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APPENDICES

APPENDIX A

SAMPLES OF CALCULATION

Preparation of 0.3%Pt/Al_2O_3 Catalysts with the Dry Impregnation Method

Reagent: Chloroplatinic acid ($H_2PtCl_6 \cdot 6H_2O$)

Molecular weight = 517.92 g

(Atomic weight of Platinum = 195.08)

Support : Alumina (γ-Al_2O_3); type KNH-3

Pore volume = 1.0 ml/g

From Sumitomo Aluminium Smelting Co., Ltd., Japan.

Calculation for prepared 0.3%Pt/Al_2O_3 (%by weight)

Based on: 0.3%Pt/Al_2O_3 Catalyst Weight = 100 g

Assume : alumina support used is X grams.

So that, the catalyst 100 grams would composed of

Platinum	0.3	g
Alumina	X	g

Then $0.3 + X = 100$ g

Support (X) = 99.7 g

The alumina support weight used for preparation is 2 grams and $H_2PtCl_6 \cdot 6H_2O$ used as precursor salt.

$$\text{Platinum required} = 2 \times 0.3 / 99.7 \text{ g}$$

$$= 6.018 \times 10^{-3} \text{ g}$$

Platinum (Pt) 6.018×10^{-3} g was prepared from 25 ml of the stock solution of chloroplatinic acid, which prepared by dissolving 1 g of H_2PtCl_6 in de-ionized water.

Pt content in stock solution $= 1 \times 195.08 / 518.1$ g

$= 0.377$ g

Therefore:

The required-solution $= 6.018 \times 10^{-3} \times 25 / 0.377$ ml

$= 0.3993$ ml

Preparation of 0.3%Pt/TiO_2 Catalysts with the Wet Impregnation Method

Reagent: Chloroplatinic acid ($H_2PtCl_6 \cdot 6H_2O$)

Molecular weight = 517.92 g.

(Atomic weight of Platinum = 195.08)

Support: Titanium dioxide (TiO_2); Anatase phase

From Fluka., A Sigma-Aldrich Company, Switzerland.

Calculation for prepared 0.3%Pt/TiO_2 (%by weight)

Based on: 0.3%Pt/TiO_2 Catalyst Weight = 100 g

Assume : Titanium oxide support used is X grams.

So that, the catalyst 100 grams would composed of

Platinum 0.3 g

Titanium oxide X g

Then $0.3 + X = 100$ g

Support (X) $= 99.7$ g

The titanium oxide support weight used for preparation is 3 grams and $H_2PtCl_6 \cdot 6H_2O$ used as precursor salt.

Platinum required $= 3 \times 0.3 / 99.7$ g

$= 9.027 \times 10^{-3}$ g

Platinum (Pt) 9.027×10^{-3} g was prepared from 25 ml of the stock solution of chloroplatinic acid which prepared by dissolving 1 g of H_2PtCl_6 in de-ionized water.

Pt content in stock solution	=	$1 \times 195.08 / 518.1$	g
	=	0.377	g

Therefore:

The required-solution	=	$9.027 \times 10^{-3} \times 25 / 0.377$	ml
	=	0.599	ml

APPENDIX B
CALCULATION OF METAL ACTIVE SITE

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 50 μl standard CO peak	=	B	unit
Amounts of CO adsorbed on catalyst	=	B – A	unit
Volume of CO adsorbed on catalyst	=	[(B – A)/B] ×50	μl
Volume of gas 1 mole at 30°C	=	24.86×10^6	μl
Mole of CO adsorbed on catalyst (mole)	=	$[(B-A)/B] \times [50/24.86\times10^6]$	

1 mole is 6.02×10^{23} molecules

Then, Molecule of CO adsorbed on catalyst

$$= 2.01\times10^{-6}\times [(B-A)/B] \times 6.02\times10^{23} \text{ molecules}$$

Metal active site $= 1.21\times10^{18} \times [(B-A)/B]/w$ molecules of CO / g catalyst

Example of calculated active site of 0.3 % Pt/Al_2O_3

0.3 % Pt/Al_2O_3	=	0.1	g
Area of CO peak after adsorption	=	1185	unit
Average area of 50 μl. standard CO peak	=	2170	unit
Amounts of CO adsorbed on catalyst	=	2170 – 1185	unit
Volume of CO adsorbed on catalyst	=	[(2170 – 1185)/2170] ×50	μl
	=	22.70	μl

The adsorption CO condition was carried out at 30°C

Then, Mole of CO adsorbed on catalyst = $(22.70/24.86\times10^6)$

Molecule of CO adsorbed on catalyst (0.1 g)

$= (22.70/24.86\times10^{6})\times6.02\times10^{23}$ molecules

$= 5.50\times10^{17}$ molecules

Metal active site $= 5.50\times10^{17}/0.1$

$= 5.50\times10^{18}$ molecules of CO / g catalyst

APPENDIX C

CALCULATION OF NO, CO AND C_3H_8 CONVERSIONS

Calculation of NO, CO and C_3H_8 conversion

The effluent gas was analyzed by gas chromatograph, the NO reduction activity was evaluated in terms of the conversion of NO to N_2

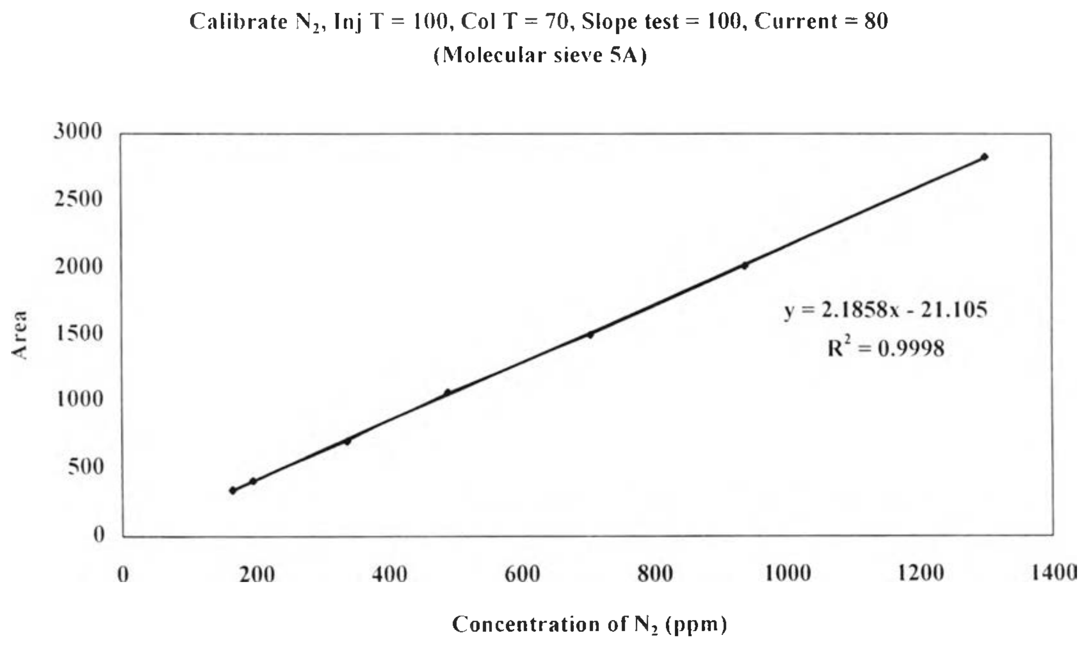
$$2NO \longrightarrow N_2 + O_2$$

NO conversion (%) = $(2[N_2]out/[NO]in) \times 100$

Where $[NO]_{in}$ = 500 ppm

$[N_2]$: analyzed by gas chromatograph from calibration curve (Figure C-1)

