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TRIFUNCTIONAL CATALYSTS FOR CONVERSION OF SYNGAS TO ALCOHOLS: TENTH QUARTERLY REPORT FOR PERIOD DECEMBER 1, 1986 TO FEBRUARY 28, 1987

DELAWARE UNIV., NEWARK. CENTER FOR CATALYTIC SCIENCE AND TECHNOLOGY

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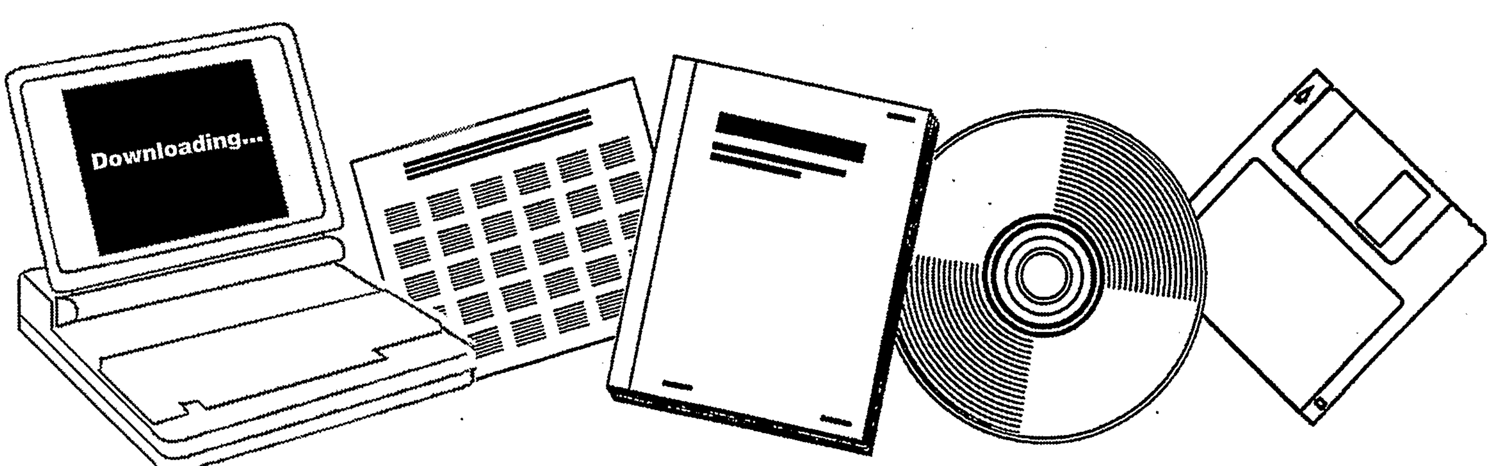

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TRIFUNCTIONAL CATALYSTS FOR CONVERSION OF SYNGAS TO ALCOHOLS

DOE/PC/70780--T6

DE87 007384

Tenth Quarterly Report for Period
December 1,1986 to Febraury 28,1987

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OBJECTIVES

Task 1. Preparation of catalyst samples
Task 2. Testing catalysts for syngas conversion
Task 3. Measurement of surface composition and structure
Task 4. Determination of nature of surface complexes
Task 5. Reaction mechanism determination by isotopic tracers and kinetics
Task 6. Design, prepare and test optimized catalysts

ABSTRACT

Changes in adsorption sites on Rh/Al_2O_3 catalysts brought about by addition of sodium or by molybdena, was quantified by adsorption of hydrogen and of carbon monoxide. Fresh and used catalyst were tested. XRD was done to rule out the presence of crystalline compound formation. Infrared measurements showed that C-O bond is strengthened slightly by molybdena addition. Hence the enhanced activity of $Rh/Mo/Al_2O_3$ is caused neither by a greater number of CO sites nor by weakening of CO bond.

The role of sodium in removing surface -OH groups, which in turn changes the distribution of different carbonyl species on the surface, was tested.

Detailed kinetic data for $Rh/Mo/Al_2O_3$ having different amounts of molybdena were collected. Analysis of rate of formation for primary products were carried out. Activation energies for various reactions were calculated and its implication on the reaction scheme is discussed. The analysis of secondary reactions is underway.

Task 3: Measurement of Surface Composition and Structure

Task 4: Determination of nature of surface complexes

Hydrogen Chemisorption

To quantify the number of sites, hydrogen chemisorption is used. Hydrogen chemisorption is done on Micromeritics 2100 surface area analyser. Hydrogen is purified with CuO trap and water is removed with zeolite trap. These experiments were done in a static mode. Since CO can be adsorbed as a variety of carbonyl species , CO chemisorption cannot be used to quantify the number of sites. However CO chemisorption can be coupled in a qualitative way with IR to find approximate number and type of CO- adsorption sites. Hydrogen chemisorption is done on used and fresh catalyst .

The striking difference between them is indicated in the table below. The used catalyst was re-reduced at 500C. The irreversibly adsorbed hydrogen decreases quite a lot when the catalyst is used. It is also seen that the difference between the irreversible and reversible hydrogen chemisorption in the used sodium promoted catalyst and the used non-promoted catalyst is not substantial. The amount of irreversible and reversible hydrogen on 3%Rh 2.8%Mo/Al_2O_3 decreases, however the turnover number based on the total Rh content increases by an order of magnitude. This proves that the enhanced activity of Mo-promoted system is not because of physical reasons such as higher dispersion.

Summary of Hydrogen Chemisorption

catalyst	state	Irreversible Hydrogen μ gmoles/gm	Reversible Hydrogen μ gmoles/gm
3%Rh/Al_2O_3	fresh	93.1	57.5
3%Rh/Al_2O_3	used	26.8	14.5
3%Rh 0.67%Na/Al_2O_3	used	23.6	14.2
3%Rh 2%Na/Al_2O_3	fresh	46.0	44.9
3%Rh 2.8%Mo/Al_2O_3	fresh	39.2	39.4

Note:

In 3%Rh 2%Na/Al_2O_3-fresh catalyst the reversible hydrogen decreases with increase in pressure.

145.9 μ gmoles of H_2 = 1 gm of 3% Rh (100% disp),1H:1Rh

CO chemisoption

CO chemisorption was done in a flow system with TPD capability (figure 1). The CO chemisorption experiments corroborate the fact that it is not the number of CO adsorption sites which makes the difference between Mo promoted and unpromoted Rh/Al_2O_3. The difference in reactivity and CO and hydrogen chemisorption is shown in figure 2. Future experiments are planned to study the effect of state(fresh,used) of catalyst on the CO adsorption on molybdena promoted Rhodium catalyst.

Summary of Carbonmonoxide chemisorption

catalyst	state	CO chemisorbed μgmoles/gm at 25C	dispersion %
$3\%Rh/Al_2O_3$	fresh	112.4	39.2
$3\%Rh\ 2.8\%Mo/Al_2O_3$	fresh	74.0	25.8
$3\%Rh\ 15\%\ Mo/\ Al_2O_3$	fres	28.1	9.8

Note:
Very little effect of temperature cycles is observed i.e. reduction and then CO chemisorption in cycles

X-Ray Diffraction

X-Ray diffraction was done on used and fresh Molybdena promoted catalyst ($3\%Rh$ 2.8% Mo/ Al_2O_3, $3\%Rh7.5\%Mo/Al_2O_3$ and $3\%Rh15\%Mo/Al_2O_3$). XRD results show the absence of Rh-crystallite, any Mo-oxide, $MoRh_2O_6$ Rhodium oxide or $Al_2(MoO_4)_3$ in the particle size range of 30A to 100A .

Reaction of surface -OH groups with Disilazanes

In the 9th quarterly report , an explanation for the differences in the stabilities of different adsorbed species on the Na-promoted and non-promoted Rh/Al_2O_3 catalyst was put forward. It was proposed that the extent of surface -OH groups play a key role in the interconversion of different carbonyl species on the surface. In the Na-promoted Rh/Al_2O_3, sodium provides a chemical way of blocking or removing -OH groups. This hypothesis was tested by reacting surface -OH groups with disilazanes. Hexamethyldisilazane (HMDS) was selected because of previous work done on Rh/Al_2O_3 [1].

The reaction with the surface -OH groups is as follows

$$2\,Al\text{-}OH + Me_3Si\underset{H}{N}SiMe_3 \longrightarrow 2\,Al\text{-}O\text{-}SiMe_3 + NH_3$$

HMDS can also bind to the anionic vacancies on Al_2O_3 surface

$$Al^{3+} + N\begin{matrix} SiMe_3 \\ SiMe_3 \\ H \end{matrix} \longrightarrow Al^{3+}\text{-}N\begin{matrix} SiMe_3 \\ SiMe_3 \end{matrix} + H^+$$

In the first set of experiments Rh/Al_2O_3 was reduced at 400C under hydrogen and then cooled to 20C. The catalyst is then exposed to vapors of HMDS insitu for 2 hours. It

[1] Zaki M., Gates B.C. and Knozinger H. submitted to J.Phys. Chem

is observed that after the insitu treatment of disilazanes there are no N-H bands. However the two CH_3 bands are clearly seen. It is also observed that the amount of g-dicarbonyl species decrease while the linear species increase. Since CO is adsorbed before exposing the catalyst to HMDS and no N-H bands are seen, we donot expect disilazanes on the metal crystallite. The doublet CH_3 bands are stable upto 300C. Substantial amount of surface -OH groups are present after this treatment. (Figure 3 and 4).

The second set of experiments were done by treating the support with excess HMDS for 24 hours. In this case most of the surface -OH reacts with HMDS as seen by the absence of the surface -OH bands.

Interpretation of Infrared shifts for CO chemisorbed on Mo-promoted Rh/Al_2O_3

The shifts in CO-adsorbed on Molybdena promoted Rh/Al_2O_3 were reported in the ninth quarterly report. These shifts can be explained using F and G [2] matrix theory of vibrational spectroscopy. The vibrational spectra of a g-dicarbonyl specie has two relevant stretching force constants (neglecting the coupling between the metal vibrations and the adsorbate stretches and also the coupling between the stretching and bending force fields). k(CO) is the vibrational force constant for each CO bond and k(CO,CO') is the force field parameter for coupling between the stretches of the adjacent CO ligands on the g-dicarbonyl specie.

The results of the calculations are summarised below

catalyst	Experimental data antisymmetric stretch cm^{-1}	Experimental data symmetric stretch cm^{-1}	Calculations k(CO) Nm^{-1}	Calculations k(CO,CO') Nm^{-1}
3%Rh/Al_2O_3 fresh	2012	2084	1694.3	59.6
3%Rh 7.5%Mo/Al_2O_3 fresh	2027	2093	1714.1	54.9

The C-O bond is strengthened on Molybdena promotion. Hence the enhanced activity is caused neither by greater number of CO sites nor by weakening of the CO bond.

Task 5: Reaction mechanism by isotopic tracers and kinetics.

Kinetic analysis of promoted Rh/Al_2O_3

The kinetic analysis of Molybena promoted Rh/Al_2O_3 is done to investigate the effect of process parameters on the activity and selectivity of the catalyst The catalyst are remarkably stable after an initial transient of about 8 hours. The kinetic analysis is done in 4 stages.

Stage I:
Identification of primary and secondary products and analysis of overall kinetics.
Stage II:
Kinetic analysis of primary products.

[2] Braterman P. S., " Metal Carbonyl Spectra", Academic Press, 1975.

Stage III:
Kinetic analysis of secondary products and analysis of complete reaction network.
Stage IV:
Estimation of Acivation Energies and effect of temperature on the reaction network.

Stage I:

Table 2,3 and 4 show data for $3\%Rh15\%Mo/Al_2O_3$ at three different temperatures. The increase in the amount of hydrocarbons is evident when the temperature is high. The x and y values for the rate expression for conversion of CO to all products

$$R_{CO} = k * (pH_2)^x * (pCO)^y$$

for $3\%Rh15\%Mo/Al_2O_3$ are $x \approx 0.8, y \approx 0.0$ compared to $x \approx 0.6$ and $y \approx -0.3$ for non promoted systems. However it should be noted that this x and y values are at different temperatures to get the same conversion range. The shift in the values of x and y reflect the shift in the product distribution. Higher amounts of oxygenates are formed at lower temperature

The %Carbon selectivity to C_{2+} oxygenates decreased sligthly with increase in temperature. This result is surprising because CH_x species are needed to form C_{2+} oxygenates and the amount of CH_x species should increase with temperature. This result indicates that CO insertion step is the rate controlling step in formation of C_{2+} oxygenates.

