



CHAPTER IV RESULTS AND DISCUSSION

4.1 Feed and Standard Analysis

The chromatogram of jatropha oil (10 wt.% crude jatropha oil in n-dodecane) analyzed by a GC/FID is shown in Figure 4.1. The chromatogram consists of two main peaks at 9, and 20 min, corresponding to n-dodecane (n-C12), and n-eicosane (n-C20) which were used as the diluent and the internal standard, respectively. The peaks representing jatropha oil appeared at 36-37 and 40-42 min which belong to diglycerides and triglycerides, respectively. Small amounts of fatty acid and monoglycerides were also observed at 26-28 and 32 min. retention time respectively.

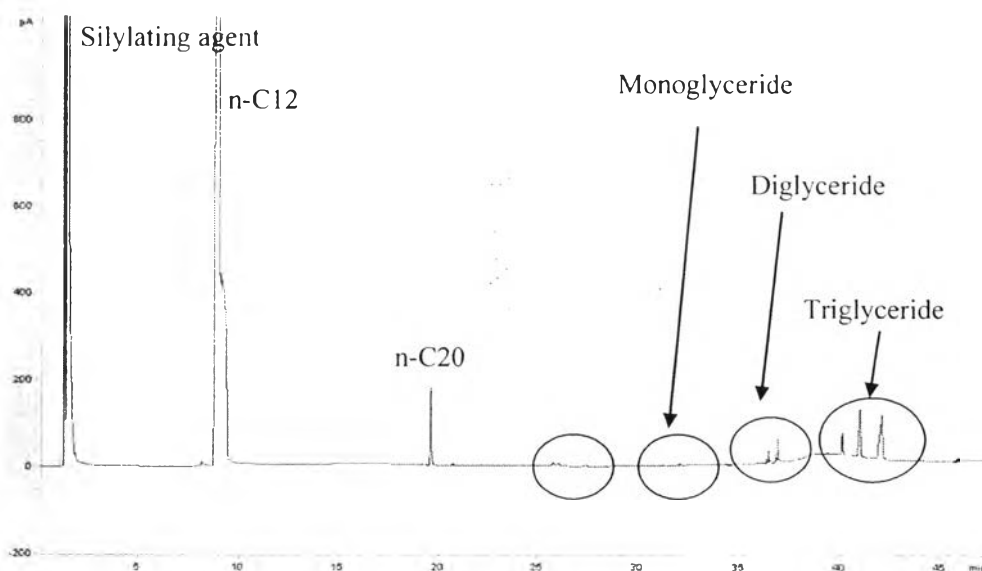


Figure 4.1 Chromatogram of 10 wt.% jatropha oil in n-dodecane.

The chromatograms of the mixture of standard chemicals are shown in Figure 4.2 and the retention times for each standard are listed in Table 4.1. To determine the response factors of each standard chemical, eicosane was used as the internal standard. The response factors of possible feed components, intermediates, and products using standard chemicals are also listed in Table 4.1.

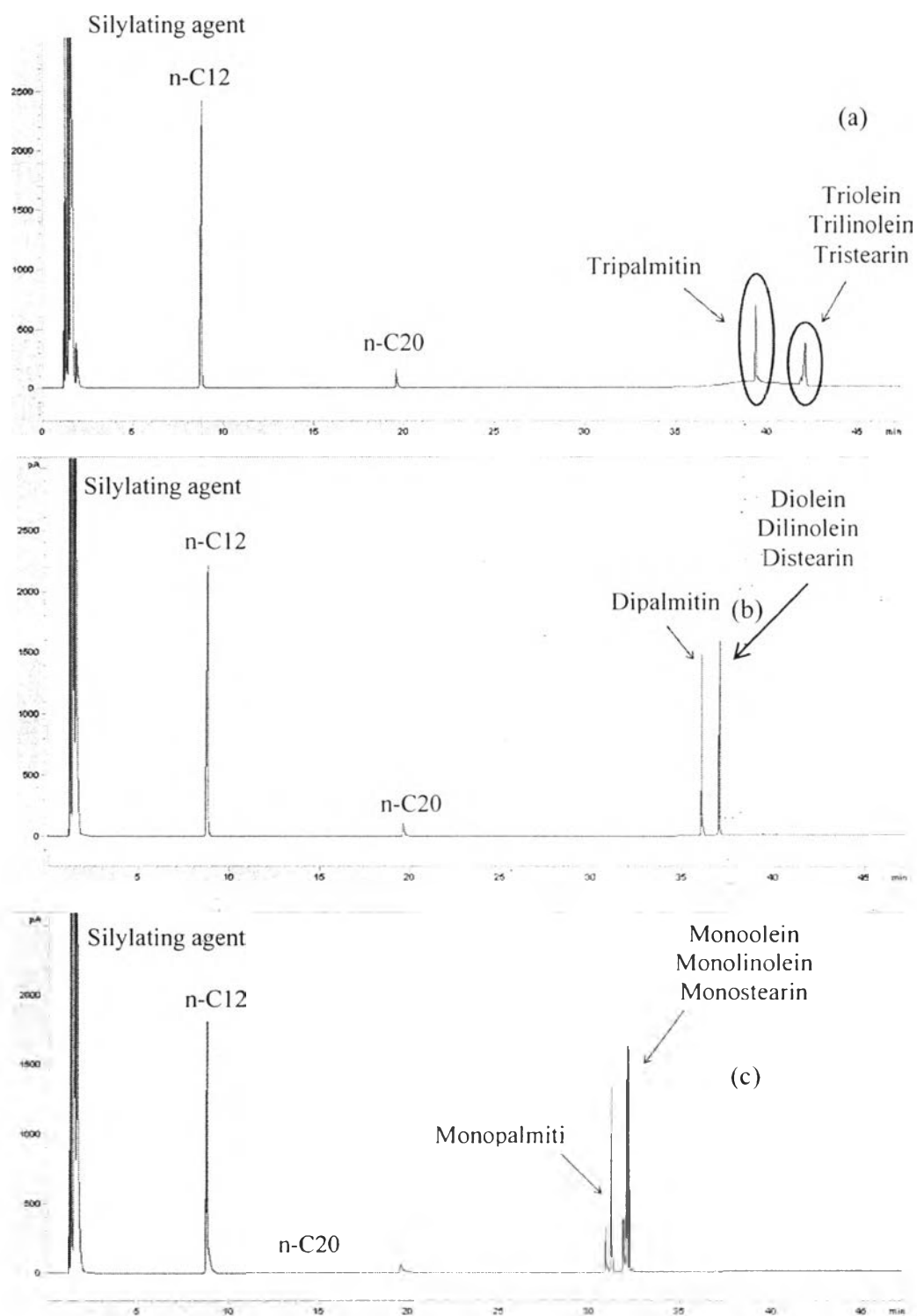


Figure 4.2 Chromatograms of standard chemicals, (a) triolein, trilinolein, tristearin, tripalmitin, (b) diolein, dilinolein, distearin, dipalmitin, (c) monoolein, monolinolein, monostearin, monopalmitin, (d) hexadecanol, octadecanol, palmitic acid, stearic acid, oleic acid (e) n-hexane, n-heptane, n-octane, n-decane, n-dodecane, n-pentadecane, n-hexadecane, n-heptadecane, n-octadecane.