Figure C-1 Calibration curve of N_2



Area = area of N_2 peak on GC 8 ATP

Area = 2.1858 × conc. of N_2 (ppm) - 21.105

Thus, $[N_2]$ = (Area + 21.105)/2.1858

The CO oxidation activity was evaluated in terms of the conversion of CO into CO_2

$$\text{CO conversion (\%)} = \frac{([CO]_{in} - [CO]_{out}) \times 100}{[CO]_{in}}$$

The C_3H_8 oxidation activity was evaluated in terms of the conversion of C_3H_8 into CO_2 and H_2O

$$C_3H_8 \text{ conversion (\%)} = \frac{([C_3H_8]_{in} - [C_3H_8]_{out}) \times 100}{[C_3H_8]_{in}}$$

APPENDIX D

CHEMICAL AND PHYSICAL PROPERTIES OF SUPPORTS

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

Chemical component	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 D-2 Chemical component of TiO_2 support

Chemical component	weight percent (%)
TiO_2	99
PO_4	0.1
SO_4	0.1
Cl	0.01
Pb	0.001
As	0.002
Fe	0.005
Zn	0.005
Cu	0.0005

APPENDIX E
OPERATING CONDITIONS AND SAMPLES OF CHROMATOGRAM

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

Operating conditions are as follows :

GC	:	SHIMADZU-GC-8ATP
Detector	:	TCD
Packed column	:	MS-5A
Carrier gas	:	Ultra high purity helium (99.999%)
Flow rate of carries gas	:	45 ml/min
Column temperature	:	70^{o}C
Detector temperature	:	100^{o}C
Injector temperature	:	100^{o}C
Detector current	:	80 mA

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

Operating conditions were similar to model 8ATP except:

Packed column	:	Porapak-Q
Flow rate of carries gas	:	30 ml/min
Column temperature	:	90^{o}C
Detector temperature	:	110^{o}C
Detector current	:	90 mA

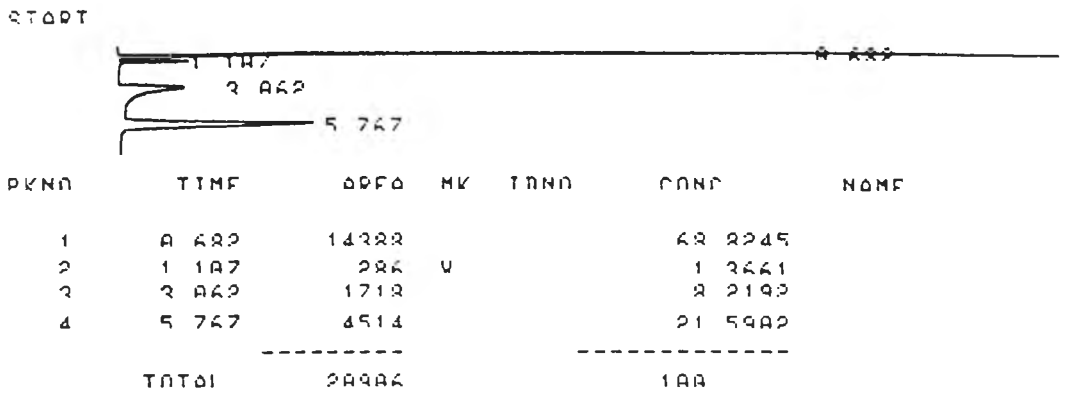
The samples of chromatogram from gas analysis are shown in Figures E-1, E-2.

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

PKNO	TIME	AREA	MK	IDNO	CONC	NAME
1	1.375	22116			77.3124	
2	2.115	724	V		2.532	
3	5.682	5766			20.1556	
	TOTAL	28605			100	

PKNO	TIME	AREA	CONC	NAME
1.	1.375	22116	77.3124	OXYGEN
2.	2.115	724	2.5320	NITROGEN
3.	5.682	5766	20.1556	CARBON MONOXIDE
		………..	…………..	
	TOTAL	28605	100	

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



PKNO	TIME	AREA	CONC	NAME
1.	0.682	14388	68.8245	AIR (N_2+O_2)
2.	1.107	286	1.3661	CO_2
3.	3.062	1718	8.2192	H_2O
4.	5.767	4514	21.5902	PROPANE
		………..	…………...	
	TOTAL	28605	100	

APPENDIX E

CO, NO AND C_3H_8 CONVERSIONS OF PREPARED CATALYSTS

Figure F-1 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in air at 380°C under stoichiometric condition

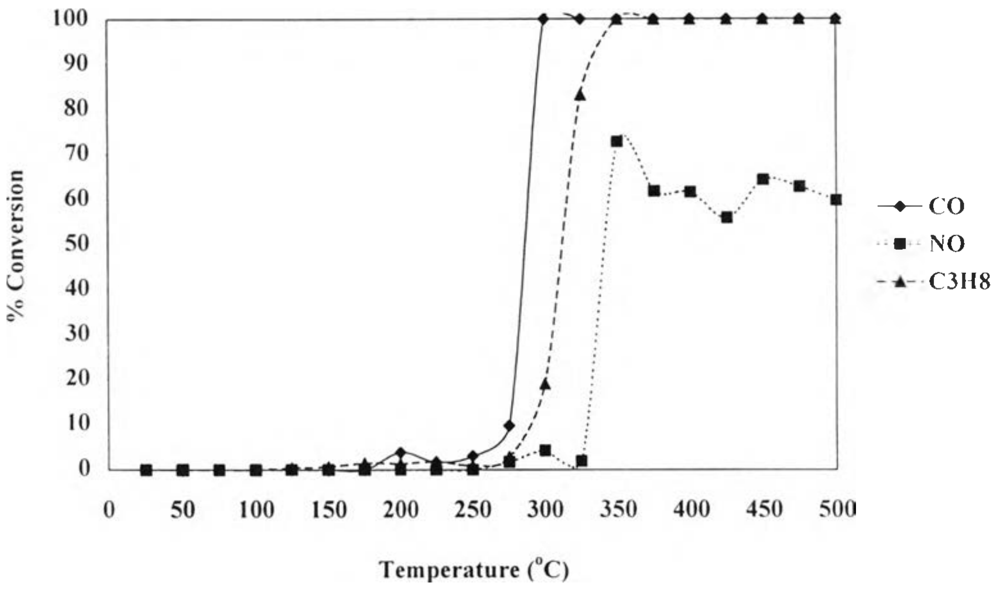


Figure F-2 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in air at 450°C under stoichiometric condition

