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APPENDIX A

SAMPLE OF CALCULATIONS

1. Preparation of 9%Ce-0.03%Co-0.03%Pd Catalysts with the Incipient Impregnation Method

Reagent : -Cerium [III] nitrate ($Ce(NO_3)_3 . 6H_2O$)

Purity 98% ; Molecular weight = 434.22 g.

Atomic weight of Cerium = 140.12

-Cobalt [II] nitrate ($Co(NO_3)_2 . 6H_2O$)

Purity 99% ; Molecular weight = 291.04 g.

Atomic weight of Cobalt = 58.933

-Palladium [II] nitrate ($Pd(NO_3)_2$)

Purity 100% ; Molecular weight = 230.43 g.

Atomic weight of Palladium = 106.4

Support : Alumina ($\gamma-Al_2O_3$) ; type KNH -3

Pore volume = 1.0 ml./ g.

From Sumitomo Aluminium Smelting Co.,Ltd.

Calculation for prepared 9%Ce-0.03%Co-0.03%Pd / Al_2O_3 (% by weight)

based on : Catalyst 9%Ce-0.03%Co-0.03%Pd/$\gamma-Al_2O_3$ = 100 g.

Hence : each 100 gram. of the catalyst is composed of

Cerium	9	g.
Cobalt	0.03	g.
Palladium	0.03	g.
Aluminium	X	g.

Then 9+0.03+0.03+X = 100 gram.

Support (X) = 90.94 gram.

The alumina support weight used for all preparations is 3 gram.

1. Cerium required = 3x9/90.94 = 0.2969 g.

Cerium (Ce) was prepared form 25 ml. of solution of Cerium nitrate which was prepared by dissolving 10 g. of Cerium nitrate in de-ionized water.

Then ; Ce content in stock solution = 10x140.12/(434.22/0.98)

= 3.1623 g.

Cerium nitrate taken = 0.2969x25/3.1623 ml.

from stock solution = 2.35 ml.

2. Cobalt required = 3x0.03/90.94 = 9.8966×10^{-4} g.

Cobalt (Co) was prepared form 25 ml. of solution of Cobalt nitrate which was prepared by dissolving 1 g. of Cobalt nitrate in de-ionized water.

Then ; Co content in stock solution = 1x58.9332/(291.04/0.99)

= 0.2005 g.

Cobalt nitrate taken = 9.8966×10^{-4} x25/0.2005 ml.

from stock solution = 0.12 ml.

3. Palladium required = 3x0.03/90.94 = 9.8966×10^{-4} g.

Palladium nitrate 0.1 g. dissolved in de-ionized water with 0.4 ml. of Hydrochloric acid (concentration of HCl is 37% Volume by Volume)

Then ; Pd content in stock solution = 0.1x106.4/(291.04)

= 0.046 g.

Palladium nitrate taken = $9.8966x10^{-4}$ x25/0.046 ml.

from stock solution = 0.54 ml.

The incipient impregnation was performed by sequential impregnate method in this research. As the pore volume of the alumina support is 1 ml./g., the total volume of each reagent used, $Ce(NO_3)_3$, $Co(NO_3)_2$, $Pd(NO_3)_2$ is made by adding de-ionized water to increase the volume of the impregnation solution volume by 3 ml. for impregnate in 3 gram of support.

2. Calculation of metal active site on catalyst

The weight of catalyst used = w g.

Area of CO peak after adsorption = A unit.

Average area of 0.18 cc. standard CO peak = B unit.

Amounts of CO adsorbed on catalyst = B-A unit.

Volume of CO adsorbed on catalyst = [(B-A)/B]x0.18 ml.

Volume of gas 1 mole at 30°C = $24.86x10^3$ ml.

Mole of CO adsorbed on catalyst (mole) = $[(B-A)/B]x[0.18/24.86x10^3]$

1 mole is $6.02x10^{23}$ molecule

Then, Molecule of CO adsorbed on catalyst

= $7.24x10^{-6}[(B-A)/B]x[6.02x10^{23}]$ molecules

Metal active site = $4.36x10^{18}x[(B-A)/B]$ molecules of CO / g. of catalyst.

Example of calculation active site of modified three-way catalyst.

CAT.1 (9%Ce-0.03%Co-0.03%Pd) 0.4 gram. was evaluated.

Area of CO peak after adsorption = 8603 unit.

Average area of 0.18 ml. standard CO peak = 9092 unit

Amount of CO adsorbed on catalyst = (9092-8603) unit.

Volume of CO adsorbed on catalyst = (9092-8603)/9092x0.18

= 9.68×10^{-3} ml.

The adsorption CO condition was carried out at 30°C

Then, Mole of CO adsorbed on catalyst = $(9.68 \times 10^{-3})/(24.86 \times 10^{3})$

Molecule of CO adsorbed on catalyst (0.40 g.)