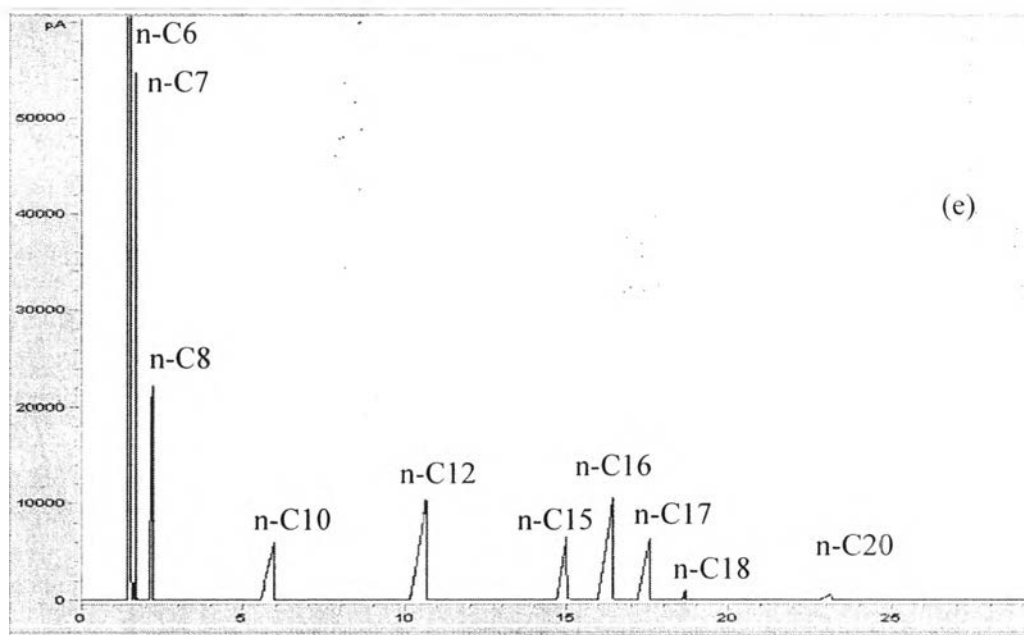
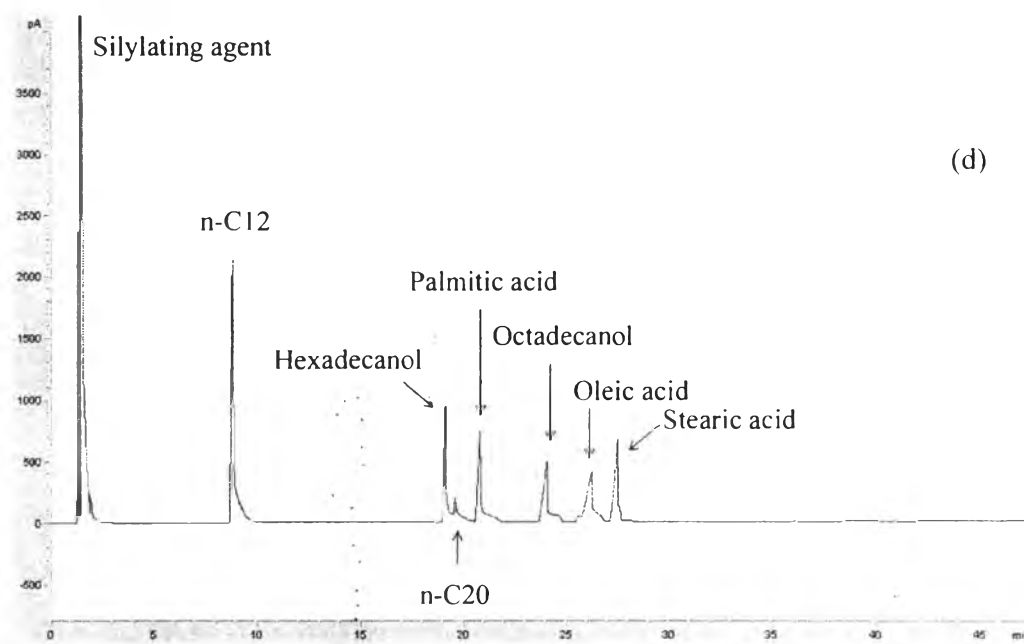


Figure 4.2 (cont.) Chromatograms of standard chemicals, (a) triolein, trilinolein, tristearin, tripalmitin, (b) diolein, dilinolein, distearin, dipalmitin, (c) monoolein, monolinolein, monostearin, monopalmitin, (d) hexadecanol, octadecanol, palmitic acid, stearic acid, oleic acid (e) n-hexane, n-heptane, n-octane, n-decane, n-dodecane, n-pentadecane, n-hexadecane, n-heptadecane, n-octadecane.

Table 4.1 Retention times and response factors of standard chemicals

Standard chemicals	Retention times	Response factors
Triolein	} 42.1	0.9913
Trilinolein		
Tristearin		
Tripalmitin	39.4	1.0305
Diiolein	} 37.0	} 0.9241
Dilinolein		
Distearin		
Dipalmitin	36.0	1.0166
Monoolein	} 32.2	} 1.6052
Monolinolein		
Monostearin		
Monopalmitin	31.3	1.5393
Hexadecanol	19.4	0.9994
Octadecanol	24.6	1.2587
Palmitic acid	20.8	1.1796
Stearic acid	27.8	0.9236
Oleic acid	26.1	0.9815
n-Hexane	1.48	1.0123
n-Heptane	1.67	1.0564
n-Octane	2.12	1.1228
n-Decane	5.95	1.0237
n-Dodecane	10.61	1.0674
n-Pentadecane	14.99	1.3341
n-Hexadecane	16.44	1.2665
n-Heptadecane	17.58	1.2002
n-Octadecane	18.70	1.1795

The reference standard for gas product was analyzed by a GC/TCD gas chromatograph with 80/100 Hyasep-Q column. Following the method for product analysis as described in Chapter III. The TCD signal of standard gas mixture is shown in Figure 4.3. It was found that the retention time of carbon monoxide, carbon dioxide, methane, ethane, and propane are 0.76, 3.2, 1.68, 7.1, and 12.8, respectively.

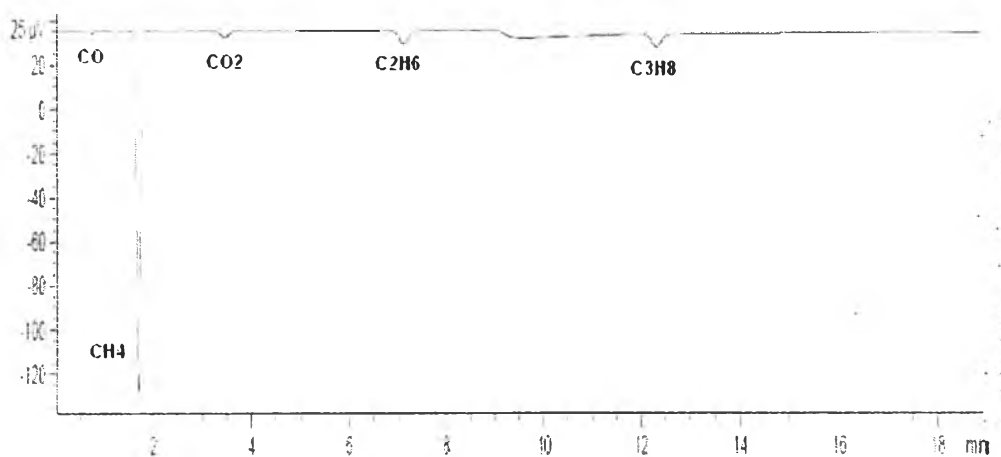


Figure 4.3 Chromatogram of the standard gases.

A typical chromatogram of liquid product over Pt/H-Y (Reaction condition: 325°C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h) is shown in Figure 4.4. The result shows that there are many components in the liquid product such as n-hexane, n-heptane, n-octane, n-nonane, n-undecane, n-dodecane, n-tridecane, n-tetradecane, n-pentadecane, n-hexadecane, n-heptadecane, n-octadecane, hexadecanol, octadecanol, stearic acid, monoglycerides, diglycerides, and triglycerides. Moreover, three unknowns were also observed at 18-21 min, 19-22.2 min, and 30.5-32.2 min retention time respectively. The unknowns are considered as other oxygenates in this work.

