

LIST OF FIGURES

FIGURE	Page
3 . 1 Experimental Setup	43
4 . 1a Conversion versus temperatures of CH ₄ on Rh / γ -Al ₂ O ₃ catalyst at different space velocities .	47
4 . 1b Conversion versus space velocities of CH ₄ on Rh / γ -Al ₂ O ₃ catalyst at different temperatures .	48
4 . 2a Conversion versus temperatures of CO ₂ on Rh / γ -Al ₂ O ₃ catalyst at different space velocities .	49
4 . 2b Conversion versus space velocities of CO ₂ on Rh / γ -Al ₂ O ₃ catalyst at different temperatures .	49
4 . 3a Conversion versus temperatures of C ₂ - alkane on Rh / γ -Al ₂ O ₃ catalyst at different space velocities .	51
4 . 4a Conversion versus temperatures of C ₃ - alkanes on Rh / γ -Al ₂ O ₃ catalyst at different space velocities .	52
4 . 3b Conversion versus space velocities of C ₂ - alkane on Rh / γ -Al ₂ O ₃ catalyst at different temperatures .	53
4 . 4b Conversion versus space velocities of C ₃ - alkanes on Rh / γ -Al ₂ O ₃ catalyst at different temperatures .	53

- 4 . 5A-C** Conversion versus space velocities of butanes on Rh / γ -Al₂O₃ at catalyst temperatures A (600) , B (700) , C (800) °C . 55
- 4 . 6A-C** Conversion versus space velocities of C₅- alkanes on Rh / γ -Al₂O₃ catalyst at temperatures A (600) , B (700) , C (800) °C . 56
- 4 . 7** Conversion versus temperatures of C₆ - alkanes on Rh / γ -Al₂O₃ catalyst at different space velocities . 58
- 4 . 8** Conversion versus temperatures of C₇ – alkanes on Rh / γ -Al₂O₃ catalyst at different space velocities . 58
- 4 . 9a** H₂ / CO ratio versus temperatures on Rh / γ -Al₂O₃ catalyst at different space velocities . 61
- 4 . 9b** H₂ / CO ratio versus space velocities on Rh / γ -Al₂O₃ catalyst at different temperatures . 61
- 4 . 10a** Conversion versus temperatures of CH₄ on Ru / γ -Al₂O₃ catalyst at different space velocities . 62
- 4 . 10b** Conversion versus space velocities of CH₄ on Ru / γ -Al₂O₃ catalyst at different temperatures . 63
- 4 . 11a** CO₂ Conversion versus temperatures on Ru / γ -Al₂O₃ catalyst at different space velocities . 64
- 4 . 11b** Conversion versus space velocities of CO₂ on Ru / γ -Al₂O₃ catalyst at different temperatures . 65

- 4 . 19a** Conversion versus temperatures of CH₄ on Ir / γ -Al₂O₃ catalyst at different space velocities . **78**
- 4 . 19b** Conversion versus space velocities of CH₄ on Ir / γ -Al₂O₃ catalyst at temperatures . **79**
- 4 . 20a** Conversion versus temperatures of CO₂ on Ir / γ -Al₂O₃ catalyst at different space velocities . **80**
- 4 . 20b** Conversion versus space velocities of CO₂ on Ir / γ -Al₂O₃ catalyst at different temperatures . **81**
- 4 . 21a** Conversion versus temperatures of C₂ - alkane on Ir / γ -Al₂O₃ catalyst at different space velocities . **83**
- 4 . 22a** Conversion versus temperatures of C₃ - alkane on Ir / γ -Al₂O₃ catalyst at different space velocities . **83**
- 4 . 21b** Conversion versus space velocities of C₂ – alkane on Ir / γ -Al₂O₃ catalyst at different temperatures . **84**
- 4 . 22b** Conversion versus space velocities of C₃ – alkanes on Ir / γ -Al₂O₃ catalyst at different temperatures . **84**
- 4 . 23A-C** Conversion versus space velocities of C₄ – alkanes on Ir / Al₂O₃ catalyst at temperatures A (600) , B (700) , C (800) °C . **86**
- 4 . 24A-C** Conversion versus space velocities of C₅ – alkanes on Ir / Al₂O₃ catalyst at temperatures A (600) , B(700) , D(800) °C . **87**