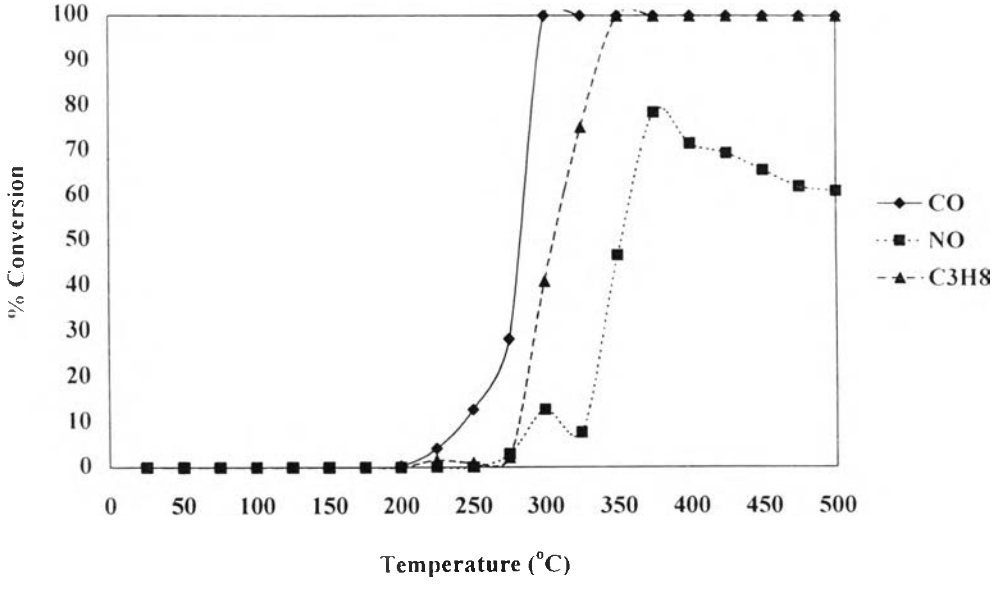


Figure F-3 Conversion of CO, NO and C_3H_8 over $0.3\%Pt/Al_2O_3$ catalyst calcined in air at 500°C under stoichiometric condition

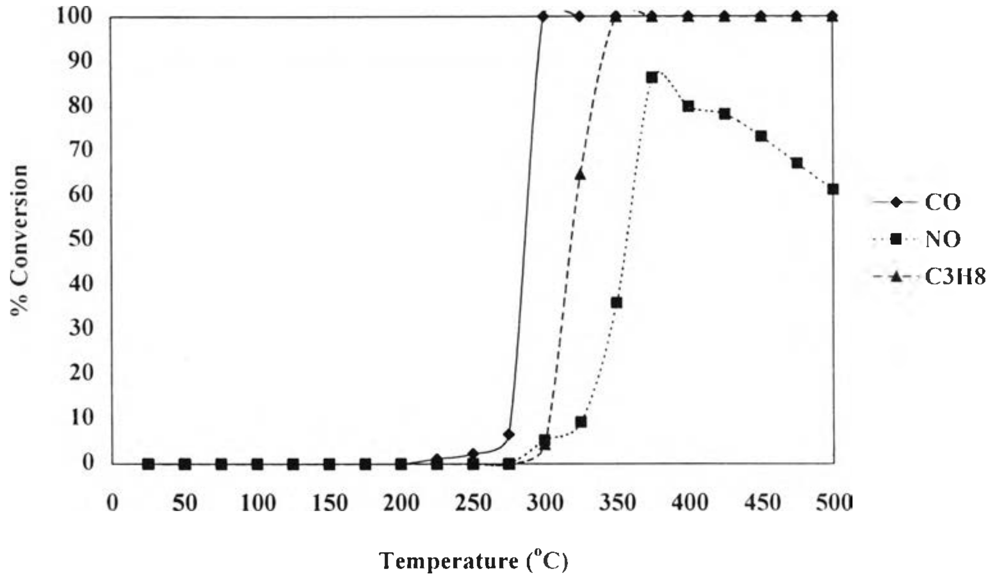


Figure F-4 Conversion of CO, NO and C_3H_8 over $0.3\%Pt/Al_2O_3$ catalyst calcined in air at 550°C under stoichiometric condition

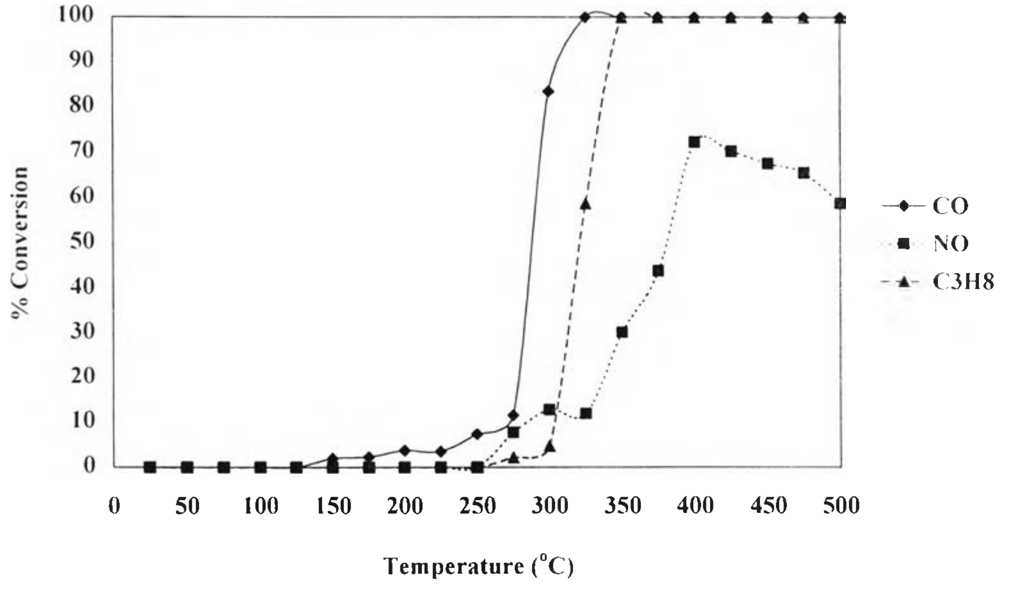


Figure F-5 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in air at 650°C under stoichiometric condition

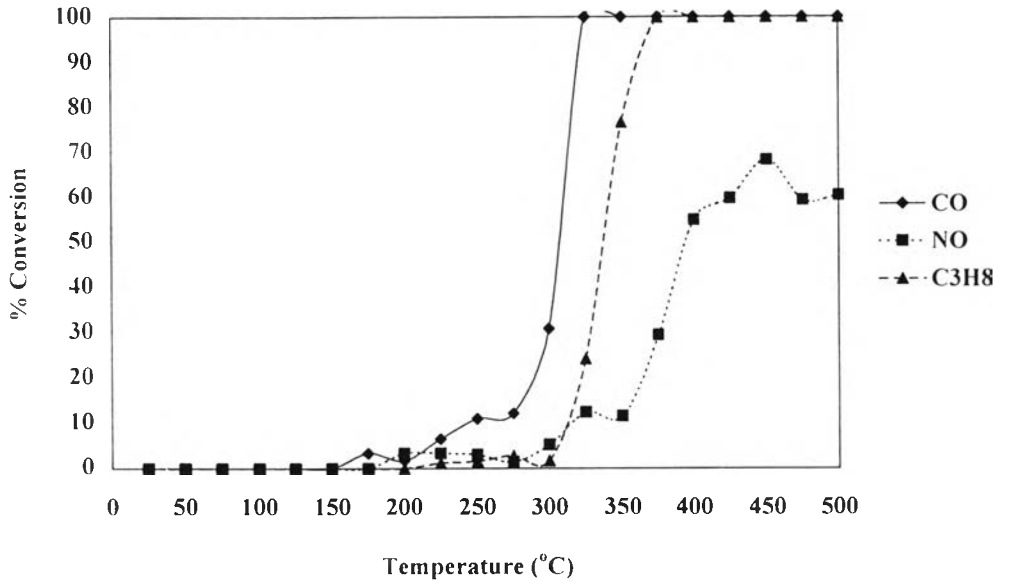


Figure F-6 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in a reducing atmosphere at 380°C under stoichiometric condition

