almighty God, with whom all things become possible
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2. M. W. Dlamini, M. S. Scurrell, N. J. Coville, “The effect of potassium on microwave modified silica-supported Fischer-Tropsch synthesis catalysts” To be submitted
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Microwave
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Mossbauer emission spectroscopy
Nitrogen
Oxidative coupling of methane
Percentage
Potassium
Powder X-ray diffraction
Quadrupole mass spectrometer
Sasol Advanced Synthol
Secondary ion mass spectrometry
Shell middle distillate synthesis
Temperature programmed reduction
Temperature programmed surface reaction- mass spectrometry
Thermal conductivity detector
Transmission electron microscopy
Ultra-high purity
Water gas shift
Watts
Weight percentage
X-Ray fluorescence

MW
MAOS
MES
N₂
OCM
%
K
PXRD
QMS
SAS
SIMS
SMDS
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TPSR-MS
TCD
TEM
UHP
WGS
W
wt. %
XRF