4 .12a	Conversion versus temperatures of C ₂ - alkane on Ru / γ -Al ₂ O ₃ catalyst at different space velocities .	66
4 . 13a	Conversion versus temperatures of C ₃ - alkanes on Ru / γ -Al ₂ O ₃ catalyst at different space velocities .	67
4 . 12b	Conversion versus space velocities of C ₂ - alkane on Ru / γ -Al ₂ O ₃ catalyst at different temperatures .	67
4 .13b	Conversion versus space velocities of C ₃ - alkanes on Ru / γ -Al ₂ O ₃ catalyst at different temperatures .	68
4 .14A-C	Conversion versus space velocities of C ₄ – alkanes on Ru / γ -Al ₂ O ₃ catalyst at A (600) , B (700) , C (800) °C .	70
4 .15A-C	Conversion versus space o velocities of C ₅ – alkanes on Ru / Al ₂ O ₃ catalyst at temperatures A (600) , B (700) , C (800) °C .	71
4 . 16	Conversion versus temperatures of C ₆ – alkanes on Ru / γ -Al ₂ O ₃ catalyst at different space velocities .	73
4 . 17	Conversion versus temperatures of C ₇ – alkanes on Ru / γ -Al ₂ O ₃ catalyst at different space velocities .	73
4 . 18a	H ₂ / CO ratio versus temperatures on Ru / γ -Al ₂ O ₃ catalyst at different space velocities .	76
4 . 18b	H ₂ / CO ratio versus space velocities on Ru / γ -Al ₂ O ₃ catalyst at different temperatures .	77

4 . 25a	Conversion versus temperatures of C ₆ - alkanes on Ir / γ -Al ₂ O ₃ catalyst at different space velocities .	89
4 . 26a	Conversion versus temperatures of C ₇ - alkanes on Ir / γ -Al ₂ O ₃ catalyst at different space velocities .	90
4 . 25b	Conversion versus space velocities of C ₆ - alkanes a on Ir/ γ -Al ₂ O ₃ catalyst different temperatures .	90
4 . 26b	Conversion versus space velocities of C ₇ - alkanes on Ir / γ -Al ₂ O ₃ catalyst at different temperatures .	91
4.27a	H ₂ / CO ratio versus temperatures on Ir / γ -Al ₂ O ₃ catalyst at different space velocities .	93
4 . 27b	H ₂ / CO ratio versus space velocities on Ir / γ -Al ₂ O ₃ catalyst at different temperatures .	94
5 . 1	A thin slice of solid catalysed plug flow reactor .	97
5 . 2	Arrheniu's plot for (A) Rh / γ -Al ₂ O ₃ , (B) Ru / γ - Al ₂ O ₃ and (C) Ir / γ -Al ₂ O ₃ .	100
5 . 3	Test for First Order Reaction Kinetics w .r .t CO ₂ and CH ₄ over Rh / γ -Al ₂ O ₃ catalyst .	104
5 . 4	Test for First Order Reaction Kinetics w .r .t CO ₂ and CH ₄ over Ir / γ - Al ₂ O ₃ catalyst .	106
5 . 5	Test for First Order Reaction Kinetics w .r .t CO ₂ and CH ₄ over Ru / γ - Al ₂ O ₃ catalyst .	107

A .2 Remaining Concentrations of CO ₂ and CH ₄ for Ru / γ -Al ₂ O ₃ at the studied conditions .	123
A .3 Remaining Concentrations of CO ₂ and CH ₄ for Ir / γ -Al ₂ O ₃ at the studied conditions .	127
A .4a The calculation needed to test the fit of Eq . (17) of CO ₂ component on Rh / γ Al ₂ O ₃ .	125
A . 4b The calculation needed to test the fit of Eq . (17) of CH ₄ component on Rh / γ - Al ₂ O ₃	126
A . 5 a The calculation needed to test the fit of Eq .(17) of CO ₂ component on Ru / γ - Al ₂ O ₃ .	127
A . 5 b The calculation of needed to test the fit of Eq . (17) CH ₄ component on Ru / γ - Al ₂ O ₃ .	128
A .6 a The calculation of needed to test the fit of Eq . (17) CO ₂ component on Ir / γ - Al ₂ O ₃ .	129
A .6b The calculation of needed to test the fit of Eq . (17) CH ₄ component on Ir / γ - Al ₂ O ₃ .	130