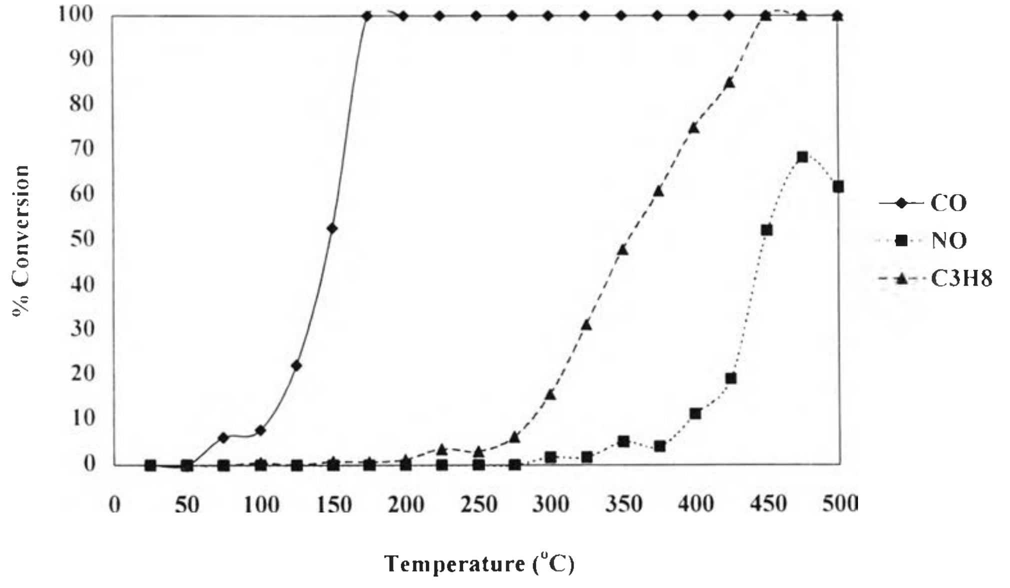


Figure F-7 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in a reducing atmosphere at 450°C under stoichiometric condition

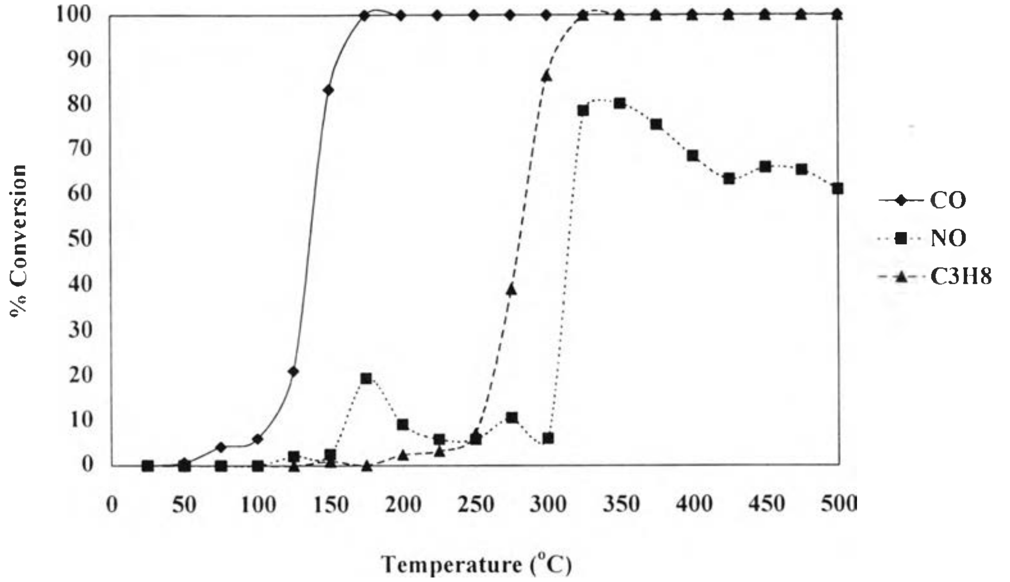


Figure F-8 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in a reducing atmosphere at 500°C under stoichiometric condition

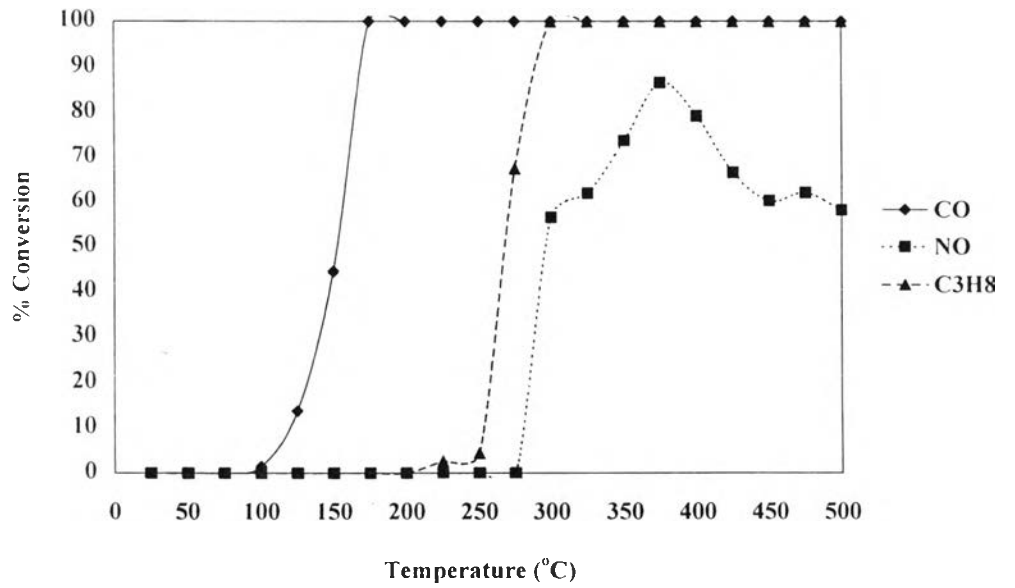


Figure F-9 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in a reducing atmosphere at 550°C under stoichiometric condition