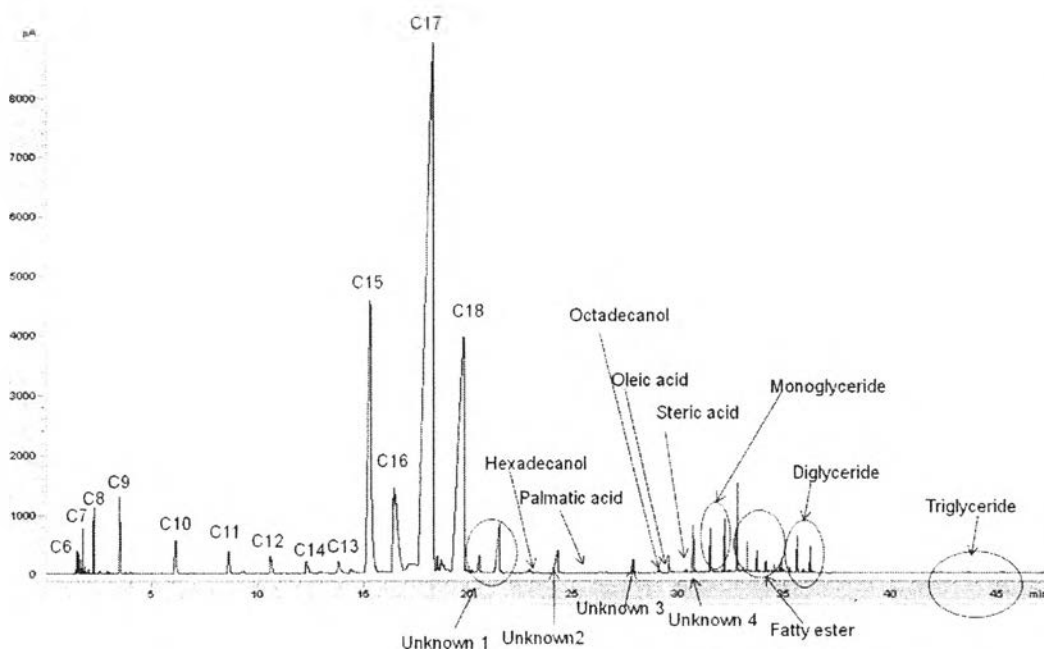


Figure 4.4 Typical chromatogram of liquid products over Pt/H-Y (Catalyst reaction condition: 325°C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).

4.2 Catalytic Activity Testing

To study the catalytic activity, selectivity and stability of the tested catalysts (Pt-Al₂O₃, Pt/F-Al₂O₃, Pt/H-Y, Ir/H-Y, and Ru/H-Y), the deoxygenation of jatropa oil was conducted at 375°C, 600 psig, liquid hourly space velocity (LHSV) of 0.5 h⁻¹, and H₂/feed molar ratio of 38.5.

4.2.1 Pt-supported Catalysts (Pt/Al₂O₃, Pt/F-Al₂O₃, and Pt/H-Y)

Distillation curves of liquid products over Pt-supported catalysts are shown as Figure 4.5. The results showed that the boiling point curves of liquid products over Pt/Al₂O₃, Pt/F-Al₂O₃, and Pt/H-Y catalysts were lower than boiling point curve of crude jatropa oil. This indicates that these three catalysts can crack crude jatropa oil to lower hydrocarbon range. Liquid products over Pt/H-Y gave lighter hydrocarbons than Pt/Al₂O₃ and Pt/F-Al₂O₃ which results from high acidity of H-Y support.

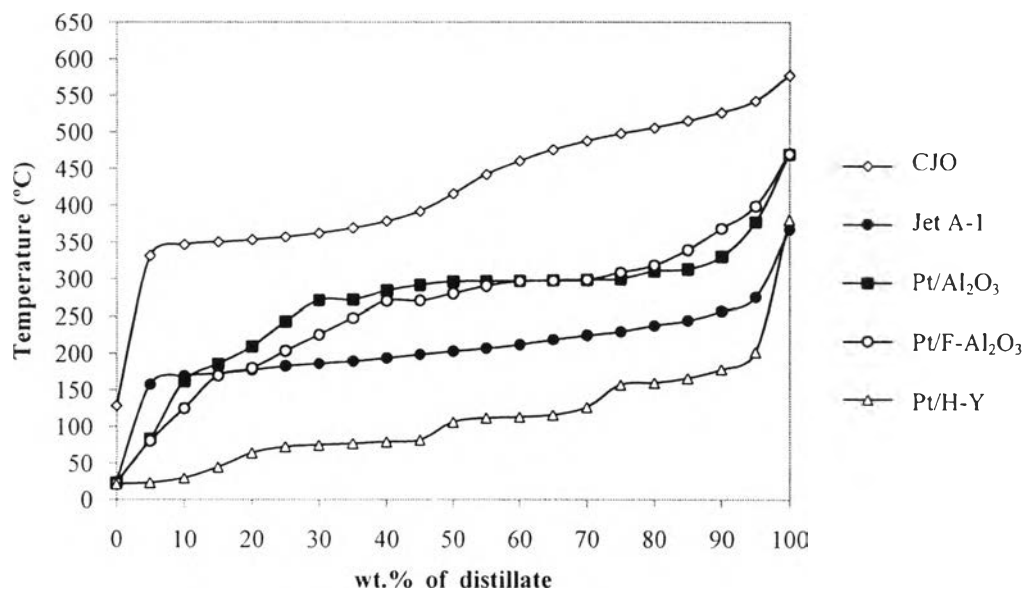


Figure 4.5 Distillation curves of liquid products obtained over Pt-supported catalysts compared with crude jatropha oil and a commercial Jet A-1 fuel. (Reaction condition: 375 °C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).

Conversion and liquid product selectivity are analyzed by GC/FID (Agilent 7890). Figure 4.6 shows product distributions of liquid products obtained from Pt-supported catalysts, including Pt/Al₂O₃, Pt/F-Al₂O₃, and Pt/H-Y catalysts. The major products obtained from Pt/Al₂O₃ and Pt/F-Al₂O₃ catalysts were n-heptadecane (n-C₁₇) and n-pentadecane (n-C₁₅) which are in the range of diesel fuel. The promotion of fluorine resulted in higher selectivity to isomerized products but it does not improve the cracking activity, which would result in bio-jet fuel range. In case of Pt/H-Y catalyst, the liquid products gave a major fraction of light hydrocarbons which could result from stronger acidity of H-Y support. Moreover, small amounts of reaction intermediates (hexadecanol, palmitic acid, oleic acid, octadecanol, and stearic acid) were also observed over Pt/Al₂O₃ and Pt/F-Al₂O₃.

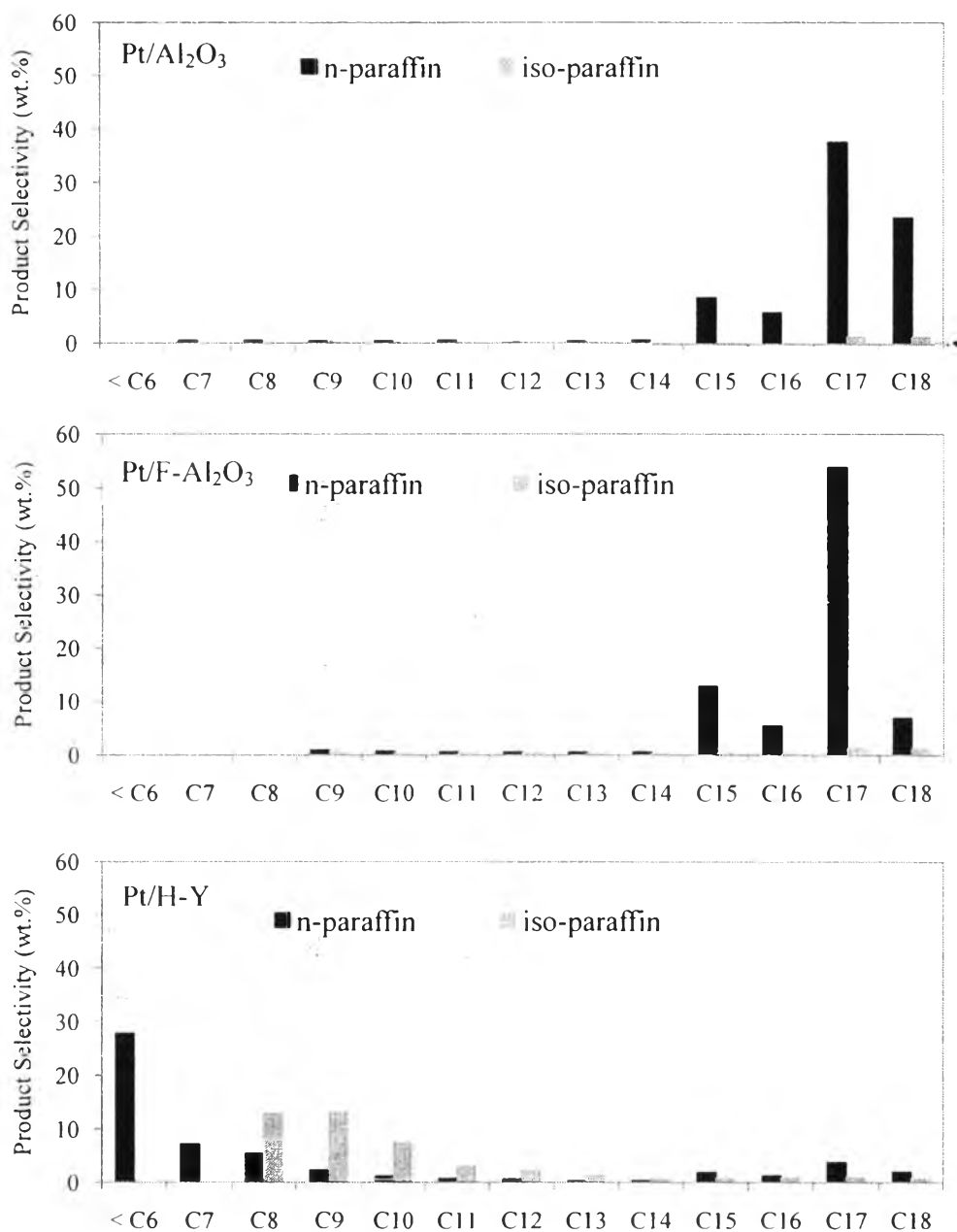


Figure 4.6 Product distribution of liquid products obtained over Pt-supported catalysts. (Reaction condition: 375°C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).