LIST OF TABLES

TABLE		Page
2.1	Activity comparison of Re based catalysts and Rh catalysts for CO ₂ reforming of methane T = 973 K ; SV of METHANE = 5000 ml /h /g ; feed ratio of CH ₄ / CO ₂ = 1 / 1.1 .	6
2.2	Comparison between MR and TR in terms of CO ₂ and CH ₄ conversion per unit of time factor, T= 400 °C , CH ₄ / CO _{2, FEED} = 70 ml / min , P = 1.2 bar (abs) (the terms in the brackets refers to the Ru percentage in the catalyst pellets packed in the TR) .	27
2.3	Results of CO ₂ - CH ₄ reforming over Ni-based catalysts in fix / fluidize bed switching mode .	28
4.1	Composition of the used Natural gas .	46
4.2	Conversion of CO ₂ and CH ₄ on Rh / γ -Al ₂ O ₃ at the studied conditions .	51
4.3	Conversion of C ₂ - and C ₃ - alkanes on Rh / γ -Al ₂ O ₃ catalyst at the studied conditions .	52
4.4	Conversion of i-C ₄ - and n-C ₄ - alkanes on Rh / γ -Al ₂ O ₃ catalyst at the studied conditions .	57
4.5	Conversion of i-C ₅ - and n-C ₅ - alkanes on Rh / γ -Al ₂ O ₃ catalyst at the studied conditions .	57

4 . 6	Conversion of C ₆ ⁺ - and C ₇ ⁺ - alkanes on Rh / γ -Al ₂ O ₃ catalyst at the studied conditions .	59
4 . 7	H ₂ and CO selectivity on Rh / γ -Al ₂ O ₃ catalyst at different temperatures and space velocities .	59
4 . 8	H ₂ / CO ratio on Rh / γ -Al ₂ O ₃ catalyst at different temperatures and space velocities .	60
4 . 9	Conversion of CO ₂ and CH ₄ on Ru / γ -Al ₂ O ₃ at the studied conditions.	65
4 . 10	Conversion of C ₂ - and C ₃ – alkanes on Ru / γ -Al ₂ O ₃ catalyst at the studied conditions .	68
4 . 11	Conversion of i-C ₄ - and n-C ₄ – alkanes on Ru / γ -Al ₂ O ₃ catalyst at the studied conditions.	72
4 . 12	Conversion of i-C ₅ - and n-C ₅ - alkanes on Ru / γ -Al ₂ O ₃ catalyst at the studied conditions .	72
4 . 13	Conversion of C ₆ ⁺ - and C ₇ ⁺ - alkanes on Ru / γ -Al ₂ O ₃ catalyst at the studied conditions .	74
4 . 14	H ₂ and CO selectivity on Ru / γ -Al ₂ O ₃ catalyst at different temperatures and space velocities .	75
4 . 15	H ₂ / CO ratio on Ru / γ -Al ₂ O ₃ catalyst at different temperatures and space velocities .	76

4 . 16 Comparison of conversion for CO ₂ and CH ₄ on Ir / γ -Al ₂ O ₃ at the studied conditions .	82
4 . 17 Conversion of C ₂ - and C ₃ - alkane on Ir / γ -Al ₂ O ₃ catalyst at the studied conditions .	85
4 . 18 Conversion of i-C ₄ - and n-C ₄ -alkanes on Ir / γ -Al ₂ O ₃ catalyst at the studied conditions .	88
4 . 19 Conversion for i-C ₅ - and n-C ₅ - alkanes on Ir / γ -Al ₂ O ₃ catalyst at the studied conditions .	89
4 . 20 Conversion of C ₆ ⁺ - and C ₇ ⁺ - alkanes on Ir / γ -Al ₂ O ₃ catalyst at the studied conditions .	91
4 . 21 H ₂ ,CO selectivity on Ir / γ -Al ₂ O ₃ catalyst at different temperatures and space velocities .	92
4 . 22 H ₂ / CO ratio on Ir / γ -Al ₂ O ₃ catalyst at different temperatures and space velocities .	94
5 . 1 Reaction rate constant as determined by least squares regression analysis.	99
5 . 2 ln k and 1 / T for 3- tested catalyst .	101
5 . 3 Activation energy and pre-exponential factor from Arrhenius' equation .	102
A .1 Remaining Concentrations of CO ₂ and CH ₄ for Rh / γ -Al ₂ O ₃ at the studied conditions .	123

NOMENCLATURE

C_A = Concentration of reactant A mol / lit.