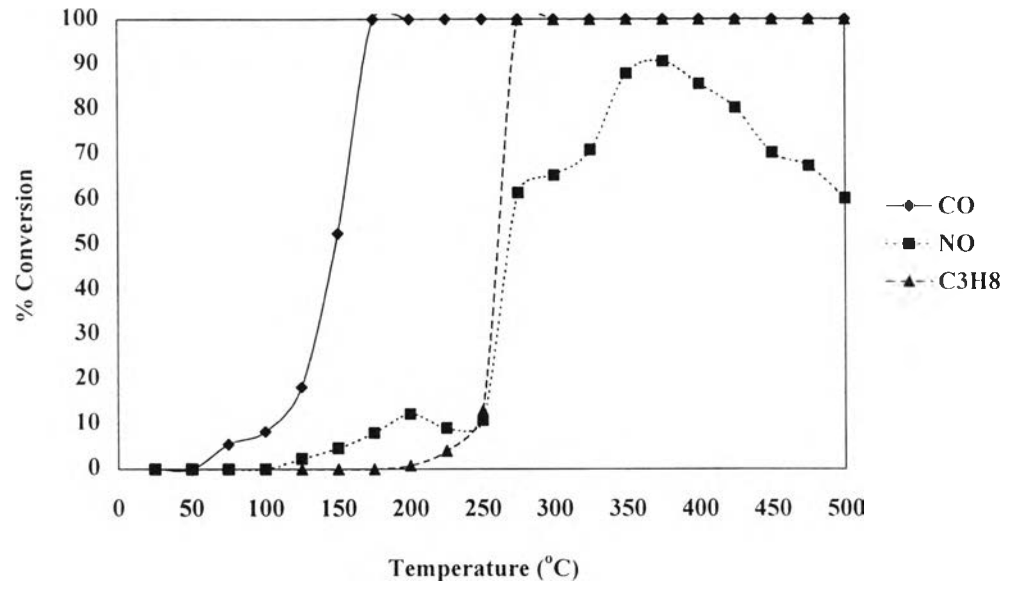


Figure F-10 Conversion of CO, NO and C_3H_8 over 0.3%Pt/Al_2O_3 catalyst calcined in a reducing atmosphere at 650°C under stoichiometric condition

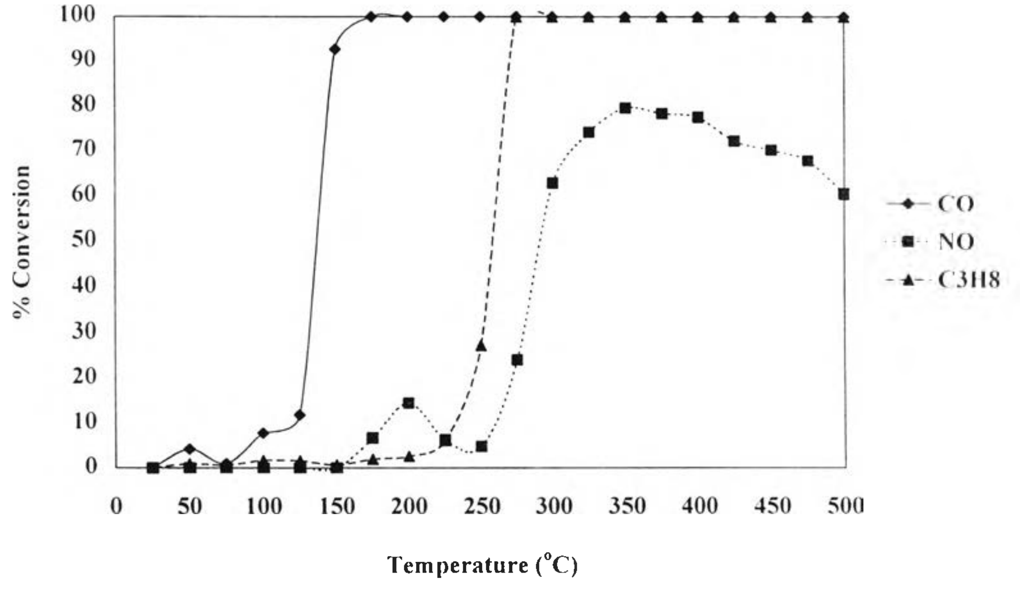


Figure F-11 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in air at 380°C under stoichiometric condition

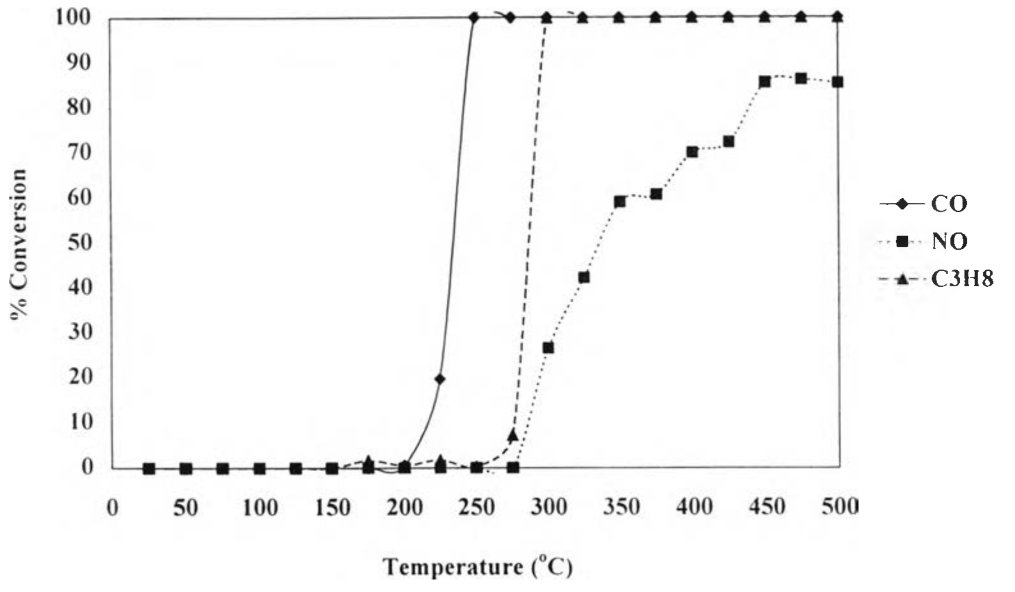


Figure F-12 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in air at 450°C under stoichiometric condition