Another set of kinetic data is reported in table 2 . This data is made up of two set of runs. The effect of pressure was investigated at same mass flow rate and at same actual contact time. There was very little effect on of pressure on the formation of hydrocarbons. The fraction of oxygenates and CO_2 increased while the secondary products decreased.

Effect of CO/H_2 ratio and space time on the activity and product distribution characteristics of the catalyst

This set of experiments were done for $3\%Rh7.5\%Mo/Al_2O_3$. The catalyst was reduced at 500C for 1 hr under 50scc/min of flowing hydorgen. The product distribution and activity of the catalyst was measured at fixed temperature and pressure and at a range of GHSV and CO/H_2 ratio. It was surprising to see that the overall conversion follows pseudo first order kinetics(see figure)

The table below shows the pseudo first order rate constants

3%Rh 7.5%Mo/ Al_2O_3 , 200C, 450 psi

CO/H_2	k(sec^{-1})
2	0.00832 ± 0.00032
1	0.02248 ± 0.00013
1/2	$0.04480 \pm .0015$
1/3	0.0623 ± 0.0028
1/5	0.1101 ± 0.0033

The data collected for 3%Rh 7.5% Mo/Al_2O_3 was plotted to see the effect on CO/H_2 on the nature of the product and the ratio of the pseudo first order rate constants. This methodology of analysing data was discussed in 8th quarterly report. The following conclusions were reached.

CH_4 is a primary product for $CO/H_2 \leq 2$. This implies the formation of CH_4 at high CO/H_2 ratio has two slow steps compared to one at low CO/H_2 ratio

The intercepts for the plot of (mole fraction of specie)/conv of CO against conversion of CO are listed on the next page. The intercepts are the ratio of the pseudo first order rate constant for the slow step in the formation of the specie to the sum of pseudo first order rate constant for the consumption of the parent specie.

3%Rh 7.5%Mo /Al_2O_3, 200C

CO/H_2	pCO psi	pH_2 psi	CO_2	Intercept MeOH	MeOMe
2	300	150	0.27	0.24	0.17
1	225	225	o.21	@	@
1/2	150	300	0.1	0.3*	@
1/3	112.5	337.5	0.09	0.40	0.15
1/5	75	375	0.06	0.43	0.13

@ - very small, cannot be accurately found

* - inverse S-shaped curve

Stage II:

The rate of formation of primary product is found experimentally at two different GHSV. The rate of primary product should be independant of GHSV. Hence the consistency of rate of the specie is taken as a test of the experimental method and the analysis of Stage I. The rate is found at 18 different combinations of pCO and pH_2. The above experiment is repeated at three different temperatures. A sample table is given below for 3%Rh 15% Mo /Al_2O_3 at 210C.

$$Rate_{specie} = k * (pCO)^y * (pH_2)^x$$

Specie	ln(k)	y	x
MeOH	-16.895 ± 0.162	-0.005 ± 0.113	1.527 ± 0.096
CO	-10.301 ± 0.091	-0.030 ± 0.064	0.724 ± 0.054
CO_2	-10.712 ± 0.091	-0.040 ± 0.064	0.377 ± 0.054
CH_4	-7.676 ± 0.126	-0.323 ± 0.088	1.021 ± 0.075

Table 4 shows comparison of x and y with different systems reported in literature for methane and methanol. Table 2,3 and 4 show preliminary kinetic data for 3%Rh 7.5%Mo/ Al_2O_3 and 3%Rh 15%Mo Al_2O_3.

Stage III:

The first approach is to use H-J-B method with models which are linear in parameter space. This method has the advantage of not needing any initial guess. Here the rate expression for primary products from Stage II are used. The second approach is to use Spline approximation combined with non-linear regression routines[3]. The advantage of this method are (i) Jacobians needed for the next guess can be found very easily by using the properties of spline and (ii) it has a variable smoothing parameter. A couple of networks have been tried using the first approach and the second approach is in the stage of writing programs.

Stage IV

An estimate of activation energy is made for differrent products and overall reaction. This estimate is based on the assumption that for small conversion the amount of CO converted is approximately proportional to the rate constant at a given contact time and that the selectivity is quite independant of the contact time. The temperature dependance of the actual rate constant is not very different from the temperature dependance of the pseudo first order rate constant. Figure 5 shows a semi-log plot of % C in a specie against 1/T for 3%Rh 7.5% Mo /Al_2O_3 at 450 psi.

The table below list the activation energies from figure 5.

Approximate activation energies

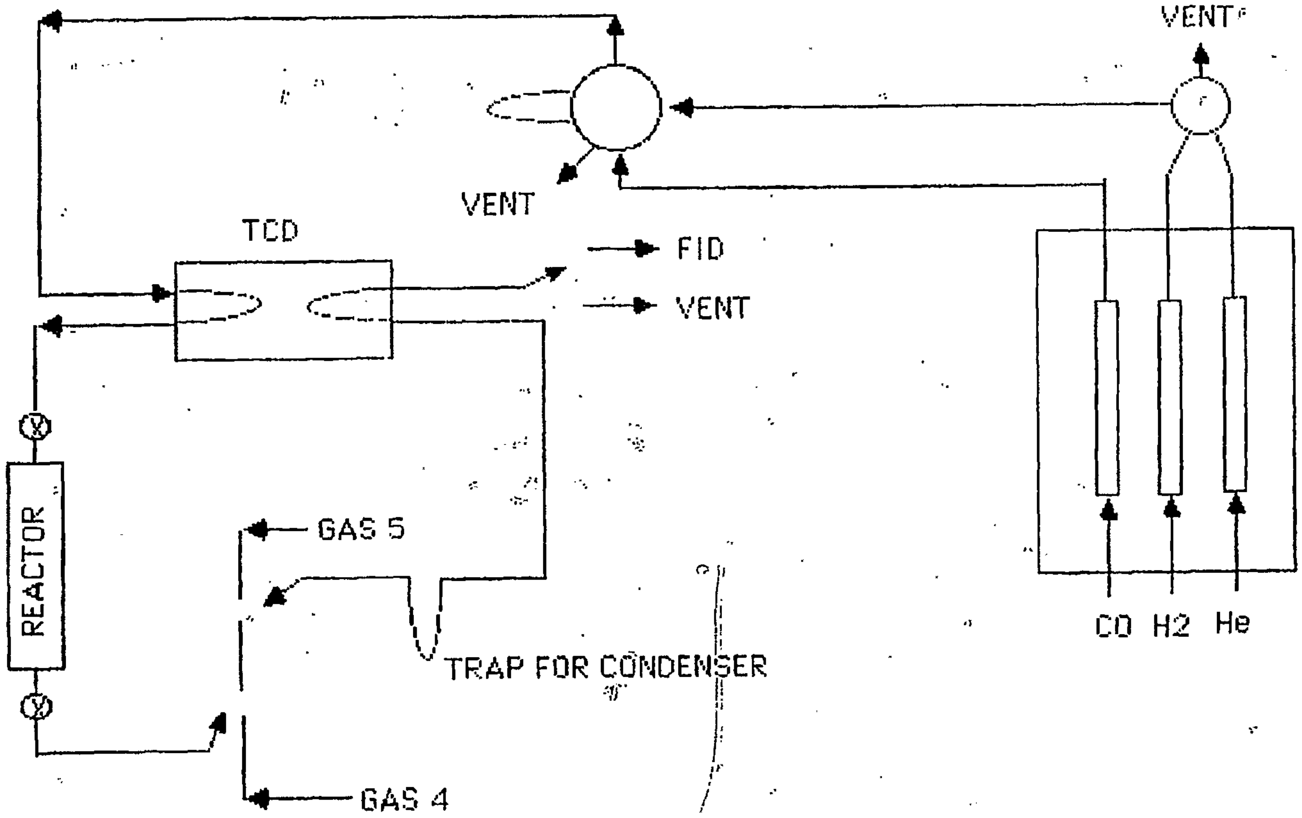
specie	ln(A*b)	E_{act} Kcal/gmol
CO	24.998 ± 0.067	21.62 ± 0.92
CO_2	23.897 ± 0.084	21.94 ± 0.66
CH_4	33.848 ± 0.196	32.39 ± 2.6
C1oxyg	19.707 ± 0.482	17.23 ± 0.66
C2oxyg	25.562 ± 0.178	24.28 ± 2.41
totoxyg	21.346 ± 0.062	18.58 ± 0.85

b- arbitrary constant

The higher E_{act} for methane compared to oxygenates is consistent with relatively increased methane formation at higher temperatures and, conversely higher relative oxygenates formation at lower temperature (Figure 6).

[3] Yermakova A., Vajda S. and Valko P., Applied Catalysis, 2(1982)139.

Figure 1:



TPD/CHEMISORPTION APPARATUS FLOW DIAGRAM

Comparison of CO chem and turnover

3%Rh x%Mo /Al2O3

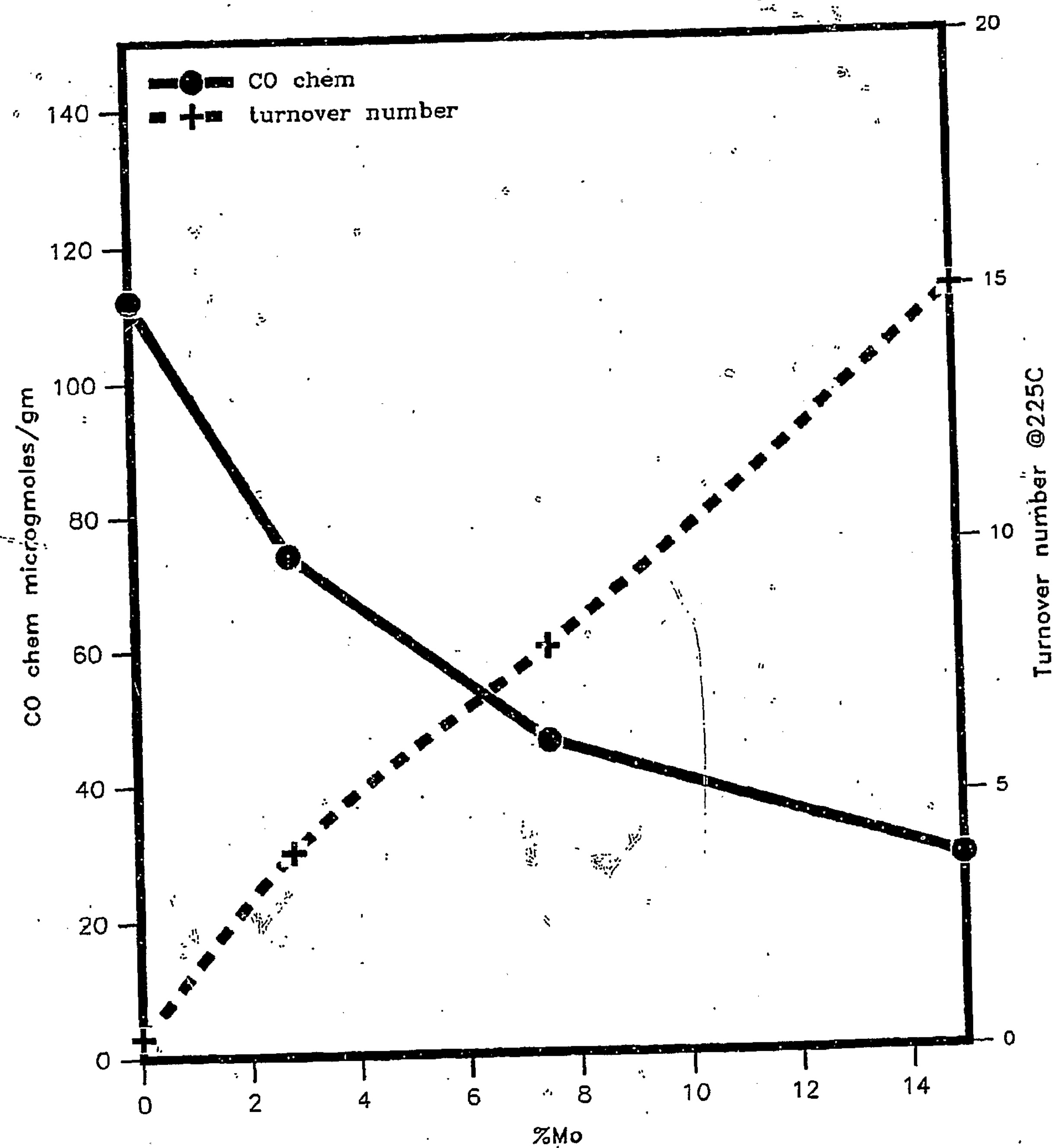


Figure 2 . Normalised to total Rh. file:q10fig2.plot

Figure 3: 3%Rh/Al2O3, reduced at 400C cooled to 30C, dosed with CO, evacuated (spectra A), Exposed to vapors of HMDS, evacuated (Spectra B). Spectrum shown is B-A. Note the negative bands in -OH region.