= $(9.68 \times 10^{-3})/(24.86 \times 10^{3}) \times 6.02 \times 10^{23} = 2.344 \times 10^{17}$ molecules

Metal active site = $(2.344 \times 10^{17})/(0.40) = 5.86 \times 10^{17}$ molecules/g. of catalyst

APPENDIX B

Table B-1 Shows Specification of Alumina Support (Al_2O_3) Type KNH-3

Chemical Composition (weight percent)		
-Al_2O_3	60-70	%
-SiO_2	30-35	%
-Fe_2O_3	0.3-0.5	%
-TiO_2	0.5-0.7	%
-CaO	0.1-0.2	%
-MgO	0.2-0.4	%
-Na_2O	0.3-0.4	%
-K_2O	0.2-0.3	%
-ZrO_2 + HfO_2	0.03-0.04	%

Physical Properties	
- Bulk density (g/ml.)	1.3 -1.5
- Apparent Specific Gravity	3.1-3.3
- Packing Density (lb./ft^3)	20-25
- Pore Volume (ml./g)	1.0-1.3
- Surface Area (m^2/g)	340-350

Table B-2 Shows the conditions of calcining the reagent used for preparation modified catalysts.

Name of reagent	Temperature of calcining and holding time (hr.)
1. $Ce(NO_3)_3.6H_2O$	500 °C : 4 hrs.
2. $Co(NO_3)_2.6H_2O$	400 °C : 3 hrs.
3. $Pd(NO_3)_2.6H_2O$	500 °C : 2 hrs.
4. $Ni(NO_3)_2.6H_2O$	300 °C : 1 hrs.
5. $Cu(NO_3)_2.3H_2O$	500 °C : 4 hrs.
6. $Cd(Cl_2).2(1/2)H_2O$	500 °C : 4 hrs.
7. $Ag(NO_3)$	500 °C : 4 hrs.
8. $Ga_2(SO_4)_3.nH_2O$	500 °C : 4 hrs.
9. $(NH_4)_6Mo_7O_{24}.4H_2O$	500 °C : 4 hrs.
10. $Mg(NO_3)_2.6H_2O$	500 °C : 4 hrs.
11. $Fe(NO_3)_3.9H_2O$	500 °C : 4 hrs.
12. $H_2PtCl_6.H_2O$	500 °C : 4 hrs.
13. $Rh(NO_3)_3$	500 °C : 4 hrs.

The operating conditions for gas chromotography.

1. A thermal conductivity detector gas chromotograph (model 8ATP) was used to analyze the concentrations of oxygen, nitrogen, carbon monoxide.

   OPERATING CONDITIONS ARE AS FOLLOWS :

GC.	:	SHIMUDZU-GC-8ATP
Detector	:	TCD.
Packed column	:	MS-5A
Carrier gas	:	Ultra high Purity Helium (99.999%)
Flow rate of Carries gas	:	30 ml./min
Column temperature	:	90 °C
Detector temperature	:	100 °C
Injector temperature	:	100 °C
Current	:	80 mA

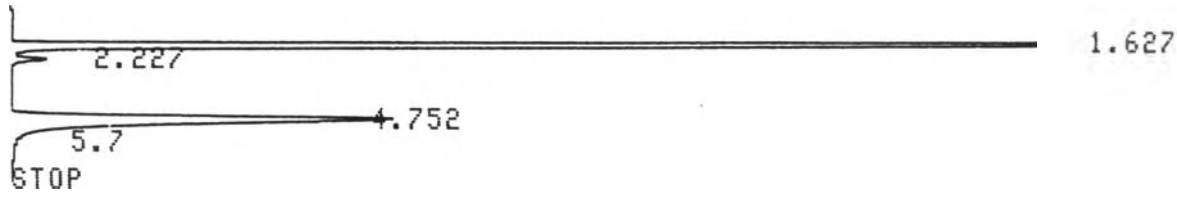
2. For Gas chromatograph model 8AIT was used to analyze the concentration of H_2O , propane, carbon dioxide.

   Operating conditions were similar to model 8ATP except :

Column packing	:	Porapak - Q
Carrier gas	:	High Purity Helium (99.99%)
Flow rate of Carrier gas	:	60 ml./min

The chromatograph from gas analysis are shown in Figure B-1 , B-2 respectively.

Figure B-1 Sample of Chromatogram from GC-8ATP (column MS-5A)



PNKO	TIME	AREA	CONC	NAME
1.	1.627	40954	82.4265	OXYGEN
2.	2.227	386	0.7766	NITROGEN
3.	4.752	8344	16.7969	CARBON MONOXIDE
		---	---	
	TOTAL	49674	100	

Figure B-2 Sample of Chromatogram from GC-8AIT (column Porapak Q)

PNKO	TIME	AREA	CONC	NAME
1.	0.558	8309	56.7033	$N_2 + O_2$
2.	1.018	2397	19.7708	CO_2
3.	2.595	504	3.4385	H_2O
4.	6.192	2943	20.0874	PROPANE
		---------	----------	
	TOTAL	14653	100	

VITA

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