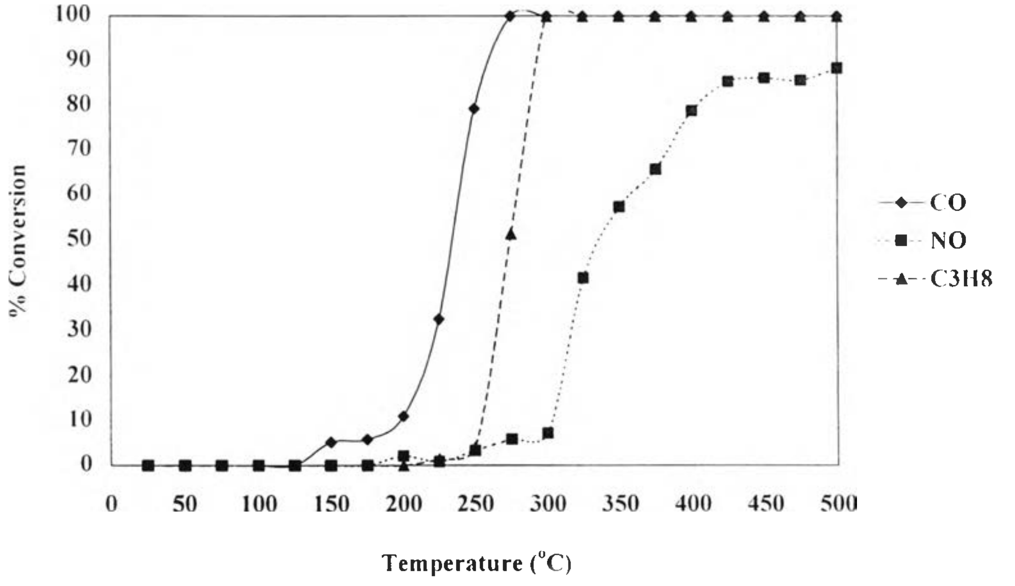


Figure F-13 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in air at 500°C under stoichiometric condition

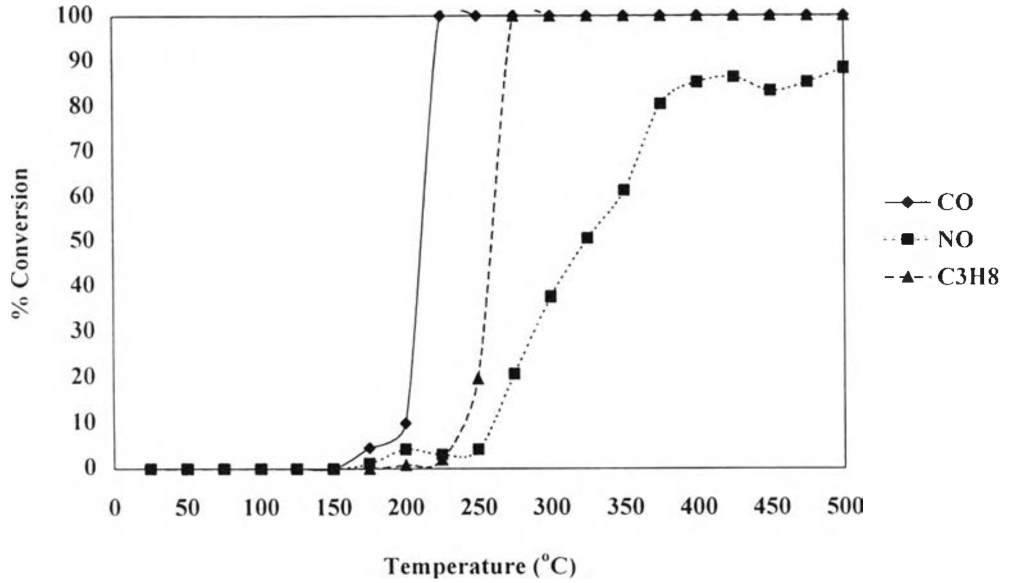


Figure F-14 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in air at 550°C under stoichiometric condition

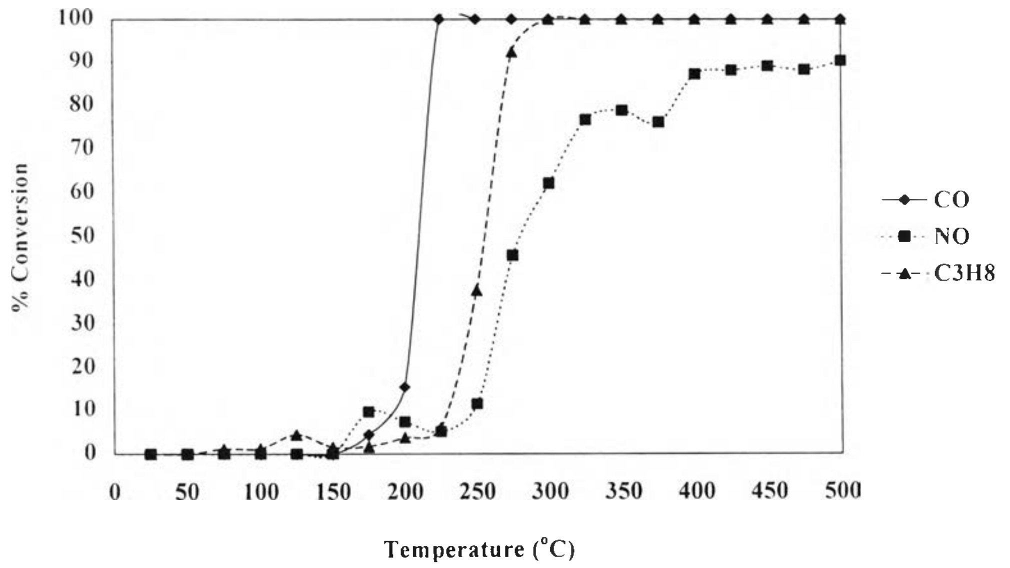


Figure F-15 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in air at 600°C under stoichiometric condition

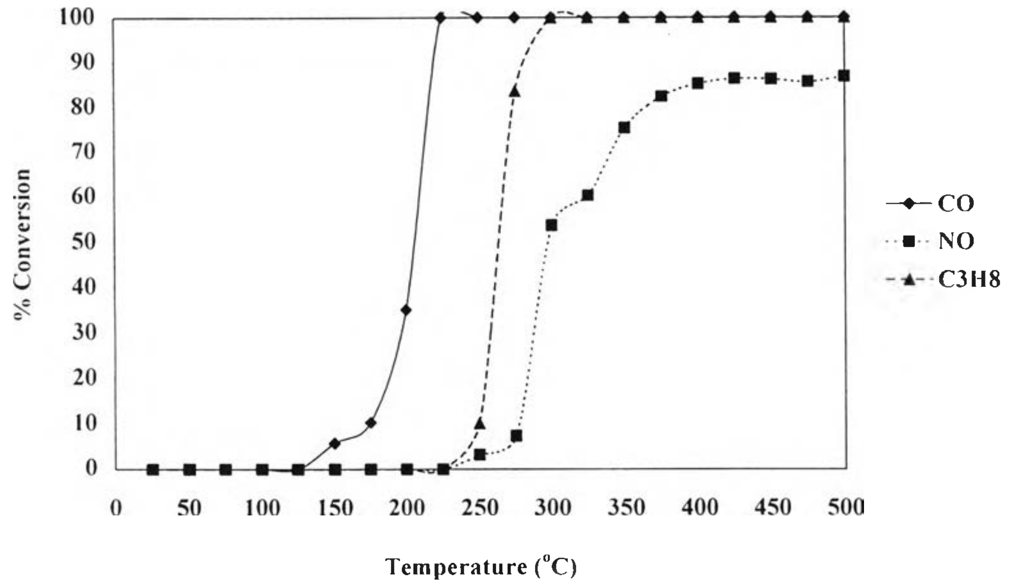


Figure F-16 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in air at 650°C under stoichiometric condition