In order to study the effect of fluorine promotion on γ -Al₂O₃ support, Pt/Al₂O₃ and Pt/F-Al₂O₃ were tested at the same reaction condition. The results are in Figure 4.7. It was found that the liquid products obtained from reaction over Pt/F-

Al_2O_3 gave higher isomerized products than liquid products obtained from reaction over $\text{Pt}/\text{Al}_2\text{O}_3$. This catalyst indicates the higher selectivity to isomerized products of fluorine promoted. Moreover, liquid products from these two catalysts gave main products in diesel range.

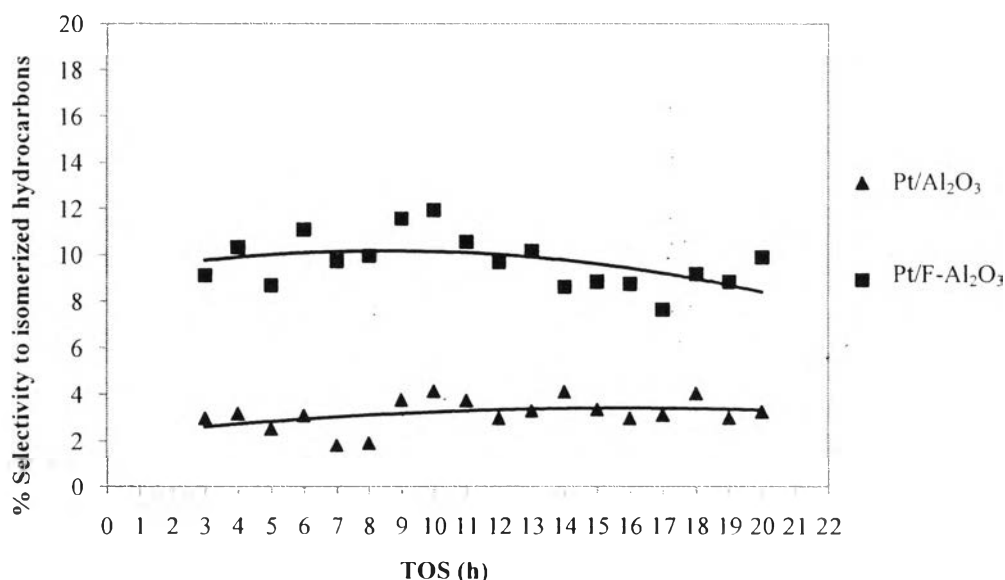


Figure 4.7 Comparison of isomerized hydrocarbons in liquid product obtained over $\text{Pt}/\text{Al}_2\text{O}_3$ and $\text{Pt}/\text{F}-\text{Al}_2\text{O}_3$. (Reaction condition: 375°C , 600 psig, LHSV of 0.5 h^{-1} , and H_2/feed molar ratio of 38.5).

4.2.2 H-Y-Supported Catalysts (Pt/H-Y, Ir/H-Y, Ru/H-Y, H-Y)

Distillation curves of liquid products over H-Y-supported catalysts are shown in Figure 4.8. The results showed that $\text{Pt}/\text{H-Y}$, $\text{Ir}/\text{H-Y}$, $\text{Ru}/\text{H-Y}$, and H-Y catalysts could also crack crude jatropha oil to lighter hydrocarbons. Liquid products obtained over $\text{Pt}/\text{H-Y}$ gave the lightest hydrocarbons followed by $\text{Ir}/\text{H-Y}$, $\text{Ru}/\text{H-Y}$, and H-Y respectively. Figure 4.9 shows product distributions of liquid products obtained over H-Y-supported catalysts, including, $\text{Pt}/\text{H-Y}$, $\text{Ir}/\text{H-Y}$, $\text{Ru}/\text{H-Y}$, and H-Y. The major products obtained over $\text{Ir}/\text{H-Y}$, $\text{Ru}/\text{H-Y}$, and H-Y were n-heptadecane (n-C17) and n-pentadecane (n-C15) which are in the range of diesel fuel. In case of $\text{Pt}/\text{H-Y}$, the liquid products gave a major fraction in the range of lighter hydrocarbon than those three catalysts which were nearly in bio-jet fuel range. This result

indicates the highest cracking activity of Pt/H-Y catalysts. Moreover, hexadecanol, palmitic acid, octadecanol, oleic acid, and stearic acid were observed as reaction intermediates for liquid products over Ir/H-Y, Ru/H-Y, and H-Y.

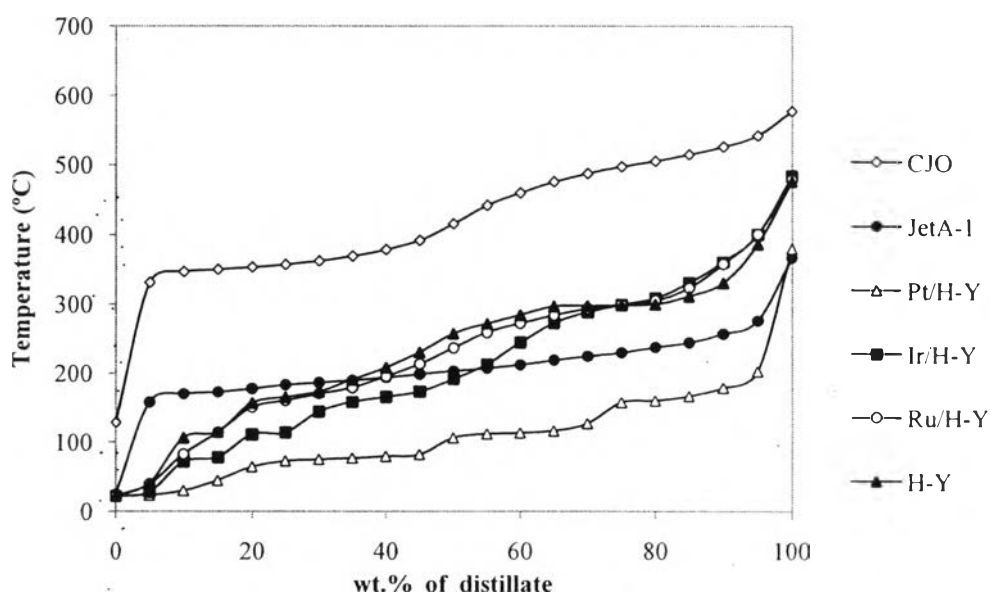


Figure 4.8 Distillation curves of liquid products obtained over H-Y-supported catalysts compared with crude jatropha oil and a commercial Jet A-1 fuel. (Reaction condition: 375°C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).