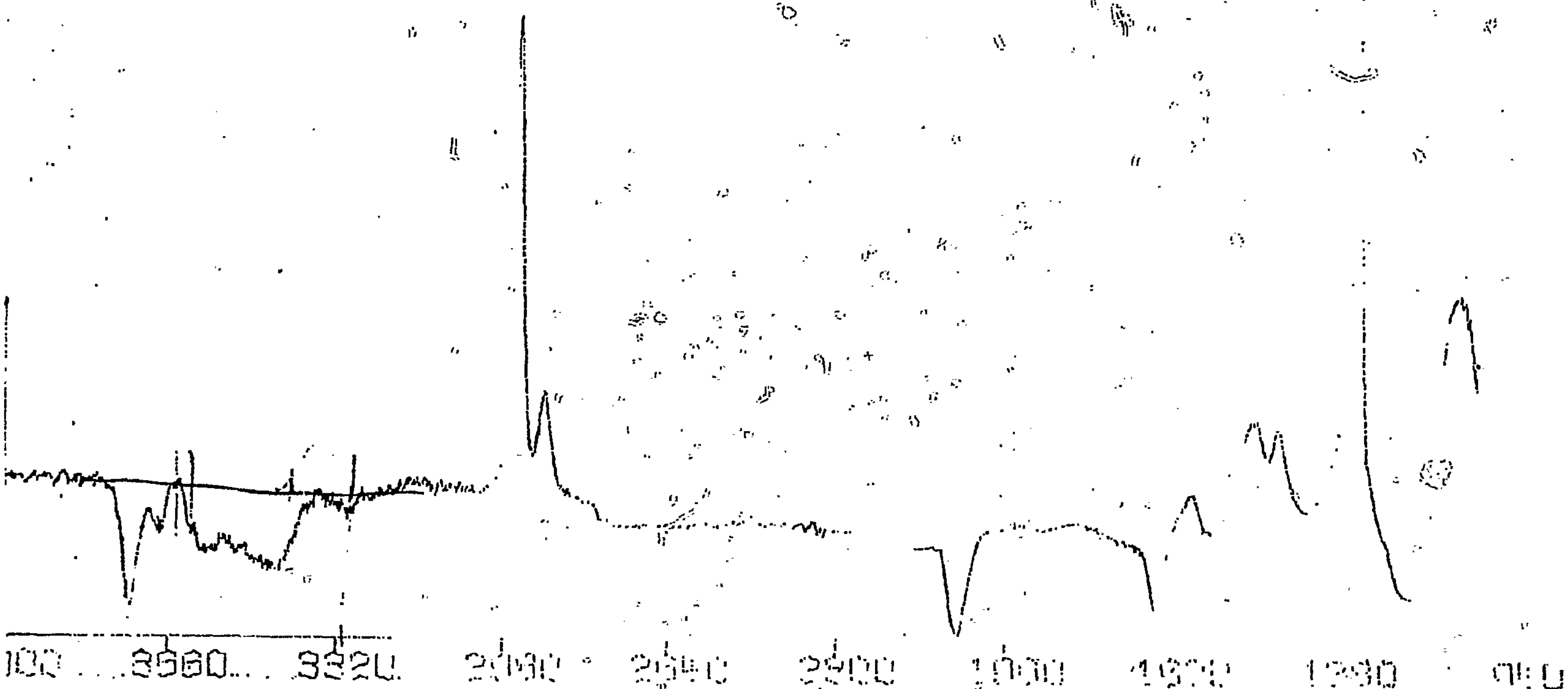


Fig 3

Figure 4: Reaction of Rh/Al203 with HMDS
Note the absence of N-H bands.

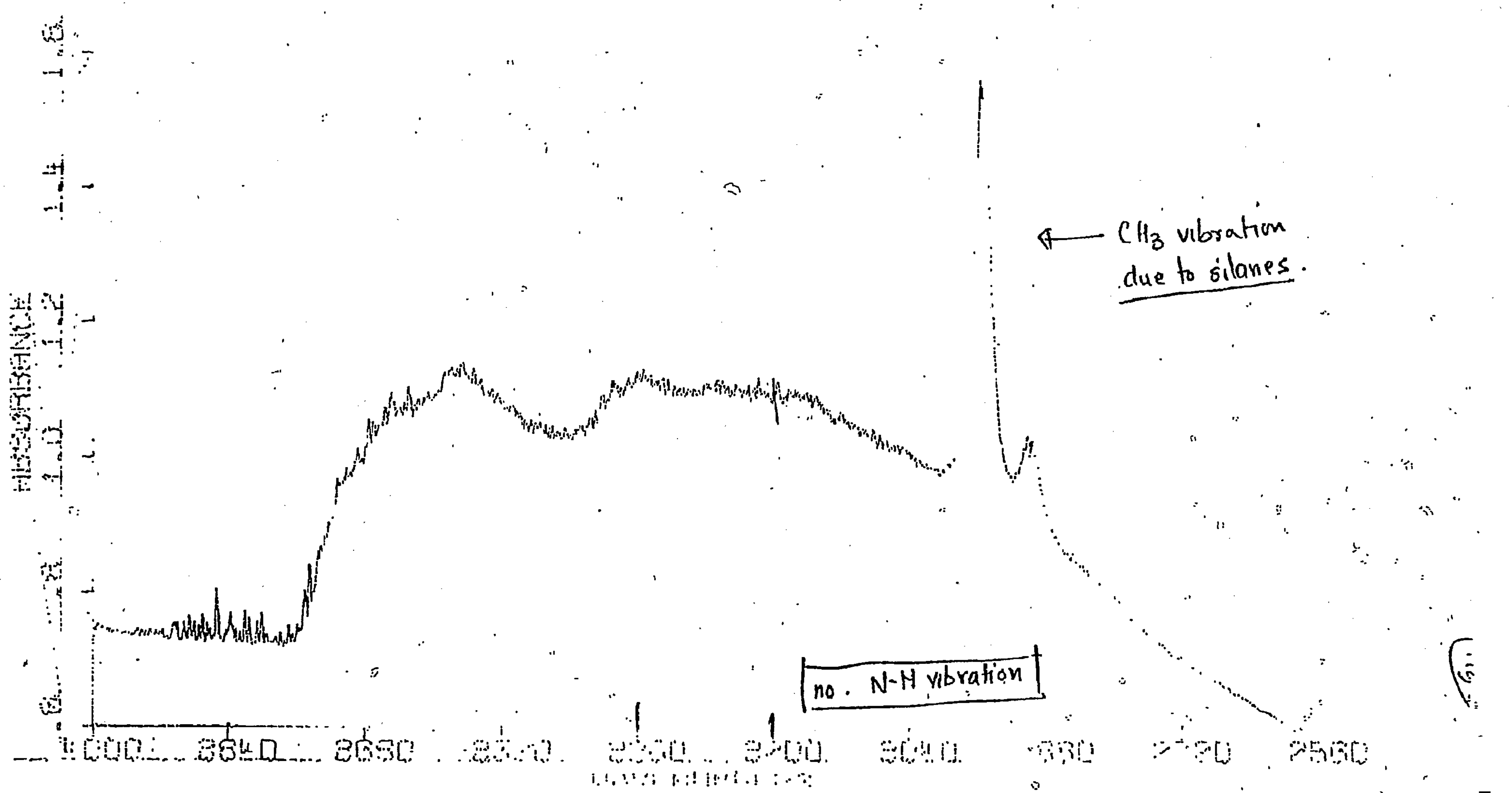


Figure 5:

Approximate activation energies

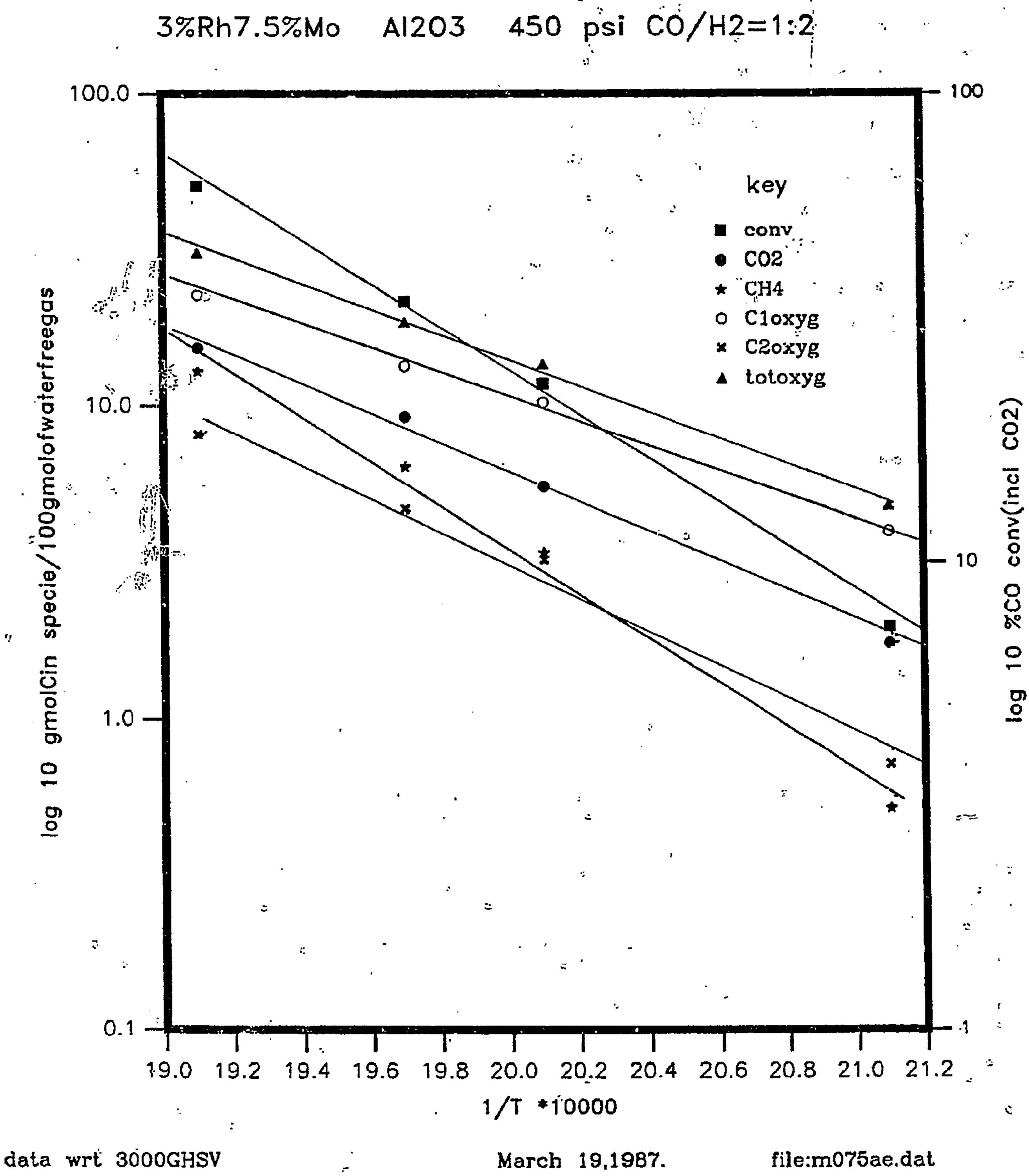
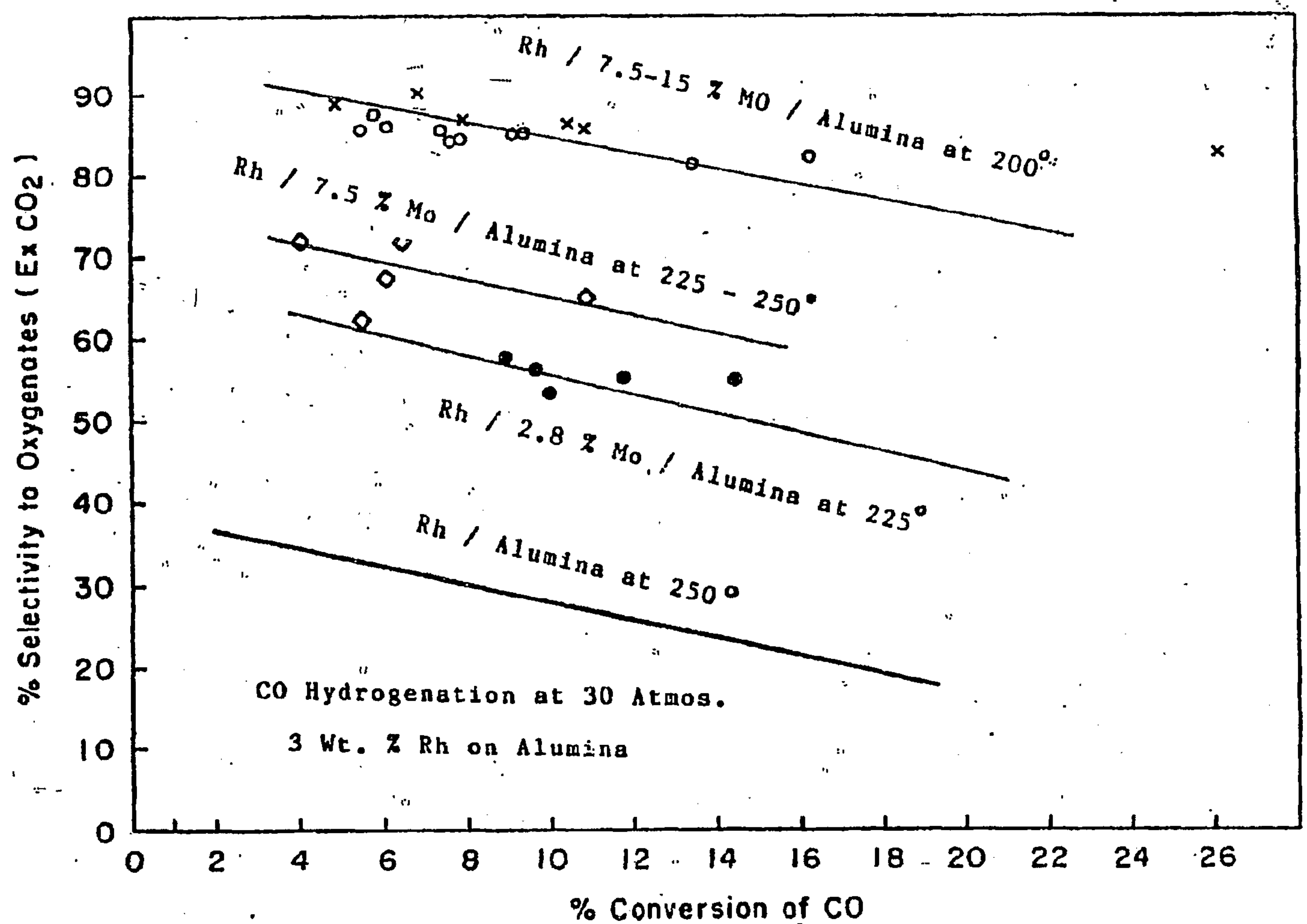