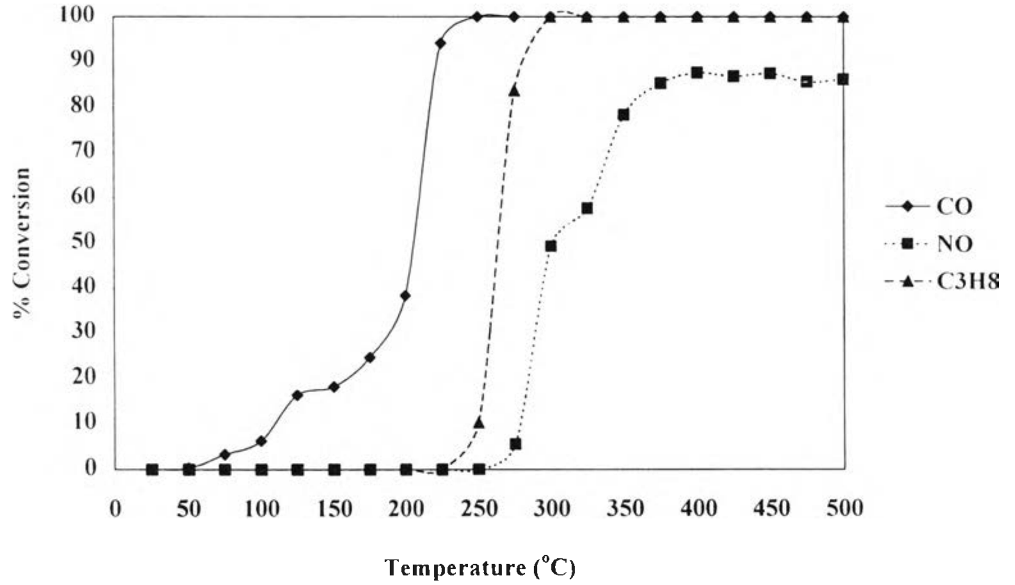


Figure F-17 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in a reducing atmosphere at 380°C under stoichiometric condition

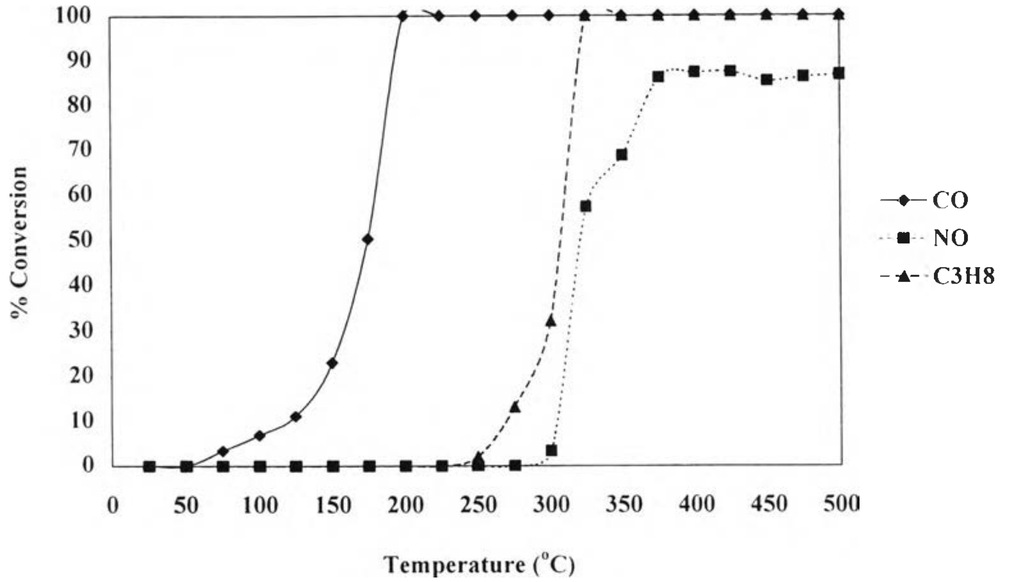


Figure F-18 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in a reducing atmosphere at 450°C under stoichiometric condition

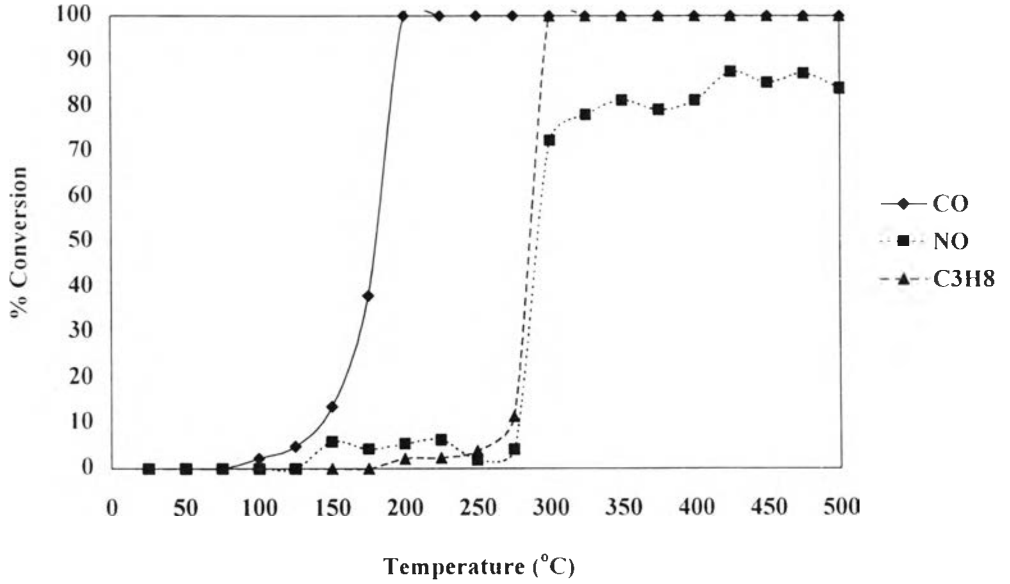


Figure F-19 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in a reducing atmosphere at 500°C under stoichiometric condition

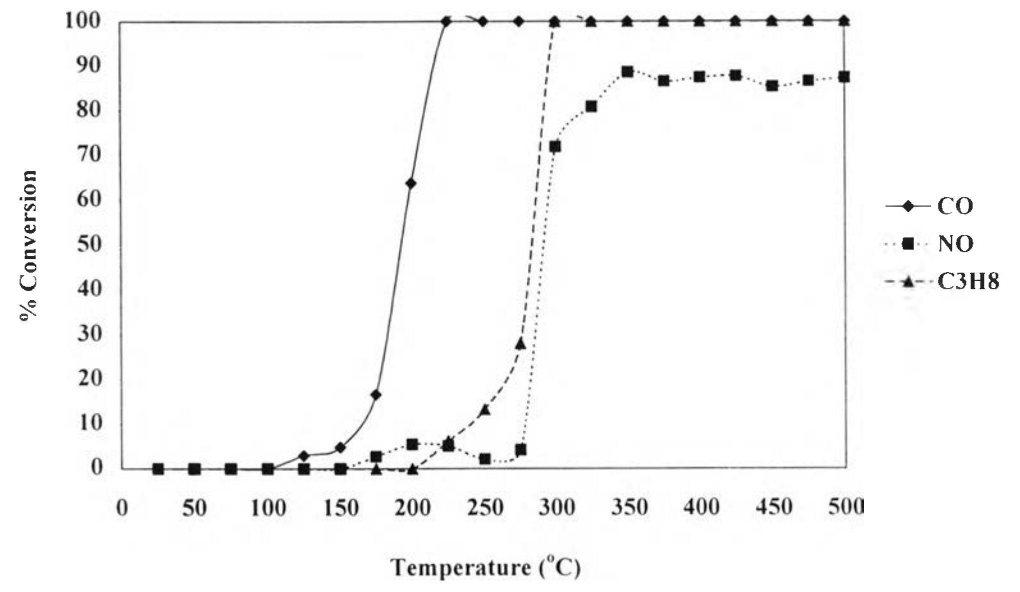


Figure F-20 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in a reducing atmosphere at 550°C under stoichiometric condition