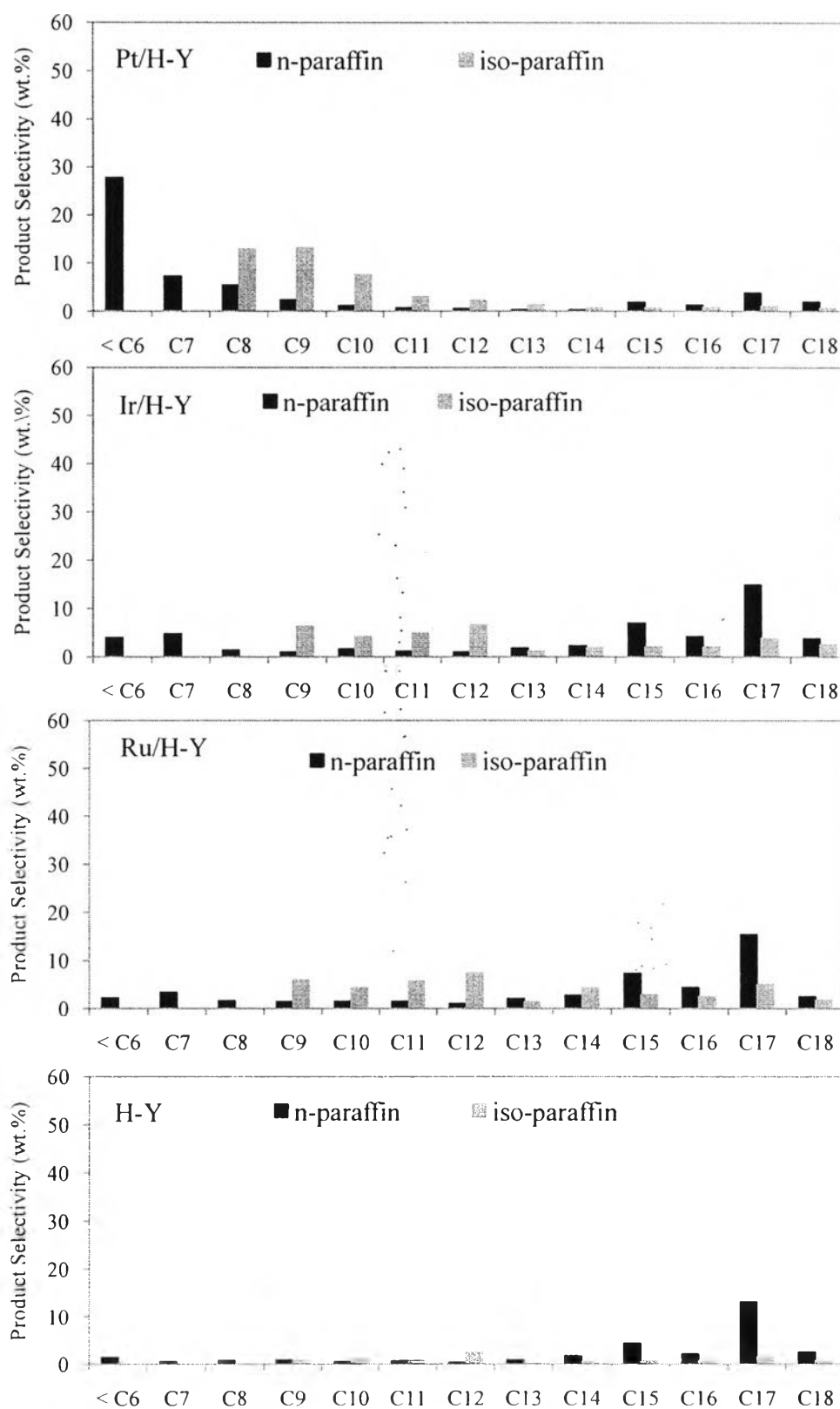


Figure 4.9 Product distribution of liquid products obtained over H-Y-supported catalysts. (Reaction condition: 375°C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).

Table 4.2 Conversion, liquid product selectivity, and C17/C18 ratio of the studied catalysts (Reaction condition: 375 °C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h)

Catalysts	Pt/Al ₂ O ₃	Pt/F-Al ₂ O ₃	Ir/H-Y	Ru/H-Y	Pt/H-Y	H-Y
Conversion	97.22	98.86	98.09	98.51	100.00	66.44
C18/C17 ratio	0.63	0.13	0.26	0.16	0.53	0.20
% Selectivity						
<C6	0.00	0.00	4.04	2.23	20.78	1.37
C7	0.43	0.00	4.79	3.44	7.23	0.55
C8	0.45	0.42	1.46	1.60	18.31	0.82
C9	0.90	1.52	7.33	7.41	15.55	1.65
C10	0.44	1.04	5.87	5.89	10.74	1.59
C11	0.52	0.90	6.05	7.13	5.75	1.81
C12	0.50	0.91	7.58	8.46	5.82	2.82
C13	0.33	0.76	3.01	3.47	1.60	1.34
C14	0.60	0.80	4.23	7.06	1.04	2.32
C15	8.70	13.21	9.10	10.22	2.60	5.02
C16	5.84	5.77	6.37	6.85	2.14	2.89
C17	39.03	55.17	18.80	20.38	4.79	14.65
C18	24.88	8.07	6.42	4.24	2.72	3.29
Hexadecanol	0.03	0.05	0.13	0.17	0.00	0.15
Palmitic acid	0.07	0.01	0.04	0.03	0.00	0.23
Octadecanol	1.04	0.04	0.09	0.06	0.00	0.74
Oleic acid	2.52	0.29	3.11	0.33	0.00	0.00
Stearic acid	0.04	0.09	0.20	0.18	0.12	8.30
Monoglyceride	0.89	0.24	0.55	0.34	0.23	1.96
Fatty esters	2.29	2.69	1.20	0.85	0.00	2.26
Other oxygenates	7.72	6.88	7.72	8.17	0.58	12.69

Table 4.2 shows conversion, liquid product selectivity, and n-C18 to n-C17 ratio of each catalyst at the same condition (375°C, 600 psig, LHSV: 0.5 h⁻¹, and H₂/feed molar ratio: 38). All catalysts gave conversion closed to 100%, except H-Y which gave conversion of 66.44%. Pt/Al₂O₃, Pt/F-Al₂O₃, Pt/H-Y, Ir/H-Y, and Ru/H-Y give the ratio between C18 to C17 less than 1. This result indicates that the deoxygenation of jatropha oil over these catalysts tends to undergo hydrodecarbonylation and hydrodecarboxylation pathway. Moreover, the corresponding glycerides fatty acids, fatty alcohols, and heavy esters (hexadecanol, octadecanol, palmitic acid, oleic acid, stearic acid, and fatty esters) were observed as intermediates in the reaction. Figure 4.10 shows the comparison of hydrocarbon of liquid products over prepared catalysts. The result showed that Pt/Al₂O₃, Pt/F-Al₂O₃, Pt/H-Y, Ir/H-Y, and Ru/H-Y gave hydrocarbons in the range of C15 to C18 as main products while Pt/H-Y gave hydrocarbons in the range of <C6 to C9 as main products. This result indicates the highest cracking activity of Pt/H-Y catalysts. In case of H-Y support, the products also contained hydrocarbons (C15-C18) as main products though catalysts did not have hydrogenation/dehydrogenation function (metal function). It may results from hydrodecarboxylation pathway which can produce aliphatic hydrocarbon chains without using hydrogen (Murzin D.Yu. *et al.*, 2007).

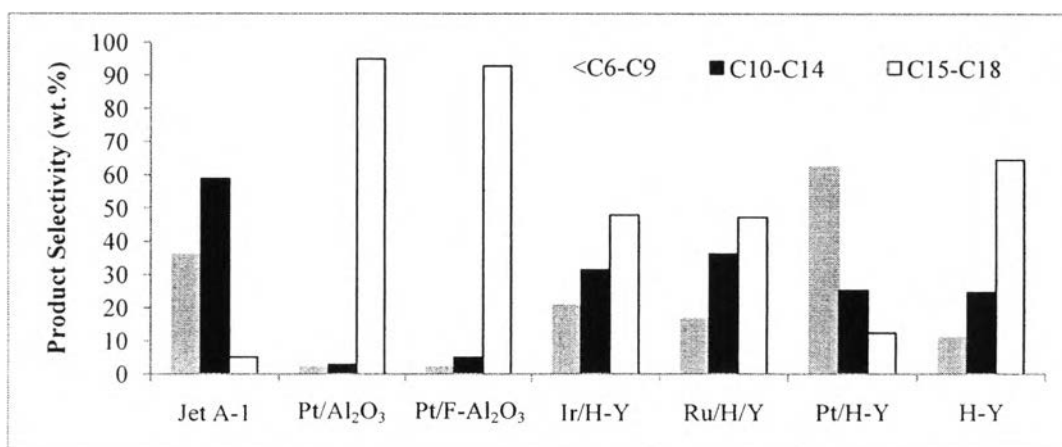


Figure 4.10 Product distribution in liquid product obtained over different catalysts compared with Jet A-1 (Reaction condition: 375°C, 600 psig, LHSV of 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).