Figure 6:



Effect of Mo-promotion, temperature on the overall selectivity

Table 1 Page 1

catal no (page no)	catalyst	temp C	CO:H2	GHSV hr-1	time hrs	time @ condition	SELECTIVIDUCTS CH4	C2H6
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	2130	10.5	10.5	9.2	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	2130	11	11	9.0	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	2130	11.5	11.5	8.9	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	2130	13	13	9.0	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	2130	14	14	8.7	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	3195	14.75	0.75	8.2	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	3195	15.25	1.25	8.2	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	3195	16	2	8.5	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	4260	16.5	0.5	8.0	2
30(80)	3%Rh 15%Mo/Al2O3	200	0.5	4260	18.5	2.5	7.9	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.333333	2840	38.5	18	8.9	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.333333	2840	39	18.5	9.0	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.333333	4260	41.5	2.5	9.4	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.333333	4260	42	3	9.0	3
30(80)	3%Rh 15%Mo/Al2O3	200	0.333333	5680	43	1	8.9	2
30(80)	3%Rh 15%Mo/Al2O3	200	0.333333	5680	43.5	1.5	8.8	2
30(80)	3%Rh 15%Mo/Al2O3	200	2	2130	47	3.5	6.8	3
30(80)	3%Rh 15%Mo/Al2O3	200	2	2130	47.5	4	5.9	3
30(80)	3%Rh 15%Mo/Al2O3	200	2	3195	48.5	1	5.3	2
30(80)	3%Rh 15%Mo/Al2O3	200	2	3195	49	1.5	5.8	2
30(80)	3%Rh 15%Mo/Al2O3	180	0.5	2130	50	1	6.6	2
30(80)	3%Rh 15%Mo/Al2O3	180	0.5	2130	50.5	1.5	6.2	2
30(80)	3%Rh 15%Mo/Al2O3	180	0.5	1065	62.5	12	ERR	E
30(80)	3%Rh 15%Mo/Al2O3	180	0.5	1065	63	12.5	ERR	E
30(80)	3%Rh 15%Mo/Al2O3	180	0.333333	1420	64.5	1.5	8.2	
30(80)	3%Rh 15%Mo/Al2O3	180	0.333333	1420	65	2	7.9	1
30(80)	3%Rh 15%Mo/Al2O3	180	0.333333	2840	67.5	2.5	6.2	2
30(80)	3%Rh 15%Mo/Al2O3	180	0.333333	2840	68	3	6.2	2
30(80)	3%Rh 15%Mo/Al2O3	180	2	2130	69	1	3.5	1
30(80)	3%Rh 15%Mo/Al2O3	180	2	2130	69.5	1.5	3.4	1
30(80)	3%Rh 15%Mo/Al2O3	180	2	2130	70	2	3.6	1
30(80)	3%Rh 15%Mo/Al2O3	180	2	1065	73	3	3.6	1
30(80)	3%Rh 15%Mo/Al2O3	180	2	1065	74	4	3.5	1
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	2130	84	10	11.2	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	2130	85	11	11.0	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	4260	85.5	0.5	11.2	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	4260	86	1	11.3	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	4260	86.5	1.5	10.4	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	6391	87.5	1	10.1	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	6391	88	1.5	10.0	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	6391	88.5	2	9.4	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.5	8521	89.5	1	7.6	2
30(80)	3%Rh 15%Mo/Al2O3	220	0.333333	8521	90.5	1	10.3	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.333333	8521	91	1.5	10.2	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.333333	7101	91.5	0.5	10.4	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.333333	7101	92	1	10.0	3
30(80)	3%Rh 15%Mo/Al2O3	220	0.333333	7101	94	3	10.0	3
30(80)	3%Rh 15%Mo/Al2O3	220	1	7101	94.5	0.5	8.7	3
30(80)	3%Rh 15%Mo/Al2O3	220	1	7101	95	1	8.5	4
30(80)	3%Rh 15%Mo/Al2O3	220	1	5600	95.5	0.5	8.6	3

Table 1 Page 2

W T	time hrs	time @ condition	SELECTIVITIES CH4	C2H6	MeOH	MeOMe	EtOH	MeOAc	MeOEt	TOTALOXY C%,CO2free	MC2+OXO total	RATE CO gmol/hr	C% to CO2 CO2 incl	COMMENTS
2130	10.5	10.5	9.2	3.5	11.7	61.3	2.1	2.4	9.8	87.3	11.0	9.1E-04	32.8	MeOAc apprx
2130	11	11	9.0	3.6	11.8	61.3	2.2	2.4	9.7	87.4	11.8	9.1E-04	32.4	
2130	11.5	11.5	8.9	3.4	12.2	60.5	2.3	2.9	9.8	87.7	12.3	9.3E-04	32.2	
2130	13	13	9.0	3.4	12.8	60.5	2.2	2.4	9.9	87.7	11.9	9.2E-04	32.3	
2130	14	14	8.7	3.4	11.7	61.0	2.4	3.1	9.7	87.8	12.5	9.2E-04	31.9	
3195	14.75	0.75	8.2	3.2	13.7	60.7	2.4	2.0	9.0	88.6	11.7	9.0E-04	28.8	
3195	15.25	1.25	8.2	3.0	13.3	61.7	2.2	2.6	9.0	88.8	11.2	8.9E-04	29.0	
3195	16	2	8.5	3.1	13.9	61.1	2.4	2.1	8.8	88.3	11.0	8.7E-04	29.0	
4260	16.5	0.5	8.0	2.9	14.7	60.7	2.3	2.3	9.1	89.1	11.2	9.1E-04	26.4	
4260	18.5	2.5	7.9	3.0	16.1	58.8	3.2	2.4	8.5	89.0	11.8	9.1E-04	25.9	MeOAc apprx
2840	38.5	10	8.9	3.0	27.7	49.7	3.6	2.0	5.1	88.1	9.5	1.5E-03	27.4	
2840	39	10.5	9.0	3.0	25.8	50.8	3.7	2.5	5.1	88.0	10.0	1.4E-03	27.4	
4260	41.5	2.5	9.4	3.3	27.5	50.7	3.5	1.4	4.1	87.3	8.3	1.6E-03	24.8	rdg may not be steady state
4260	42	3	9.0	3.0	23.8	53.3	3.1	2.7	5.0	88.0	9.4	1.4E-03	24.8	
5600	43	1	8.9	2.9	26.3	51.3	3.6	2.3	4.8	88.2	9.4	1.4E-03	21.7	
5600	43.5	1.5	8.8	2.9	25.1	53.4	3.4	1.4	5.0	88.2	8.7	1.3E-03	21.2	
2130	47	3.5	6.8	3.7	8.5	62.7	1.5	4.1	12.7	89.4	14.2	6.7E-04	39.8	MeOH and MeOMe peak fused, MeOH 15%
2130	47.5	4	5.9	3.4	10.2	64.1	1.3	4.5	10.8	90.8	12.6	6.9E-04	36.2	Ethane peak apprx
3195	48.5	1	5.3	3.3	10.5	64.7	2.4	3.0	11.0	91.5	12.8	5.0E-04	37.8	MeOH and MeOMe peak fused
3195	49	1.5	3.8	2.6	14.5	61.5	1.9	4.6	11.1	93.7	13.3	6.0E-04	31.1	EtOH peak apprx
2130	50	1	6.6	2.8	25.1	53.7	3.7	2.6	5.4	90.6	10.0	2.3E-04	25.0	
2130	50.5	1.5	6.2	2.6	26.1	54.1	4.0	2.0	5.0	91.1	9.5	2.7E-04	23.6	
1065	62.5	12	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	8.2E-05	100.0	
1065	63	12.5	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	8.3E-05	100.0	
1420	64.5	1.5	0.2	.0	0.7	1.4	0.1	0.1	0.1	91.6	97.7	3.7E-03	0.8	
1420	65	2	7.3	1.9	25.1	55.3	3.4	2.7	4.4	90.9	9.0	3.1E-04	24.3	
2840	67.5	2.5	6.2	2.1	29.5	52.7	3.5	1.7	4.3	91.7	8.2	3.5E-04	19.5	
2840	68	3	6.2	2.1	27.2	55.0	3.5	1.7	4.2	91.7	8.2	3.4E-04	18.2	
2130	69	1	3.5	1.6	14.1	69.8	2.3	2.5	6.2	94.9	8.5	2.8E-04	29.3	
2130	69.5	1.5	3.4	1.6	13.6	66.8	2.2	2.4	10.0	95.1	11.1	2.6E-04	28.4	
2130	70	2	3.6	1.7	14.4	68.4	2.3	2.6	7.1	94.8	9.3	2.5E-04	29.6	
1065	73	3	3.6	1.4	14.9	63.6	2.1	3.8	10.6	95.0	12.4	2.1E-04	32.9	
1065	74	4	3.5	1.4	14.6	63.3	2.1	3.7	11.4	95.1	12.8	2.1E-04	32.3	
2130	84	10	11.2	3.6	10.0	60.2	1.8	2.5	9.7	85.2	13.0	2.7E-03	35.1	
2130	85	11	11.0	3.5	10.0	61.7	1.8	2.4	9.7	85.6	11.6	2.7E-03	34.6	
4260	85.5	0.5	11.2	3.6	10.7	61.4	1.9	2.3	8.9	85.2	11.0	2.7E-03	31.7	Note the presence of MeCHO
4260	86	1	11.3	3.4	10.7	62.3	1.9	1.9	9.1	85.4	10.5	2.7E-03	31.7	
4260	86.5	1.5	10.4	3.3	13.6	60.3	2.5	1.9	8.5	86.3	10.6	2.8E-03	29.0	
1391	87.5	1	10.1	3.7	13.5	60.1	2.2	2.0	8.3	86.1	10.6	2.7E-03	27.1	
1391	88	1.5	10.0	3.5	13.9	59.8	2.4	2.1	8.2	86.4	10.8	2.7E-03	26.9	
1391	88.5	2	9.4	3.2	17.5	57.6	2.9	2.0	7.3	87.3	10.4	2.8E-03	25.4	
2521	89.5	1	7.6	2.8	26.5	52.2	4.1	1.3	5.5	89.6	9.7	3.2E-03	20.6	
2521	90.5	1	10.3	3.3	17.1	58.2	2.5	1.8	6.7	86.4	9.6	3.0E-03	22.3	
2521	91	1.5	10.2	3.4	18.8	56.6	2.6	1.6	6.7	86.4	9.5	3.1E-03	22.4	
7101	91.5	0.5	10.4	3.2	17.2	58.1	2.4	2.0	6.8	86.4	9.6	3.1E-03	23.6	
7101	92	1	10.0	3.0	18.5	57.6	2.7	2.1	6.2	87.0	9.5	3.2E-03	23.2	
7101	94	3	10.0	3.1	19.9	55.7	2.7	2.3	6.4	87.0	9.7	3.3E-03	23.1	
7101	94.5	0.5	8.7	3.4	12.8	61.9	2.4	2.3	9.0	88.4	11.3	2.4E-03	30.9	
7101	95	1	8.5	4.2	10.8	61.9	1.9	2.9	9.8	87.3	11.9	2.2E-03	29.9	
1600	95.5	0.5	8.6	3.3	10.5	61.7	2.4	3.2	9.8	87.5	12.7	2.1E-03	30.7	