Contact Time = volume of catalyst bed / volumetric flow rate

DME = Di Methyl Ether .

E = Activation Energy of the Reaction J / mol .

F = Molar Flow Rate mol . / h .

GHSV = Gas Hourly Space Velocity h⁻¹

GTL = Gas – to – Liquid

ΔH = Enthalpy of Reaction k J / mol .

k = Reaction Rate Constant

k_0 = Frequency or Pre – Exponential Factor

Mpa = Mega Pascal

MR = Membrane Reactor

n = Order of Reaction

N_A = no. of moles A left un reacted

N_{A0} = Initial no. moles A

P = Pressure atm .

R = The Universal Gas Constant 0.082 lit . atm .

RWGS = Reverse Water Gas Shift Reaction .

SEM = Scanning Electron Microscope .

SMSI = Strong Metal Support Interaction

T = Temperature °C

TG = Thermal Gravimetric Analysis .

TOF = Turn Over Frequency

TPR = Temperature Programmed Reduction

TR = Tubular Reactor

V₀ = Initial Volume of Reactants

W = Weight of Catalyst gm .

WGSR = Water Gas Shift Reaction

WHSV = Weight Hourly Space Velocity ccg⁻¹h⁻¹

X_A = Conversion

XANES = X – Ray Absorption Near – Edge Structure

τ' = Weight – Time Term kg.h lit⁻¹

ε_A = change in the system volume between no conversion and complete conversion .

AIM OF THE WORK

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This work aims to study the reforming of Egyptian natural gas rather than pure methane (as usually reported in literature) by carbon dioxide .

Three proposed noble metals namely Rh , Ru and Ir supported on γ - alumina in the ratio 0.5 % by wt are used as catalysts .

The effect of reaction conditions ; temperatures , space velocities are studied at different levels in order to optimize the reaction parameters .

Finally the reaction kinetics for the reforming of CO₂ and methane using the different catalysts are studied .

ABSTRACT

ABSTRACT

Elsalamony, Radwa Abbas. On Reforming of Natural Gas by Carbon dioxide to Produce Synthesis Gas. MSc, Egyptian Petroleum Research Institute , 2005.

Reforming of natural gas with carbon dioxide to synthesis gas ($H_2 + CO$) has been investigated over rhodium , ruthenium and iridium (0.5 wt %) supported on γ - alumina catalyst . The catalysts were prepared from the corresponding metal salts by the impregnation technique . 2 gm of each catalyst were tested in a tubular flow reactor 13 mm diameter and 120 mm length . The catalyst's activity was investigated at three reaction temperatures namely 600 , 700 and 800°C , and different weight hourly space velocities 18000 , 36000 , 45000 and 60000 $cc.g^{-1}.h^{-1}$. Both major and minor components in the natural gas were determined using high sensitive gas chromatographic techniques .

All the catalysts showed reactivity towards the reforming reaction but with varying degrees.

Generally ; the activity of the reforming reaction towards all natural gas components increased with increasing temperature and decreasing space velocity i.e. increasing contact time . From the results obtained, the optimum reforming conditions for each catalyst w.r.t . natural gas components could be established .

In addition , the optimum conditions for obtaining the maximum H_2 / CO ratio were also evaluated for the investigated catalysts .

The maximum ratio for Rh / γ - Al_2O_3 catalyst was at 700°C and 36000 $cc g^{-1} h^{-1}$, for Ru / γ - Al_2O_3 catalyst was at 800°C and 18000 $cc g^{-1} h^{-1}$ and for Ir / γ - Al_2O_3 catalyst was at 700°C and 36000 $cc g^{-1} h^{-1}$.

All three catalyst obeyed the 1st order reaction rate assumption w.r.t. both reactants CO_2 and CH_4 under all reaction temperatures . The dependence of the

reaction rate constant on temperature was determined by the Arrhenius' plot .
The average activation energy for CO₂ was 46.25E3 J / mol. and that of CH₄
was 31.52E3 J / mol ,

Key words :-

natural gas , CO₂ , Rh , Ru , Ir , γ - Al₂O₃ , CO₂ reforming of CH₄ , heavy
components , chromatograph , space velocity , temperature , kinetics .