Mass balance of deoxygenation of jatropha oil is shown in Table 4.3. CO and CO₂ were detected as gas products. This result indicates that the deoxygenation of jatropha oil over these catalysts tends to undergo hydrodecarbonylation/hydrodecarboxylation pathway. Reaction over Pt/H-Y catalyst gave many other gas products such as CH₄, C₂H₂, C₂H₄, and C₃H₈. It can indicate that Pt/H-Y catalyst has high cracking activity which leads to higher amount of light hydrocarbons in gas phase. This result agrees with the result from catalytic activity testing indicating Pt/H-Y catalyst has higher cracking activity than the other prepared catalysts.

Table 4.3 Overall Product Distribution over different catalysts

	Feed	Products (wt.%)					
		Pt/Al ₂ O ₃	Pt/F-Al ₂ O ₃	Pt/H-Y	Ir/H-Y	Ru/H-Y	H-Y
Conversion (%)	-	97.22	98.86	100	98.09	98.51	66.44
Triglyceride	91.86	2.21	0.88	0	7.33	1.19	26.88
H ₂	8.14	3.89	3.89	5.6	3.63	2.87	4.94
Gas Product							
CO	-	0.05	0.05	0.31	0.06	0.06	0.07
CO ₂	-	0.08	0.08	0.3	0.07	0.06	0.11
CH ₄	-	0.17	0.17	0.78	0.31	0.15	0.20
C ₂ H ₂	-	-	-	0.18	-	-	-
C ₂ H ₄	-	-	-	0.18	-	0.0001	-
C ₃ H ₈	-	0.004	0.004	0.02	0.006	-	0.004
Liquid Product							
<n-C ₆	-	-	-	21.39	3.09	1.78	1.09
n-C ₇	-	0.34	-	5.57	3.67	2.75	0.44
n-C ₈	-	0.36	-	4.2	1.12	1.28	0.66
n-C ₉	-	0.31	0.71	1.81	0.77	1.15	0.70
n-C ₁₀	-	0.3	0.59	0.91	1.3	1.22	0.43
n-C ₁₁	-	0.38	0.47	0.54	0.9	1.18	0.56
n-C ₁₂	-	0.03	0.43	0.43	0.76	0.86	0.24
n-C ₁₃	-	0.25	0.43	0.24	1.4	1.67	0.71
n-C ₁₄	-	0.39	0.47	0.26	1.77	2.19	1.40
n-C ₁₅	-	6.84	9.94	1.47	5.38	5.91	3.54
n-C ₁₆	-	4.63	4.23	1.01	3.28	3.53	1.75
n-C ₁₇	-	29.89	41.48	2.93	11.46	12.34	10.51
n-C ₁₈	-	18.73	5.35	1.56	2.93	2	2.06
isomerized products	-	3.1	4.09	33.98	27.29	32.9	8.03
Hexadecanol	-	0.02	0.03	0	0.1	0.14	0.12
Palmitic acid	-	0.06	0.01	0	0.03	0.02	0.19
Octadecanol	-	0.82	0.03	0	0.07	0.05	0.59
Oleic acid	-	2	0.23	0	2.38	0.26	0.00
Stearic acid	-	0.03	0.07	0.09	0.15	0.14	6.65
Monoglyceride	-	0.7	0.18	0.18	0.42	0.27	1.57
Fatty esters	-	1.81	2.07	0	0.92	0.68	1.81
Other oxygenates	-	6.12	5.29	0.44	5.91	6.54	10.16

4.2.3 Characterization of Fresh Catalysts

4.2.3.1 Temperature Programmed Reduction (TPR)

Temperature programmed reduction is used to evaluate the reduction temperature for investigated catalysts. TPR profiles of Pt/Al₂O₃, Pt/F-Al₂O₃, Pt/H-Y, Ir/H-Y, and Ru/H-Y catalysts are shown in Figure 4.11. Two reduction peaks were observed on the TPR profiles of Pt/Al₂O₃ and Pt/F-Al₂O₃ at 270 and 450 °C. These two peaks could indicate the different dispersions of platinum oxide (Ivanova *et al.*, 2010). For the Pt/H-Y, a broad peak at 450 °C is observed which may account for the reduction of Pt²⁺ (Navarro, R. *et al.*, 1999). For Ru/H-Y catalyst, the narrow peak at 200 °C may be assigned to reduction of ruthenium oxide (Navarro, R. *et al.*, 1999). The presence of three peaks in TPR profiles of Ir/H-Y catalyst may account for the reduction of Ir in different oxidation states which was expected from different locations within the zeolite structure (Navarro, R. *et al.*, 1999). From TPR result, the suitable reduction temperatures for each catalyst are listed in Table 4.4.

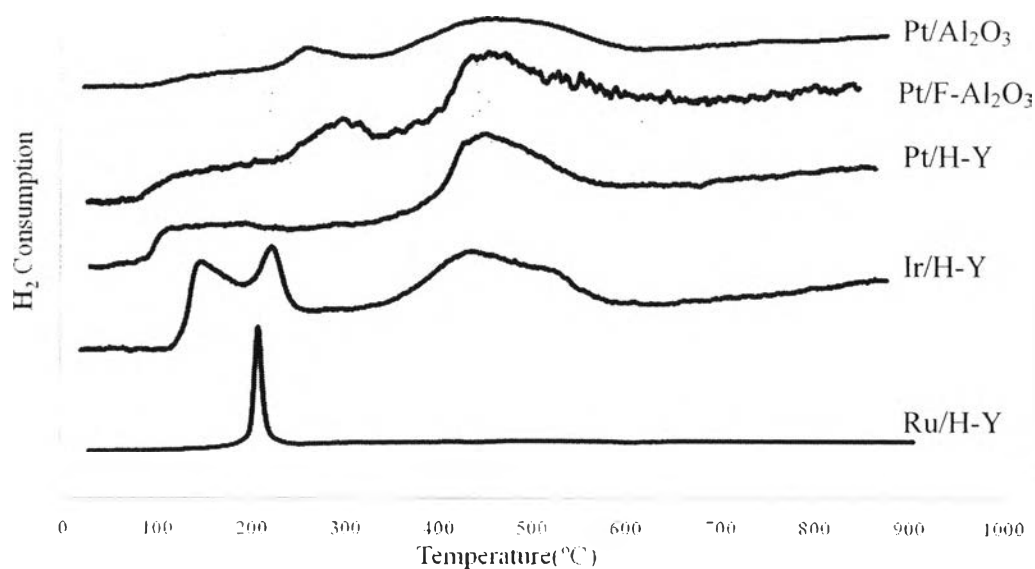


Figure 4.11 TPR profiles of the prepared catalysts.

Table 4.4 The reduction temperature for each catalyst

Catalysts	Reduction temperature (°C)
Pt/Al ₂ O ₃	500
Pt/F-Al ₂ O ₃	500
Pt/H-Y	500
Ir/H-Y	500
Ru/H-Y	200

4.2.3.2 Brunauer-Emmett-Tellet Method (BET)

Table 4.5 BET surface areas of the prepared catalysts

Catalysts	Surface area (m ² /g)
Pt/Al ₂ O ₃	256.4
Pt/F-Al ₂ O ₃	243.0
Pt/H-Y	547.7
Ir/H-Y	516.6
Ru/H-Y	520.6
H-Y	571.7

The surface areas of the prepared catalyst are summarized in Table 4.5. The surface areas of alumina-supported catalysts were less than H-Y-supported catalysts. Pt/H-Y catalyst has the highest surface areas. Based on the result from liquid product over Pt/H-Y, the result showed that Pt/H-Y was the most selective metals for hydrocracking. Thus, the highest surface area of Pt/H-Y may also lead to the higher cracking ability.

4.2.3.3 Thermal Gravimetric Analysis (TGA)

Thermogravimetric-differential thermal analyzer (TG-DTA) was used to evaluate the calcination temperature of the prepared catalysts. TG-DTA

thermograms of the prepared catalyst are shown in Figure 4.12. The suitable calcination temperatures of the prepared catalyst are summarized in Table 4.6.