Table 1 Page 3

tate

sol. MeOH 15%

HYDRO. C% C1	c2	oxyg C% C1	C2	turnover no. sec-1	ln(rate)	ln(ppCO)	ln(ppH2)			
								Regression Output:		
								Constant		15.40941
9.2	3.5	77.0	10.2	2.04E-03	-7.00682	5.010635	5.703782	Std Err of Y Est		0.055443
9.0	3.6	77.1	10.2	2.05E-03	-7.00408	5.010635	5.703782	R Squared		0.967766
9.9	3.4	76.8	10.7	2.10E-03	-6.97725	5.010635	5.703782	No. of Observations		20
9.0	3.4	77.3	10.3	2.08E-03	-6.98624	5.010635	5.703782	Degrees of Freedom		17
8.7	3.4	76.9	10.8	2.07E-03	-6.99576	5.010635	5.703782			
8.2	3.2	78.3	10.2	2.04E-03	-7.00875	5.010635	5.703782	X Coefficient(s)	-2.34431	-1.87056
8.2	3.0	78.8	9.9	2.00E-03	-7.02950	5.010635	5.703782	Std Err of Coef.	0.181915	0.208945
8.5	3.1	78.6	9.6	1.96E-03	-7.04791	5.010635	5.703782	Regression Output:		
8.0	2.9	79.2	9.8	2.05E-03	-7.00235	5.010635	5.703782	Constant		3.004125
7.9	3.0	78.5	10.4	2.05E-03	-7.00540	5.010635	5.703782	Std Err of Y Est		0.104999
8.9	3.0	79.7	8.3	3.30E-03	-6.49955	4.722953	5.821565	R Squared		0.633641
9.0	3.0	79.2	8.7	3.09E-03	-6.59280	4.722953	5.821565	No. of Observations		13
9.4	3.3	80.0	7.2	3.69E-03	-6.41517	4.722953	5.821565	Degrees of Freedom		10
9.0	3.0	79.7	8.2	3.12E-03	-6.58258	4.722953	5.821565			
8.3	2.9	79.9	8.2	3.09E-03	-6.59289	4.722953	5.821565	X Coefficient(s)	-1.11749	-0.99029
8.8	2.9	80.6	7.6	2.97E-03	-6.63136	4.722953	5.821565	Std Err of Coef.	0.477893	0.547571
								Regression Output:		
6.8	3.7	76.7	12.6	1.51E-03	-7.31187	5.703782	5.010635	Constant		-6.10509
5.9	3.4	79.3	11.3	1.55E-03	-7.26307	5.703782	5.010635	Std Err of Y Est		0.054136
5.3	3.3	79.8	11.6	1.32E-03	-7.44495	5.703782	5.010635	R Squared		0.849330
3.8	2.6	81.2	12.3	1.52E-03	-7.29923	5.703782	5.010635			
6.6	2.8	81.5	9.0	5.23E-04	-8.36864	5.010635	5.703782	No. of Observations		17
6.2	2.6	82.5	8.6	6.04E-04	-8.22487	5.010635	5.703782	Degrees of Freedom		14
ERR	ERR	ERR	ERR	1.85E-04	-9.40033	5.010635	5.703782			
ERR	ERR	ERR	ERR	1.87E-04	-9.39713	5.010635	5.703782	X Coefficient(s)	-0.31891	0.317626
8.2	.0	2.1	0.4	8.31E-03	-5.60396	4.722953	5.821565	Std Err of Coef.	0.307159	0.521839
7.3	1.9	82.7	8.1	6.92E-04	-8.00945	4.722953	5.821565			
6.2	2.1	84.1	7.5	7.92E-04	-7.95431	4.722953	5.821565			
6.2	2.1	84.2	7.4	7.78E-04	-7.97197	4.722953	5.821565			
3.5	1.6	86.8	8.0	6.26E-04	-8.18998	5.703782	5.010635			
3.4	1.6	84.5	10.4	5.93E-04	-8.24165	5.703782	5.010635			
3.6	1.7	86.0	[illegible]	[illegible]	[illegible]	5.703782	5.010635			
3.6	1.4	83.3	11.6	4.77E-04	-8.46059	5.703782	5.010635			
3.5	1.4	82.9	12.1	4.74E-04	[illegible]	5.703782	5.010635			
11.2	3.6	74.2	10.9	6.02E-03	-5.92672	5.010635	5.703782			
11.0	3.5	75.7	9.8	6.06E-03	-5.91002	5.010635	5.703782			
11.2	3.6	75.8	9.3	6.07E-03	-5.91825	5.010635	5.703782			
11.3	3.4	76.4	8.8	6.02E-03	-5.92652	5.010635	5.703782			
10.4	3.3	77.2	9.0	6.25E-03	-5.88913	5.010635	5.703782			
10.1	3.7	77.0	9.0	6.14E-03	-5.90593	5.010635	5.703782			
10.0	3.5	77.1	9.2	6.07E-03	-5.91808	5.010635	5.703782			
9.4	3.2	78.2	9.0	6.35E-03	-5.87205	5.010635	5.703782			
7.6	2.8	80.9	8.6	7.20E-03	-5.74656	5.010635	5.703782			
10.3	3.3	79.1	8.2	6.73E-03	-5.81454	4.722953	5.821565			
10.2	3.4	70.2	8.1	7.03E-03	-5.77037	4.722953	5.821565			
10.4	3.2	78.1	8.2	7.09E-03	-5.76297	4.722953	5.821565			
10.0	3.0	78.3	8.2	7.23E-03	-5.74280	4.722953	5.821565			
10.0	3.1	78.5	8.4	7.39E-03	-5.72035	4.722953	5.821565			
8.2	3.4	78.5	9.8	5.41E-03	-6.03280	5.416100	5.416100			
8.5	4.2	76.9	10.3	4.87E-03	-6.13699	5.416100	5.416100			
8.6	3.9	76.4	11.0	4.73E-03	-6.16695	5.416100	5.416100			

Table 1 Page 4

ln(ppH2)	Regression Output:			ppMeOH psi	ppMeOMe psi	ppEtOH psi	ppCO2 psi	ppH2O psi	ppH2 psi	ppCO psi	k-ugsr H2O-H2	k-MeOH CO-MeOH	ppMeOEt psi
	Constant		15.40941										
5.703782	Std Err of Y Est		0.055448	0.900	2.360	0.083	3.751	0.232	297.857	143.662	33.522	7.06E-08	0.250
5.703782	R Squared		0.967766	0.915	2.377	0.085	3.724	0.282	297.795	143.668	27.381	7.18E-08	0.251
5.703782	No. of Observations		20	0.974	2.419	0.091	3.807	0.291	297.728	143.500	27.115	7.66E-08	0.261
5.703782	Degrees of Freedom		17	1.013	2.394	0.087	3.779	0.261	297.740	143.560	29.973	7.96E-08	0.260
5.703782				0.925	2.406	0.093	3.692	0.360	297.712	143.649	21.231	7.26E-08	0.256
5.703782	X Coefficient(s)	-2.34491	-1.07056	0.736	1.629	0.064	2.174	0.508	298.137	146.020	8.826	5.67E-08	0.161
5.703782	Std Err of Coef.	0.181915	0.208945	0.698	1.617	0.057	2.139	0.483	298.197	146.097	9.035	5.38E-08	0.157
5.703782	Regression Output:			0.715	1.571	0.061	2.104	0.467	298.206	146.170	9.201	5.50E-08	0.151
5.703782	Constant		3.004125	0.612	1.266	0.048	1.495	0.558	298.365	147.105	5.435	4.67E-08	0.127
5.703782	Std Err of Y Est		0.104399	0.675	1.230	0.068	1.460	0.568	298.319	147.133	5.216	5.15E-08	0.118
5.821565	R Squared		0.639641	2.908	2.603	0.190	3.948	0.519	335.200	103.293	24.675	2.51E-07	0.177
5.821565	No. of Observations		13	2.459	2.419	0.176	3.584	0.555	335.490	104.130	20.780	2.10E-07	0.161
5.821565	Degrees of Freedom		10	2.145	1.972	0.137	2.563	0.788	335.355	106.035	10.288	1.80E-07	0.107
5.821565				1.561	1.746	0.100	2.158	0.756	335.768	107.053	8.955	1.29E-07	0.110
5.821565	X Coefficient(s)	-1.11749	-0.99029	1.323	1.288	0.089	1.395	0.773	335.911	108.582	5.583	1.08E-07	0.080
5.821565	Std Err of Coef.	0.477893	0.547571	1.219	1.298	0.082	1.311	0.826	335.907	108.751	4.902	9.93E-08	0.081
5.010635	Regression Output:			0.424	1.575	0.037	3.319	-0.682	146.299	298.310	-2.387	6.65E-08	0.213
5.010635	Constant		-6.10509	0.558	1.761	0.034	3.111	-0.333	145.510	298.665	-1.548	8.83E-08	0.197
5.010625	Std Err of Y Est		0.054136	0.315	0.971	0.035	1.824	-0.312	147.663	299.157	-2.887	4.82E-08	0.110
5.010635	R Squared		0.840330	0.561	1.187	0.038	1.744	0.070	146.501	299.509	12.227	8.72E-08	0.143
5.703782	No. of Observations		17	0.540	0.577	0.039	0.717	0.198	299.138	148.562	7.272	4.06E-08	0.039
5.703782	Degrees of Freedom		14	0.660	0.604	0.050	0.783	0.276	298.929	148.368	5.723	4.97E-08	0.042
5.703782				3.248	4.489	0.223	6.212	0.646	-24.908	459.034	-0.522	1.14E-05	0.284
5.703782	X Coefficient(s)	-0.31891	0.317626	3.277	4.564	0.236	6.294	0.608	-25.173	459.129	-0.567	1.13E-05	0.300
5.821565	Std Err of Coef.	0.307159	0.521839	7.631	7.806	0.476	9.735	2.383	-356.022	775.251	-1.876	7.77E-08	0.447
5.821565				1.087	1.199	0.074	1.396	0.440	336.421	108.926	9.799	8.82E-08	0.064
5.821565				0.773	0.691	0.046	0.634	0.412	336.650	110.551	4.682	6.17E-08	0.037
5.821565				0.713	0.720	0.046	0.582	0.491	336.601	110.605	3.605	5.69E-08	0.037
5.010635				0.348	0.846	0.028	1.005	0.112	147.703	299.709	4.421	5.24E-08	0.050
5.010635				0.317	0.777	0.026	0.922	0.169	147.756	299.841	2.691	4.84E-08	0.078
5.010635				0.311	0.741	0.025	0.910	0.091	147.957	299.800	4.954	4.74E-08	0.051
5.010635				0.525	1.122	0.038	1.726	-0.097	146.947	299.420	-8.717	8.11E-08	0.125
5.010635				0.517	1.119	0.037	1.684	-0.044	146.897	299.465	-18.698	8.00E-08	0.134
5.703782				2.322	7.019	0.208	12.699	-0.129	294.352	129.479	-222.995	2.07E-07	0.756
5.703782				2.372	7.383	0.214	12.551	0.147	293.947	129.463	193.954	2.12E-07	0.766
5.703782				1.263	3.626	0.114	5.493	0.786	296.203	140.541	14.723	1.02E-07	0.350
5.703782				1.250	3.659	0.114	5.437	0.811	296.172	140.642	14.100	1.01E-07	0.356
5.703782				1.701	3.782	0.158	5.334	1.093	295.530	140.469	10.271	1.39E-07	0.355
5.703782				1.187	2.524	0.093	3.116	1.183	296.586	144.067	5.424	8.97E-08	0.232
5.703782				1.154	2.487	0.100	3.054	1.173	296.610	144.155	5.356	9.10E-08	0.227
5.703782				1.561	2.565	0.127	3.027	1.289	296.184	143.984	4.829	1.24E-07	0.216
5.703782				2.124	2.096	0.166	2.081	1.344	296.055	145.232	3.156	1.67E-07	0.148
5.821565				1.251	2.120	0.093	2.101	1.409	335.123	106.731	4.431	1.04E-07	0.164
5.821565				1.440	2.167	0.101	2.204	1.406	335.019	106.460	4.667	1.21E-07	0.171
5.821565				1.573	2.600	0.110	2.820	1.661	334.726	105.075	5.422	1.34E-07	0.207
5.821565				1.736	2.708	0.125	2.837	1.676	334.692	104.941	5.399	1.48E-07	0.194
5.821565				1.919	2.607	0.128	2.898	1.657	334.560	104.764	5.583	1.64E-07	0.206
5.416100				0.807	1.953	0.076	2.738	0.446	220.883	222.237	6.105	7.44E-08	0.189
5.416100				0.618	1.764	0.055	2.428	0.538	221.211	222.544	4.408	5.67E-08	0.186
5.416100				0.718	2.118	0.082	3.049	0.529	220.569	221.915	5.729	6.65E-08	0.224