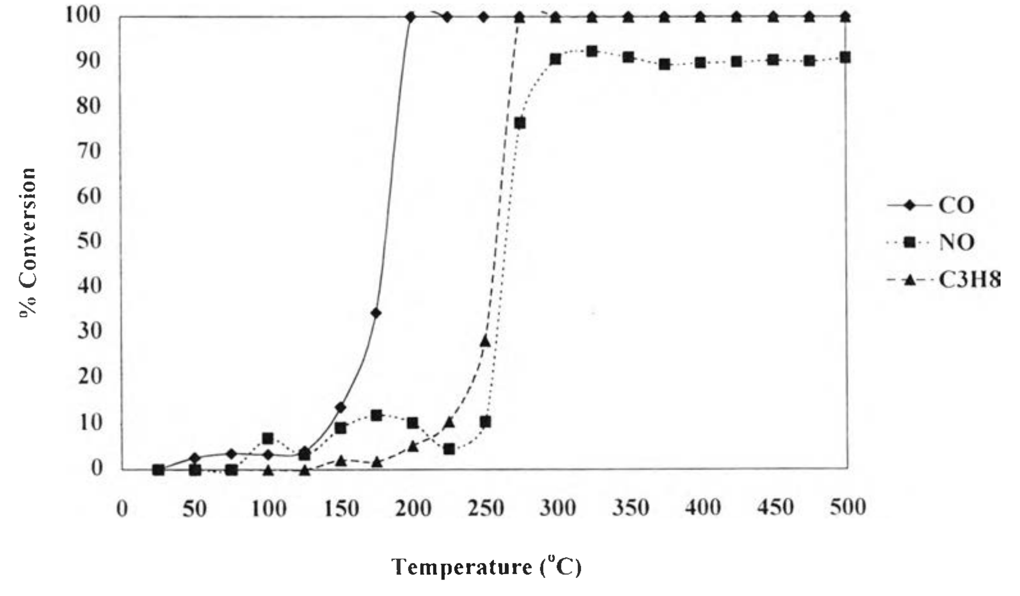


Figure F-21 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in a reducing atmosphere at 600°C under stoichiometric condition

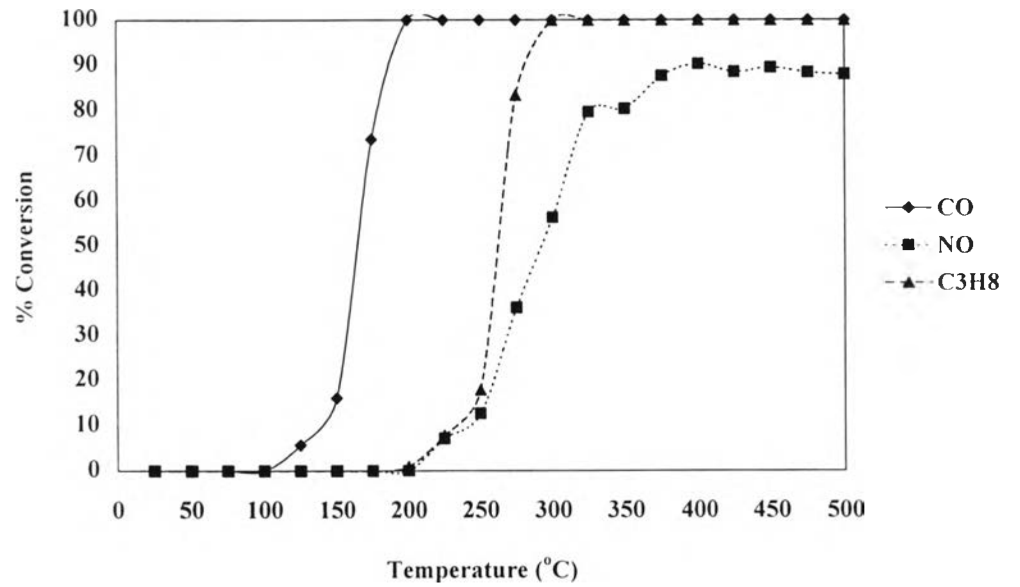
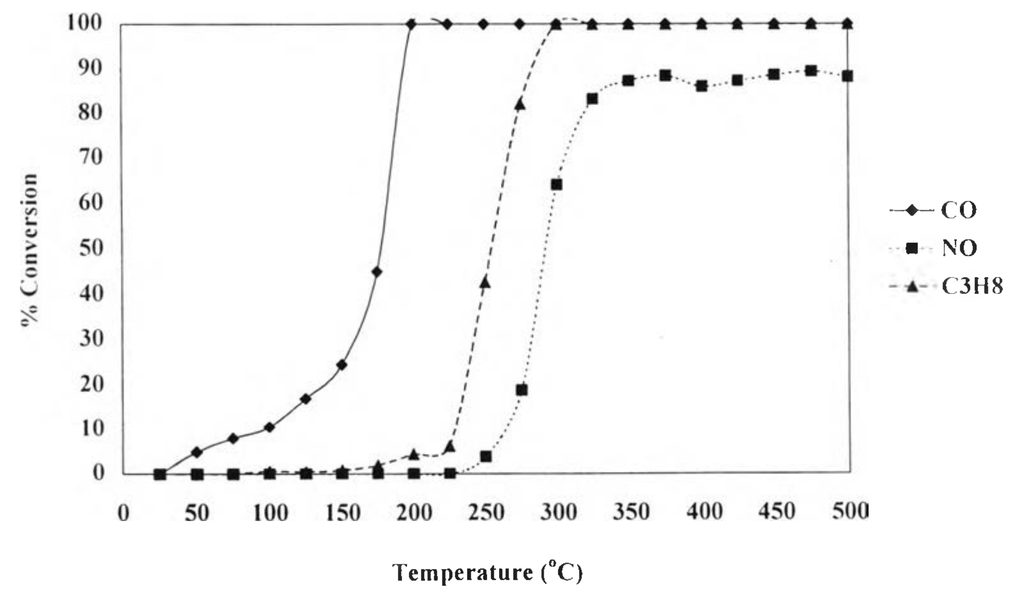


Figure F-22 Conversion of CO, NO and C_3H_8 over 0.3%Pt/TiO_2 catalyst calcined in a reducing atmosphere at 650°C under stoichiometric condition



VITA

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