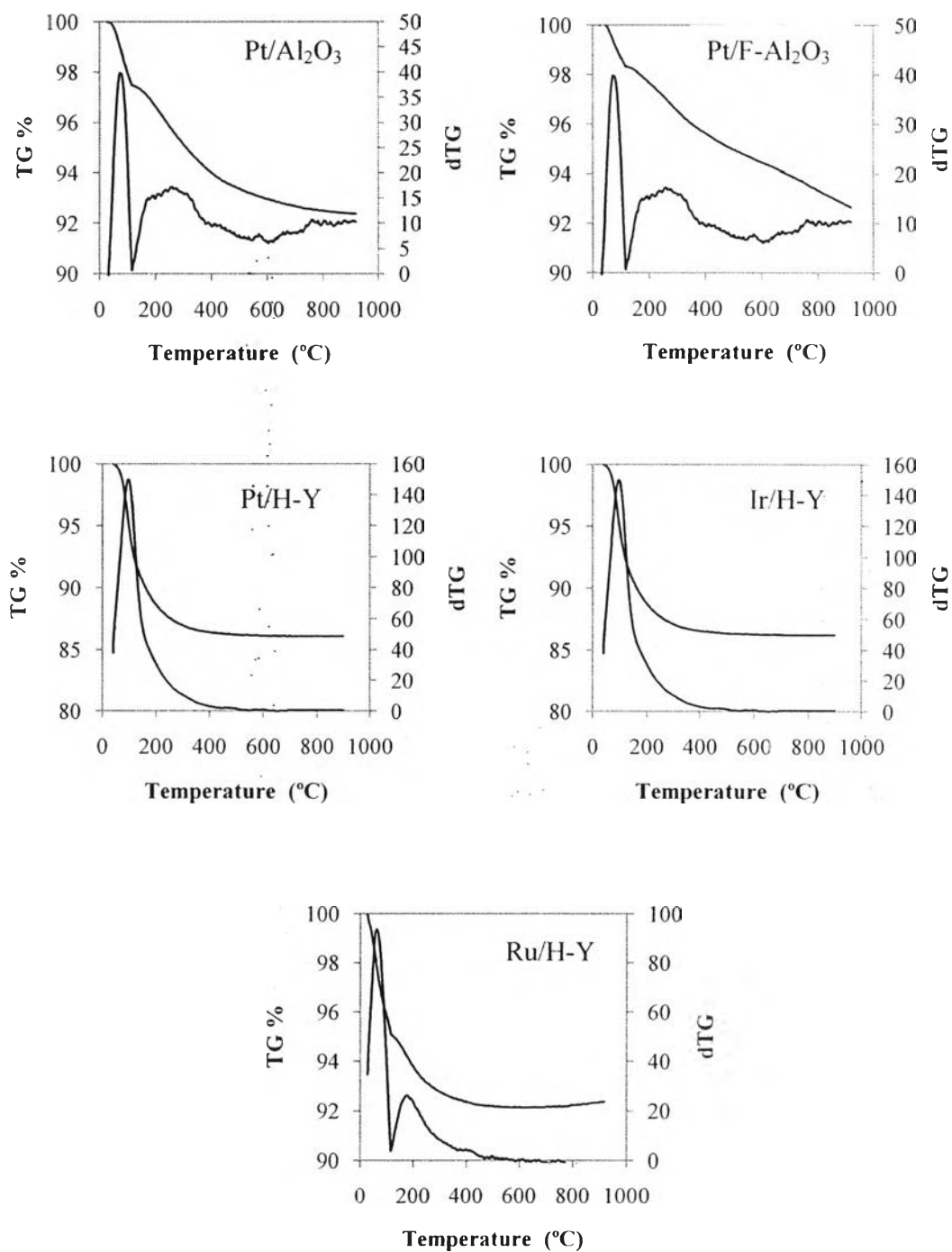


Figure 4.12 TG-DTA thermograms of the prepared catalysts.

Table 4.6 The calcination temperatures of the prepared catalysts

Catalysts	Reduction temperature (°C)
Pt/Al ₂ O ₃	500
Pt/F-Al ₂ O ₃	500
Pt/H-Y	350
Ir/H-Y	350
Ru/H-Y	350

4.2.3.4 TPD of Isopropylamine

The relative acidity and TPD of isopropylamine profiles of prepared catalysts investigated by TPD of isopropylamine are summarized in Table 4.7. The results showed that alumina supported catalysts (Pt/Al₂O₃ and Pt/F-Al₂O₃) had lower acidity than H-Y supported catalysts (Pt/H-Y, Ir/H-Y, and Ru/H-Y). In order to consider the effect of catalyst on liquid product, the liquid product from H-Y supported catalyst gave higher in the range of lighter hydrocarbons compared to alumina supported catalysts because of strong acidity of H-Y support. This result agrees well with the result from TPD of isopropylamine. However, Ir/H-Y and Ru/H-Y did not give lighter hydrocarbons as main products but they gave hydrocarbons in the range of C15 to C18 (diesel range) as main products. It may result from high acidity which leads to high coke deposit on catalyst surface, thus inhibiting cracking activity.

Table 4.7 The relative acidity of prepared catalysts from TPD of isopropylamine

Catalyst	Relative acidity of catalyst
Pt/Al ₂ O ₃	0.22
Pt/F-Al ₂ O ₃	0.23
Pt/H-Y	0.50
Ir/H-Y	0.65
Ru/H-Y	1

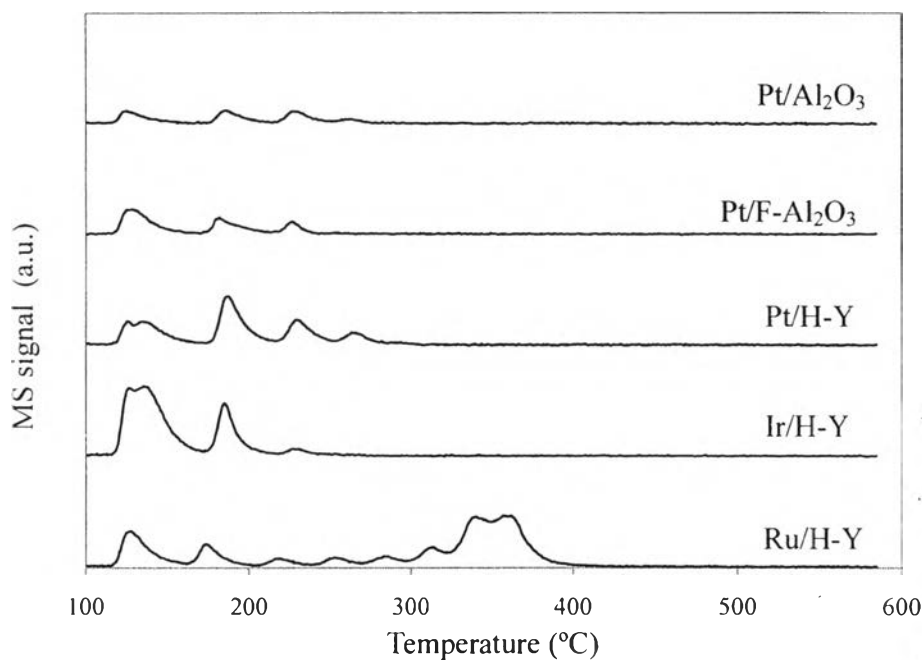


Figure 4.13 TPD of isopropylamine profiles of prepared catalysts.

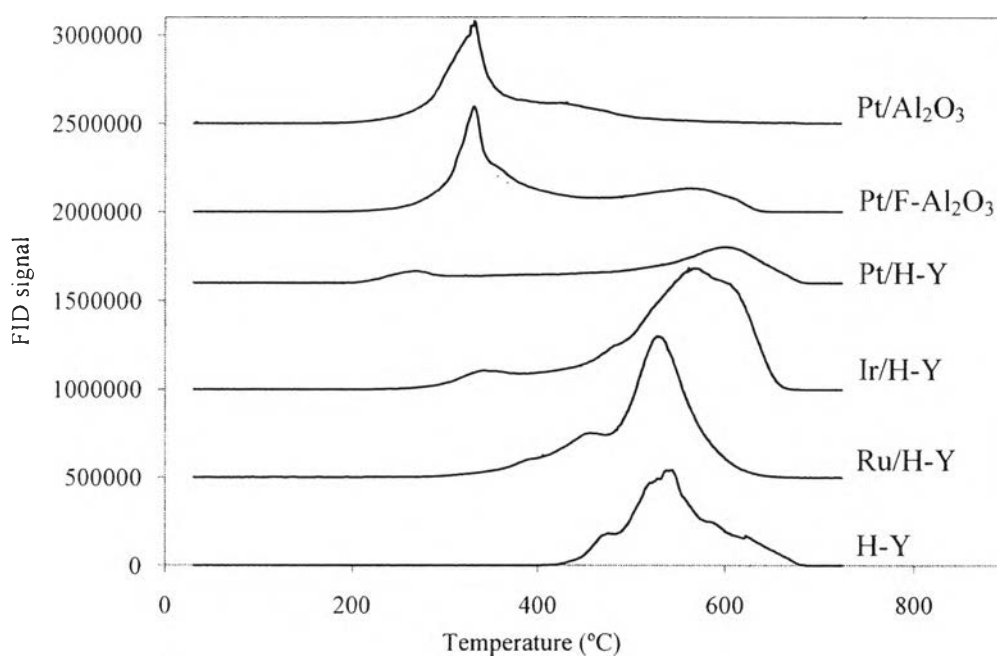
4.2.4 Characterization of Spent Catalysts