Table 2: Page 1

catal (ml) (mesh no)	catalyst	temp C	pressure psig	CO:H2	GHSV hr-1	time hrs	%COcon incl C
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.5	2130	10.5	7
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.5	4260	157	4
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.5	4260	157.5	3
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.5	2130	159	5
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.5	2130	160	5.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.5	3195	161	4.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.5	3195	161.5	4
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.333333	2840	162.5	6.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.333333	2840	163	6.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.333333	4260	164	5.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.333333	4260	164.5	5
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.333333	4260	165	5.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	1	2840	167	2.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	1	2840	167.5	2.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	2	3195	179.5	1.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	2	3195	180	1.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	1.5	3550	[illegible]	1.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	1.5	3550	[illegible]	1.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.25	3550	184	2.
30(80)	3%Rh 15%Mo/Al_2O_3	200	450	0.25	3550	184.5	2.

Table 2 Page 2

H_2	GHSV hr^{-1}	Time hrs	%COconv incl CO_2	Time @ condition	SELECTIVITY IN PRODUCTS CARBON% CH_4	C_2H_4	C_2H_6	C_3H_6	C_3H_8	MeOH	MeOMe	MeCHO	EtOH	C_4H_{10}	MeOAc
0.5	2130	156.5	2.4	10.5	9.2	0.0	3.5	0.0	0.0	11.7	61.9	0.0	2.1	0.0	2.4
0.5	4260	157	4.0	1.5	7.8	0.0	2.2	0.0	0.0	21.8	58.1	0.0	2.9	0.0	2.5
0.5	4260	157.5	3.0	2	7.5	0.0	2.6	0.0	0.0	21.1	58.6	0.0	2.9	0.0	2.1
0.5	2130	159	5.3	1.5	7.5	0.0	2.4	0.0	0.0	10.0	64.9	0.0	3.4	0.0	2.3
0.5	2130	160	5.3	2.5	7.9	0.0	2.4	0.0	0.0	9.9	64.5	0.0	3.3	0.0	2.1
0.5	3195	161	4.3	1	7.4	0.0	1.9	0.0	0.0	17.4	62.5	0.0	2.4	0.0	1.8
0.5	3195	161.5	4.2	1.5	7.4	0.0	1.9	0.0	0.0	16.7	63.4	0.0	2.3	0.0	2.2
.33333	2840	162.5	6.4	1	8.1	0.0	1.7	0.0	0.0	19.2	60.8	0.0	2.6	0.0	1.9
.33333	2840	163	6.5	1.5	8.2	0.0	1.8	0.0	0.0	16.9	62.9	0.0	2.2	0.0	2.0
.16333	4260	164	5.0	1	7.9	0.0	2.2	0.0	0.0	24.1	56.6	0.0	2.9	0.0	1.8
.16333	4260	164.5	5.6	1.5	7.8	0.0	2.2	0.0	0.0	23.0	57.9	0.0	3.0	0.0	1.6
.16333	4260	165	5.5	2	7.9	0.0	2.2	0.0	0.0	22.9	57.5	0.0	2.9	0.0	2.1
1	2840	167	2.5	2	6.1	0.0	2.6	0.0	0.0	7.0	66.4	0.0	3.6	0.0	2.1
1	2840	167.5	2.6	2.5	5.9	0.0	2.6	0.0	0.0	9.0	66.6	0.0	3.7	0.0	2.1
2	3195	179.5	1.3	1	4.5	0.0	3.7	0.0	0.0	8.7	68.1	0.0	2.1	0.0	2.4
2	3195	180	1.2	1.5	1.5	0.0	2.0	0.0	0.0	9.1	71.7	0.0	2.2	0.0	2.3
1.5	3550	183	1.5	1.5	5.4	0.0	2.1	0.0	0.0	9.2	67.8	0.0	2.3	0.0	2.9
1.5	3550	183.5	1.6	1	9.5	0.0	2.6	0.0	0.0	8.0	72.0	0.0	1.8	0.0	2.6
0.25	3550	184	7.4	1.5	8.7	0.0	1.6	0.0	0.0	22.2	58.4	0.0	3.2	0.0	1.3
0.25	3550	184.5	7.2	[illegible]	8.5	0.0	1.6	0.0	0.0	21.6	59.4	0.0	2.7	0.0	1.4

Table 2 Page 3

CHO	EtOH	C4H10	MeOAc	AcOH	n-PrOH	EtCHO	C5H12	MeOEt	EtOAc	n-BuOH	i-BuOH	TOTALOXY C%,CO2Free	%C2+OXG total	RATE CO gmol/hr	% to CO CO2 incl
0.0	2.1	0.0	2.4	0.0	0.0	0.0	0.0	9.8	0.0	0.0	0.0	87.3	11.8	9.1E-04	32.8
0.0	2.9	0.0	2.5	0.0	0.0	0.0	0.0	5.4	0.0	0.0	0.0	90.5	9.0	9.8E-04	21.2
0.0	2.9	0.0	2.1	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	89.9	8.7	9.4E-04	22.3
0.0	3.4	0.0	2.3	0.0	0.0	0.0	0.0	9.6	0.0	0.0	0.0	90.2	12.6	6.5E-04	26.4
0.0	3.3	0.0	2.1	0.0	0.0	0.0	0.0	10.0	0.0	0.0	0.0	89.0	12.7	6.5E-04	26.9
0.0	2.4	0.0	1.8	0.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0	90.7	8.8	7.9E-04	24.1
0.0	2.3	0.0	2.2	0.0	0.0	0.0	0.0	6.6	0.0	0.0	0.0	90.7	9.1	7.8E-04	24.3
0.0	2.6	0.0	1.9	0.0	0.0	0.0	0.0	6.2	0.0	0.0	0.0	90.2	8.9	7.9E-04	22.4
0.0	2.2	0.0	2.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	90.0	8.4	8.1E-04	23.0
0.0	2.9	0.0	1.0	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	89.9	7.9	1.1E-03	20.3
0.0	3.0	0.0	1.6	0.0	0.0	0.0	0.0	4.6	0.0	0.0	0.0	90.0	7.9	1.0E-03	20.0
0.0	2.9	0.0	2.1	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	89.9	8.1	1.0E-03	20.1
0.0	3.6	0.0	2.1	0.0	0.0	0.0	0.0	10.2	0.0	0.0	0.0	91.3	13.0	6.3E-04	28.6
0.0	3.7	0.0	2.1	0.0	0.0	0.0	0.0	10.2	0.0	0.0	0.0	91.5	13.0	6.4E-04	27.6
0.0	2.1	0.0	2.4	0.0	0.0	0.0	0.0	10.6	0.0	0.0	0.0	91.0	11.8	5.0E-04	36.4
0.0	2.2	0.0	2.3	0.0	0.0	0.0	0.0	11.2	0.0	0.0	0.0	96.6	11.7	4.4E-04	35.6
0.0	2.3	0.0	2.9	0.0	0.0	0.0	0.0	10.8	0.0	0.0	0.0	92.5	12.5	5.5E-04	30.2
0.0	1.8	0.0	2.6	0.0	0.0	0.0	0.0	9.4	0.0	0.0	0.0	93.1	10.5	5.9E-04	26.5
0.0	3.2	0.0	1.3	0.0	0.0	0.0	0.0	4.7	0.0	0.0	0.0	89.0	8.0	9.1E-04	19.3
0.0	2.7	0.0	1.4	0.0	0.0	0.0	0.0	4.9	0.0	0.0	0.0	89.9	7.7	8.9E-04	19.0

MEOCO mol/hr	CX to CO2 incl	COMMENTS
9.1E-04	32.8	MeOAc approx
9.8E-04	21.2	MeOAc approx
9.4E-04	22.3	MeOAc approx
4.5E-04	26.4	MeOAc approx
6.5E-04	26.9	MeOAc approx
6.9E-04	24.1	MeOAc approx
7.0E-04	24.3	MeOAc approx
7.9E-04	22.4	MeOAc approx
9.0E-04	23.0	MeOAc approx
1.1E-03	20.3	MeOAc approx
1.0E-03	20.0	MeOAc approx
1.0E-03	20.1	MeOAc approx
6.3E-04	20.6	MeOAc approx
5.4E-04	27.6	MeOAc approx
5.0E-04	36.4	MeOAc approx
4.4E-04	35.6	MeOAc approx
5.5E-04	30.2	MeOAc approx
5.9E-04	26.5	MeOAc approx
9.0E-04	19.3	MeOAc approx
9.9E-04	19.0	MeOAc approx

HYDRO CX C1	c2	C3	c4	OXYG CX C1	C2
9.2	3.5	0.0	0.0	77.0	10.
7.3	2.2	0.0	0.0	82.4	8.
7.5	2.6	0.0	0.0	82.1	7.
7.5	2.4	0.0	0.0	78.0	11.
7.9	2.4	0.0	0.0	78.3	11.
7.4	1.9	0.0	0.0	82.	7.
7.4	1.9	0.0	0.0	82.5	8.
8.1	1.7	0.0	0.0	82.1	8.
8.2	1.0	0.0	0.0	82.4	7.
7.9	2.2	0.0	0.0	82.4	7.
7.8	2.2	0.0	0.0	82.9	7.
7.9	2.2	0.0	0.0	82.6	7.
6.1	2.6	0.0	0.0	79.4	11.
5.9	2.6	0.0	0.0	79.6	11.
4.5	3.7	0.0	0.0	81.0	10.
1.5	2.0	0.0	0.0	85.3	11.
5.4	2.1	0.0	0.0	81.0	11.
3.5	2.6	0.0	0.0	84.0	9.
8.7	1.6	0.0	0.0	82.6	7.
8.5	1.6	0.0	0.0	83.0	6.

Table 2 Page 5

C3	c4	oxyg C1	C2	C2	C3	C4	turnover no. sec-1	ln(rate)	ln(ppCO)	ln(ppH2)	Constant	Regression Output:	-10.2741	Rate CO gmol/hr
3.5	0.0	0.0	77.0	10.2	0.0	0.0	2.04E-03	-7.007	5.011	5.704	Std Err of Y Est		0.049510	2.97E-0
2.2	0.0	0.0	82.4	8.0	0.0	0.0	2.21E-03	-6.928	5.011	5.704	R Squared		0.966025	2.08E-0
2.6	0.0	0.0	82.1	7.7	0.0	0.0	2.12E-03	-6.970	5.011	5.704	No. of Observations		20	2.09E-0
2.4	0.0	0.0	78.9	11.2	0.0	0.0	1.46E-03	-7.345	4.317	5.011	Degrees of Freedom		17	1.70E-0
2.4	0.0	0.0	78.9	11.3	0.0	0.0	1.46E-03	-7.345	4.317	5.011				1.74E-0
1.9	0.0	0.0	82.7	7.9	0.0	0.0	1.70E-03	-7.145	4.723	5.416	X Coefficient(s)	-0.05871	0.628140	1.90E-0
1.9	0.0	0.0	82.5	8.1	0.0	0.0	1.70E-03	-7.150	4.723	5.416	Std Err of Coef.	0.031010	0.033043	1.89E-0
1.7	0.0	0.0	82.1	8.0	0.0	0.0	1.78E-03	-7.146	4.317	5.416	ln(rate CO)=a+bln(ppCO)+cln(ppH2)			1.76E-0
1.8	0.0	0.0	82.4	7.5	0.0	0.0	1.80E-03	-7.[illegible]	4.317	5.416				1.84E-0
2.2	0.0	0.0	82.8	7.1	0.0	0.0	2.39E-03	-6.[illegible]	4.723	5.822	ln(rateCO2)=a+bln(ppCO)+cln(ppH2)			2.15E-0
2.2	0.0	0.0	82.9	7.1	0.0	0.0	2.31E-03	-6.089	4.723	5.822	Regression Output:			2.05E-0
2.2	0.0	0.0	82.6	7.2	0.0	0.0	2.30E-03	-6.089	4.723	5.822	Constant		-10.6637	2.04E-0
2.6	0.0	0.0	79.4	11.7	0.0	0.0	1.43E-03	-7.370	5.011	5.011	Std Err of Y Est		0.109476	1.80E-0
2.6	0.0	0.0	79.[illegible]	11.8	0.0	0.0	1.44E-03	-7.354	5.011	5.011	R Squared		0.479267	1.77E-0
3.7	0.0	0.0	81.8	10.7	0.0	0.0	1.12E-03	-7.611	5.416	4.723	No. of Observations		20	1.80E-1
2.0	0.0	0.0	86.3	11.1	0.0	0.0	9.94E-04	-7.727	5.416	4.723	Degrees of Freedom		17	1.57E-1
2.1	0.0	0.0	81.0	11.4	0.0	0.0	1.24E-03	-7.506	5.416	5.011				1.66E-1
2.6	0.0	0.0	84.0	9.7	0.0	0.0	1.34E-03	-7.420	5.416	5.011	X Coefficient(s)	0.114370	0.285524	1.58E-1
1.6	0.0	0.0	82.6	7.1	0.0	0.0	2.04E-03	-7.010	4.317	5.704	Std Err of Coef.	0.068569	0.078065	1.74E-1
1.6	0.0	0.0	83.0	6.0	0.0	0.0	2.00E-03	-7.027	4.317	5.704				1.60E-1

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Regression Output:		-10.2744	Rate CO2 gmol/hr	-ln(rate CO2)	ppMeOH psi	ppMeOMe	ppEtOH	ppCO2	ppH2O	ppH2	ppCO	k-wgsr H2O-H2	k-MeOH CO-MeOH	ppMeOEt
of Y Est		0.049510	2.97E-04	-8.123	0.900	2.360	0.083	3.751	0.232	297.857	143.662	33.522	7.06E-08	0.250
d		0.966[illegible]25	2.08E-04	-8.478	1.046	1.399	0.069	1.299	0.037	297.736	147.082	3.140	8.04E-08	0.086
Observations		20	2.09E-04	-8.472	0.961	1.336	0.066	1.305	0.747	297.909	147.166	3.537	7.36E-08	0.080
of Freedom		17	1.70E-04	-8.679	0.294	0.956	0.049	1.054	0.451	146.312	71.980	4.767	1.89E-07	0.094
			1.74E-04	-8.657	0.208	0.943	0.049	1.077	0.428	146.951	71.971	5.149	1.85E-07	0.097
ient(s)	-0.05871	0.628140	1.90E-04	-8.569	0.647	1.164	0.045	1.180	0.561	222.179	109.454	4.268	1.20E-07	0.082
r Coef.	0.031010	0.033043	1.89E-04	-8.571	0.595	1.159	0.043	1.177	0.552	222.252	109.486	4.326	1.10E-07	0.080
U)=a+bln(ppCO)+cln(ppH2)			1.76E-04	-8.643	0.729	1.146	0.049	1.096	0.655	221.989	71.365	5.204	2.07E-07	0.079
			1.84E-04	-8.600	0.648	1.204	0.041	1.144	0.665	222.002	71.290	5.356	1.85E-07	0.077
O2)=a+bln(ppCO)+cln(ppH2)			2.15E-04	-8.444	1.276	1.497	0.077	1.347	0.951	335.767	108.500	4.383	1.04E-07	0.079
Regression Output:			2.05E-04	-8.495	1.101	1.484	0.077	1.279	0.970	335.791	108.649	4.042	9.64E-08	0.078
		-10.[illegible]87	2.04E-04	-8.495	1.168	1.464	0.079	1.278	0.961	335.017	108.660	4.108	9.53E-08	0.076
Y Est		0.10[illegible]476	1.80E-04	-8.622	0.249	0.924	0.051	1.115	0.310	147.292	147.952	3.576	7.76E-08	0.094
		0.473[illegible]57	1.77E-04	-8.640	0.257	0.954	0.052	1.094	0.370	147.101	147.944	2.940	8.03E-08	0.097
ervations		20	1.80E-04	-8.621	0.168	0.661	0.021	1.112	-0.119	110.605	223.001	-4.604	6.14E-08	0.060
of Freedom		17	1.57E-04	-8.759	0.160	0.627	0.020	0.967	-0.116	110.824	224.026	-4.108	5.80E-08	0.065
			1.66E-04	-8.704	0.218	0.798	0.027	1.025	0.171	147.749	223.963	3.946	4.45E-08	0.086
ient(s)	0.114370	0.20[illegible]24	1.58E-04	-8.756	0.718	0.973	0.025	0.975	0.3[illegible]1	147.200	224.014	1.601	4.48E-08	0.085
of Coef.	0.060569	0.073005	1.74E-04	-8.657	1.011	1.320	0.072	1.084	0.[illegible]49	297.648	70.892	4.829	1.61E-07	0.071
			1.69E-04	-8.606	0.968	1.330	0.062	1.053	0.[illegible]	297.677	70.956	4.628	1.54E-07	0.071

Table 3 Page L

catal no (page no)	catalyst		pressure psig	CO:H2	GHSV hr-1	time hrs
30(00)	3%Rh 15%Mo/Al2O3	200	450	0.5	2130	10.5
30(00)	3%Rh 15%Mo/Al2O3	200	450	0.5	4260	107
30(00)	3%Rh 15%Mo/Al2O3	200	450	0.5	4260	107.5
30(00)	3%Rh 15%Mo/Al2O3	200	300	0.5	4260	108.5
30(00)	3%Rh 15%Mo/Al2O3	200	300	0.5	4260	109
30(00)	3%Rh 15%Mo/Al2O3	200	600	0.5	4260	110.5
30(00)	3%Rh 15%Mo/Al2O3	200	600	0.5	4260	111
30(00)	3%Rh 15%Mo/Al2O3	200	750	0.5	4260	112.5
30(00)	3%Rh 15%Mo/Al2O3	200	750	0.5	4260	113
30(00)	3%Rh 15%Mo/Al2O3	200	750	0.5	4260	113.5
30(00)	3%Rh 15%Mo/Al2O3	200	150	0.5	4260	115
30(00)	3%Rh 15%Mo/Al2O3	200	15	0.5	4260	117
30(00)	3%Rh 15%Mo/Al2O3	200	15	0.5	4260	117.5
30(80)	3%Rh 15%Mo/Al2O3	200	450	0.5	4260	135.5
30(00)	3%Rh 15%Mo/Al2O3	200	450	0.5	4260	136.5
30(00)	3%Rh 15%Mo/Al2O3	200	450	0.000900	4259	137
30(00)	3%Rh 15%Mo/Al2O3	200	450	0.300120	4259	137.5
30(00)	3%Rh 15%Mo/Al2O3	200	750	0.499049	7099	138.5
30(00)	3%Rh 15%Mo/Al2O3	200	750	0.499019	7099	139
30(00)	3%Rh 15%Mo/Al2O3	200	300	0.[illegible]	[illegible]	141
[illegible]	[illegible]	200	300	0.[illegible]	[illegible]	141.5
30(00)	3%Rh 15%Mo/Al2O3	200	150	0.5	1419	144
30(00)	3%Rh 15%Mo/Al2O3	200	150	0.5	1419	144.5

Table 3 Page 2

pressure psin	CO:H2	GHSV hr-1	time hrs	%CO conv incl CO2	time @ condition	SELECTIVITY IN PRODUCTS CH4	C2H4	C2H6	CARBON% C3H6	C3H8	MeOH	MeOMe	MeCHO	EtOH	C4H10
450	0.5	2130	10.5	7.4	10.5	9.2	0.0	3.5	0.0	0.0	11.7	61.9	0.0	2.1	
450	0.5	4260	107	3.0	1	7.5	0.0	1.3	0.0	0.0	17.6	64.4	0.0	2.2	
450	0.5	4260	107.5	3.0	1.5	7.6	0.0	1.3	0.0	0.0	17.6	63.4	0.0	2.2	
300	0.5	4260	108.5	3.2	1	6.9	0.0	1.6	0.0	0.0	15.0	66.2	0.0	1.7	
300	0.5	4260	109	3.2	1.5	7.1	0.0	1.6	0.0	0.0	15.6	64.0	0.0	2.2	
600	0.5	4260	110.5	4.2	1	8.5	0.0	1.2	0.0	0.0	22.2	58.3	0.0	2.5	
600	0.5	4260	111	4.3	1.5	7.7	0.0	2.5	0.0	0.0	23.9	56.5	0.0	2.8	
750	0.5	4260	112.5	5.1	1.5	8.1	0.0	2.1	0.0	0.0	20.9	52.1	0.0	3.3	
750	0.5	4260	113	4.7	2	8.0	0.0	2.2	0.0	0.0	24.3	55.6	0.0	3.0	
750	0.5	4260	113.5	4.7	2.5	8.4	0.0	2.2	0.0	0.0	24.2	56.1	0.0	3.1	
150	0.5	4260	115	2.5	1.5	6.4	0.0	4.3	0.0	0.0	12.1	63.5	0.0	1.3	
15	0.5	4260	117	0.9	1	5.1	0.0	4.4	0.0	0.0	4.1	75.0	0.0	0.0	
15	0.5	4260	117.5	1.0	1.5	2.6	0.0	3.1	0.0	0.0	9.8	71.7	0.0	0.0	
450	0.5	4260	135.5	3.9	2	7.6	0.0	1.5	0.0	0.0	22.2	50.1	0.0	[illegible]	
450	0.5	4260	136.5	3.8	2.5	8.1	0.0	2.7	0.0	0.0	18.5	59.7	0.0	[illegible]	
450	0.000300	4259	137	4.1	1	6.8	0.0	8.9	0.0	0.0	25.7	49.4	0.0	[illegible]	
450	0.800120	4259	137.5	3.7	1.5	7.0	0.0	2.6	0.0	0.0	25.4	54.6	0.0	3.4	
750	0.499849	7099	138.5	3.6	1	7.1	0.0	2.5	0.0	0.0	30.0	50.3	0.0	3.7	
750	0.499849	7009	139	3.4	1.5	7.7	0.0	2.7	0.0	0.0	28.1	52.0	0.0	[illegible]	
300	0.499624	2899	141	4.3	2	7.6	0.0	2.1	0.0	0.0	15.0	63.2	0.0	[illegible]	
300	0.499624	2899	141.5	4.3	2.5	7.1	0.0	2.1	0.0	0.0	14.7	64.6	0.0	[illegible]	
150	0.5	1419	144	5.9	2.5	8.1	0.0	2.8	0.0	0.0	7.5	68.5	0.0	1.2	
150	0.5	1419	144.5	1.9	3	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	

Table 3, Page3

MeOMe	MeCHO	EtOH	C4H10	MeOMe	MeOH	n-PrOH	EtCHO	C5H12	MeOEt	EtOMe	n-BuOH	i-BuOH	TOTALOXY C%,CO2free	%C2+OXG total	RATE C gmol/h
61.3	0.0	2.4	0.0	2.4	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	87.3	11.8	9.1E-
64.4	0.0	2.2	0.0	1.9	0.0	0.0	0.0	0.0	[illegible]	0.0	0.0	0.0	91.2	7.6	9.3E-
63.4	0.0	2.2	0.0	1.5	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	91.0	8.2	9.4E-
66.2	0.0	1.7	0.0	3.0	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	92.1	8.6	7.0E-
64.[illegible]	0.0	2.2	0.0	1.8	0.0	0.0	0.0	0.0	6.0	0.0	0.0	0.0	91.3	8.7	7.7E-
58.3	0.0	[illegible]	0.0	2.1	0.0	0.0	0.0	0.0	5.9	0.0	0.0	0.0	90.3	8.2	1.0E
56.5	0.0	2.8	0.0	2.0	0.0	0.0	0.0	0.0	5.2	0.0	0.0	0.0	89.0	8.5	1.1E
52.1	0.0	3.5	0.0	2.3	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	89.9	8.4	1.2E
55.0	0.0	3.0	0.0	2.3	0.0	0.0	0.0	0.0	4.5	0.0	0.0	0.0	89.7	9.4	1.2E
56.1	0.0	3.1	0.0	2.1	0.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0	89.4	7.9	1.2E
63.5	0.0	1.8	0.0	2.7	0.0	0.0	0.0	0.0	9.2	0.0	0.0	0.0	89.3	10.9	6.1E
75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	10.5	0.0	0.0	0.0	90.5	7.8	2.3E
71.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	12.0	0.0	0.0	0.0	94.3	9.7	2.4E
60.1	0.0	3.2	0.0	1.9	0.0	0.0	0.0	0.0	5.6	0.0	0.0	0.0	90.9	9.0	9.7E
59.7	0.0	[illegible]	0.0	2.1	0.0	0.0	0.0	0.0	6.4	0.0	0.0	0.0	89.2	9.2	9.4E
49.8	0.0	[illegible]	0.0	1.9	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	84.3	8.7	1.3E
54.0	0.0	[illegible]	0.0	2.0	0.0	0.0	0.0	0.0	4.1	0.0	0.0	0.0	90.5	9.0	1.2E
50.3	0.0	[illegible]	0.0	2.1	0.0	0.0	0.0	0.0	3.6	0.0	0.0	0.0	90.4	8.1	1.5E
[illegible]	0.0	3.2	0.0	2.0	0.0	0.0	0.0	0.0	3.5	0.0	0.0	0.0	89.6	7.7	1.4E
[illegible]	0.0	[illegible]	0.0	[illegible]	0.0	0.0	0.0	0.0	[illegible]	0.0	0.0	0.0	90.9	9.1	7.1E
[illegible]	0.0	[illegible]	0.0	[illegible]	0.0	0.0	0.0	0.0	[illegible]	0.0	0.0	0.0	90.8	9.3	7.1E
[illegible]	0.0	[illegible]	0.0	2.2	0.0	0.0	0.0	0.0	[illegible]	0.0	0.0	0.0	[illegible]	[illegible]	[illegible]
ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	ERR	[illegible]

Table 3 Page 4

[illegible] (%)	RATE CO gmol/hr	C% to CO2 incl	COMMENTS	HYDRO C% C1	c2	C3	c4	oxyg C% C1	C
11.8	9.1E-04	32.8	MeOMe approx	9.2	3.5	0.0	0.0	77.0	
7.6	9.3E-04	24.5		7.5	1.9	0.0	0.0	84.9	
9.2	9.4E-04	24.5		7.6	1.3	0.0	0.0	83.6	
9.6	7.0E-04	23.1		6.8	1.6	0.0	0.0	84.2	
9.7	7.7E-04	22.9		7.1	1.6	0.0	0.0	83.3	
9.2	1.0E-03	25.0		8.5	1.2	0.0	0.0	82.9	
9.5	1.1E-03	23.3		7.7	2.5	0.0	0.0	82.1	
9.4	1.2E-03	29.3		8.1	2.1	0.0	0.0	82.4	
9.4	1.3E-03	24.6		8.0	2.2	0.0	0.0	82.2	
7.9	1.3E-03	24.6		8.4	2.2	0.0	0.0	82.3	
10.9	6.1E-04	22.7	MeOH and MeOMe peaks fused, MeOH shoulder seen(apprx as 15%),EtOH peak s	6.4	4.3	0.0	0.0	79.6	
7.8	2.3E-04	43.1	MeOH ,EtOH and MeOMe not seen, rdg very inaccurate	5.1	4.4	0.0	0.0	83.4	
9.1	2.4E-04	22.7		2.6	3.1	0.0	0.0	85.7	
9.0	9.7E-04	22.6		7.6	1.5	0.0	0.0	82.7	
9.2	9.4E-04	23.2		8.1	2.7	0.0	0.0	81.0	
9.7	1.3E-03	18.9		6.8	8.9	0.0	0.0	77.0	
9.0	1.2E-03	20.1		7.0	2.6	0.0	0.0	82.3	
9.1	1.5E-03	18.7		7.1	2.5	0.0	0.0	83.0	
7.7	1.4E-03	19.8		7.7	2.7	0.0	0.0	82.7	
9.1	7.1E-04	25.1		7.6	2.1	0.0	0.0	82.0	
9.3	7.0E-04	24.9		7.1	2.1	0.0	0.0	82.4	
10.3	4.0E-04	30.6	MeOMe approx	8.1	2.8	0.0	0.0	79.9	
ERR	1.5E-04	100.0	MeOMe approx	ERR	ERR	ERR	ERR	ERR	

Table 3 Page 5

H.O CX c2	C3	c4	exxn C1	CX C2	C3	C4		Turnover no. sec-1	ln(rate)	ln(ppCO)	ln(ppH2)	Actual Contact E
9.[illegible]	3.5	0.0	0.0	77.0	10.2	0.0	0.0	2.04E-03	-7.00[illegible]	5.010635	5.703702	0.582867
7.8	1.3	0.0	0.0	84.9	6.9	0.0	0.0	2.10E-03	-6.97669	5.010635	5.703782	0.266189
7.6	1.3	0.0	0.0	83.6	7.4	0.0	0.0	2.12E-03	-6.96956	5.010695	5.703782	0.266189
6.9	1.6	0.0	0.0	84.2	7.8	0.0	0.0	1.76E-03	-7.15456	4.605170	5.298317	0.177455
7.1	1.6	0.0	0.0	83.5	7.9	0.0	0.0	1.74E-03	-7.16506	4.605170	5.298317	0.177455
8.5	1.2	0.0	0.0	82.9	7.4	0.0	0.0	2.31E-03	-6.08194	5.298317	5.991464	0.354911
7.7	2.5	0.0	0.0	82.1	7.5	0.0	0.0	2.38E-03	-6.05489	5.298317	5.991464	0.354911
8.1	2.1	0.0	0.0	82.4	7.5	0.0	0.0	2.82E-03	-6.68511	5.521460	6.214600	0.443639
8.0	2.2	0.0	0.0	82.2	7.5	0.0	0.0	2.61E-03	-6.76161	5.521460	6.214608	0.443639
8.4	2.2	0.0	0.0	82.3	7.0	0.0	0.0	2.62E-03	-6.75648	5.521460	6.214608	0.443639
6.4	4.3	0.0	0.0	79.6	9.6	0.0	0.0	1.37E-03	-7.40739	3.912023	4.605170	0.088727
5.1	4.4	0.0	0.0	83.4	7.0	0.0	0.0	5.19E-04	-8.37[illegible]	1.609437	2.302585	0.008872
2.6	3.1	0.0	0.0	85.7	8.5	0.0	0.0	5.50E-04	-8.31805	1.609437	2.302585	0.008872
7.6	1.5	0.0	0.0	82.7	8.1	0.0	0.0	2.10E-03	-6.94101	5.010695	5.703702	0.266189
8.1	2.7	0.0	0.0	81.0	8.1	0.0	0.0	2.12E-03	-6.97000	5.010635	5.703702	0.266189
6.0	8.9	0.0	0.0	77.0	7.3	0.0	0.0	3.09E-03	-6.61152	5.2[illegible]	5.521294	0.266246
7.0	2.6	0.0	0.0	[illegible]	8.1	0.0	0.0	2.70E-03	-6.70[illegible]	5.298400	5.521394	0.266272
7.1	2.5	0.0	0.0	83.0	7.3	0.0	0.0	3.36E-03	-6.51039	5.521260	6.214700	0.266237
7.7	2.7	0.0	0.0	82.7	6.0	0.0	0.0	3.12E-03	-6.5[illegible]	[illegible]	6.214700	0.266217
[illegible]	[illegible]	0.0	0.0	[illegible]	8.1	0.0	0.0	1.[illegible]	-7.[illegible]	4.[illegible]	5.[illegible]	0.[illegible]
[illegible]	[illegible]	0.0	0.0	[illegible]	8.1	0.0	0.0	1.[illegible]	-7.[illegible]	4.[illegible]	5.298[illegible]	0.[illegible]
[illegible]	[illegible]	0.0	0.0	[illegible]	9.0	0.0	0.0	1.00E-[illegible]	-7.[illegible]	[illegible]	4.605170	0.266450
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.42E-0[illegible]	-8.[illegible]	[illegible]	4.605170	0.266450

Table 3 Page 6

ppMeOH psi	ppMeOMe	ppEtOH	ppCO2	ppH2O	ppH2 H2O-H2	ppCO CO-MeOH	k-wgsr H2O-H2	k-MeOH CO-MeOH	ppMeOEt
0.900	2.960	0.083	3.751	0.292	297.857	143.662	33.522	7.06E-08	0.250
0.771	1.413	0.048	1.425	0.604	298.175	147.102	4.781	5.89E-08	0.076
0.779	1.400	0.048	1.438	0.616	298.154	147.081	4.731	5.96E-08	0.094
0.373	0.824	0.023	0.740	0.420	198.946	98.414	3.603	9.57E-08	0.050
0.384	0.002	0.027	0.734	0.417	198.912	98.490	3.394	9.86E-08	0.056
1.420	1.967	0.081	2.135	0.704	397.341	195.715	6.158	4.60E-08	0.113
1.571	1.903	0.094	2.051	0.713	397.014	195.687	4.556	5.09E-08	0.116
2.893	2.614	0.170	3.143	1.102	495.552	243.590	5.720	4.74E-08	0.121
2.210	2.593	0.137	2.971	0.979	496.158	243.971	6.169	3.60E-08	0.130
2.216	2.568	0.142	2.986	0.985	496.099	243.941	6.101	3.69E-08	0.116
0.117	0.307	0.009	0.284	0.203	99.568	49.390	2.818	2.40E-07	0.030
0.001	0.010	0.000	0.020	-0.006	10.000	4.971	-7.153	2.23E-06	0.001
0.004	0.014	0.000	0.011	0.008	9.984	4.976	2.041	7.63E-06	0.002
1.038	1.357	0.074	1.163	0.695	297.899	147.070	3.975	7.95E-08	0.087
0.830	1.342	0.055	1.359	0.749	297.979	147.132	3.072	6.35E-08	0.096
1.765	1.097	0.114	1.549	1.519	244.736	197.661	1.303	1.49E-07	0.093
1.559	1.676	0.105	1.547	1.058	245.645	197.762	1.825	1.31E-07	0.088
2.325	1.099	0.192	1.782	1.241	496.191	245.683	2.775	3.84E-08	0.081
1.950	1.028	0.112	1.710	1.157	496.575	245.914	2.985	3.22E-08	0.080
0.529	1.049	0.039	1.112	0.470	198.694	97.723	4.806	1.37E-07	0.074
0.494	1.066	0.036	1.096	0.490	198.711	97.745	4.552	1.25E-07	0.077
0.156	0.718	0.012	0.924	0.187	99.347	40.373	10.159	3.28E-07	0.068
0.127	6.589	0.012	0.842	6.108	91.490	44.564	0.283	3.40E-07	0.062

Table 4:

COMPARISON OF POWER LAW RATE PARAMETERS

$$\text{RATE} = A \cdot e^{-E/RT} \; P_{H_2}^{x} \cdot P_{CO}^{y}$$

CATALYST	CH4		MeOH		REFERENCE
	x	y	x	y	
Rh / SiO2	0.57	-0.2			a
Rh / SiO2	0.7	-0.2	1.3	-0.1	b
Rh / La2O3	0.8	-0.6	1.1	0.1	c
Rh / La2O3	0.9	-0.5	1.5	-0.1	b
Rh/Mo/Al2O3	1.0	-0.3	2.0	0	U. Del.

a F. Solymosi, I. Tombacz, M. Kocis. J.Catal., 75 (1982) 78

b R.P. Underwood, A.T. Bell. Applied Catal., 21 (1986) 157

c M. Ichikawa, K. Shikakura. Proc. 7th Int. Congr. Catal. Tokyo (1980)

U. Del. C. Sudakar, N. Bhore, K. Bischoff, W. Manogue, A. Mills

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