4.2.4.1 Temperature Programmed Oxidation (TPO)

The TPO profiles and amounts of coke deposit of spent catalysts obtained after reaction over Pt/Al₂O₃, Pt/F-Al₂O₃, Pt/H-Y, Ir/H-Y, and Ru/H-Y catalysts are illustrated in Figure 4.14 and Table 4.8, respectively. Alumina supported catalysts (Pt/Al₂O₃ and Pt/F-Al₂O₃) exhibited main peaks at lower temperature than H-Y supported catalysts. This result indicates that all carbon deposits on H-Y supported catalysts were located on strong acid sites. Ir/H-Y catalyst has the highest area (%C = 61.75). In order to consider about the effect of catalyst on liquid product, the liquid product from H-Y supported catalyst should be higher in the range of lighter hydrocarbon because of strong acidity of H-Y support. The result showed that liquid product from reaction over Ir/H-Y and Ru/H-Y catalysts gave main products in diesel specification range while Pt/H-Y catalysts gave main product in gasoline range. This may result from the high amount of coke deposit on Ir/H-Y and Ru/H-Y catalysts, thus inhibiting cracking activity.

Table 4.8 Amount of carbon deposit on prepared catalyst after reaction

Catalyst	Coke (wt.%)
Pt/Al ₂ O ₃	55.33
Pt/F-Al ₂ O ₃	57.07
Pt/H-Y	32.23
Ir/H-Y	61.75
Ru/H-Y	55.49
H-Y	50.85

**Figure 4.14** TPO Profiles of prepared catalysts after reaction (20 h time on stream).

4.3 Effect of Reaction Condition on Liquid Product over Pt/H-Y

Based on the result in the catalytic activity testing section, Pt/H-Y showed high potential in bio-jet fuel production. In this section operating parameters were varied i.e. temperature (325-375 °C), pressure (500-600 psig), and liquid hourly space velocity (0.5-1.0 h⁻¹) in order to find the optimum reaction condition.

4.3.1 Effect of Reaction Temperature

To study the effect of reaction temperature on product selectivity, the deoxygenation of jatropha oil was conducted at 600 psig, LHSV of 0.5 h^{-1} , and H_2/feed molar ratio of 38.5. The reaction temperature was varied from 325 to 375 °C. Figure 4.15 shows distillation curves of liquid products obtained over Pt/H-Y catalyst at different reaction temperatures. The result shows that higher temperature led to lighter hydrocarbons in the product. This result indicates that higher reaction temperature gave higher cracking product.

The product distributions of liquid products at three different reaction temperatures are given in Figure 4.16. The result shows that hydrocarbons in the range of C10 to C14 which are main components in jet fuel increased with increasing reaction temperature. This result agreed well with the distillation curve. Therefore, the reaction temperature at 375 °C was selected for further study.

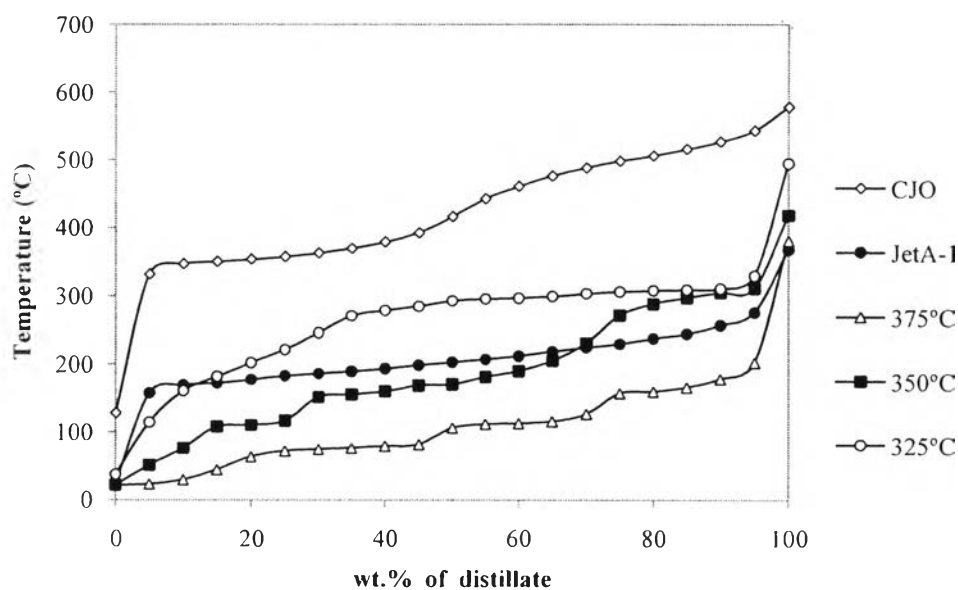


Figure 4.15 Distillation curves of liquid products obtained over Pt/H-Y catalysts at different reaction temperatures. (Reaction condition: 600 psig, LHSV of 0.5 h^{-1} , H_2/feed molar ratio of 38.5, and TOS of 8 h).

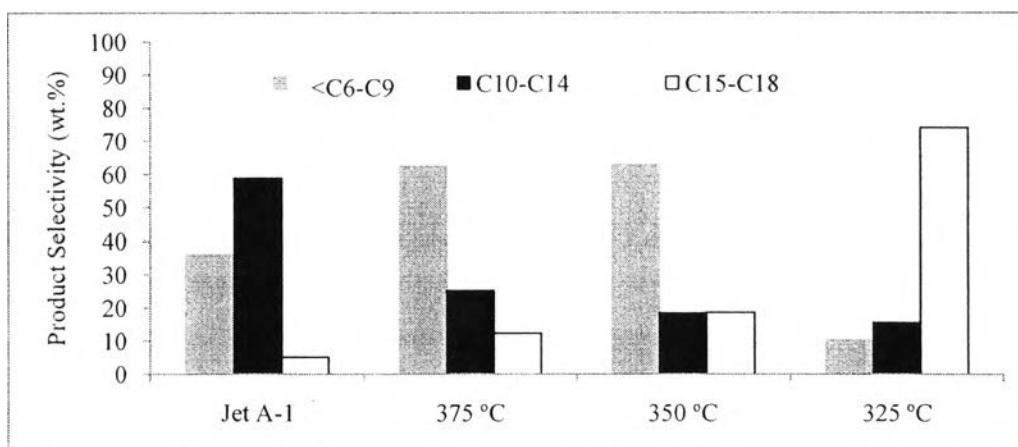


Figure 4.16 Product distribution of liquid products obtained over Pt/H-Y catalysts at different reaction temperature. (Reaction condition: 600 psig, LHSV of 0.5 h^{-1} , H_2 /feed molar ratio of 38.5, and TOS of 8 h).

4.3.2 Effect of Liquid Hourly Space Velocity (LHSV)

To study the effect of the liquid hourly space velocity on product selectivity, the deoxygenation of jatropha oil was conducted at 375°C , 600 psig, and H_2 /feed molar ratio of 38.5. The liquid hourly space velocity was varied from 0.5 to 1.0 h^{-1} . Figure 4.17 shows distillation curves of liquid products obtained over Pt/H-Y catalysts at different liquid hourly space velocity. The result shows that higher liquid hourly space velocity lead to heavier hydrocarbon range. It can indicate that the increase in liquid hourly space velocity causes less cracking and less production of hydrocarbons in jet fuel range due to shorter residence time (Bezergianni *et al.* 2009). This result agreed well with the product distribution of liquid products obtained over Pt/H-Y at different liquid hourly space velocity as shown in Figure 4.18.

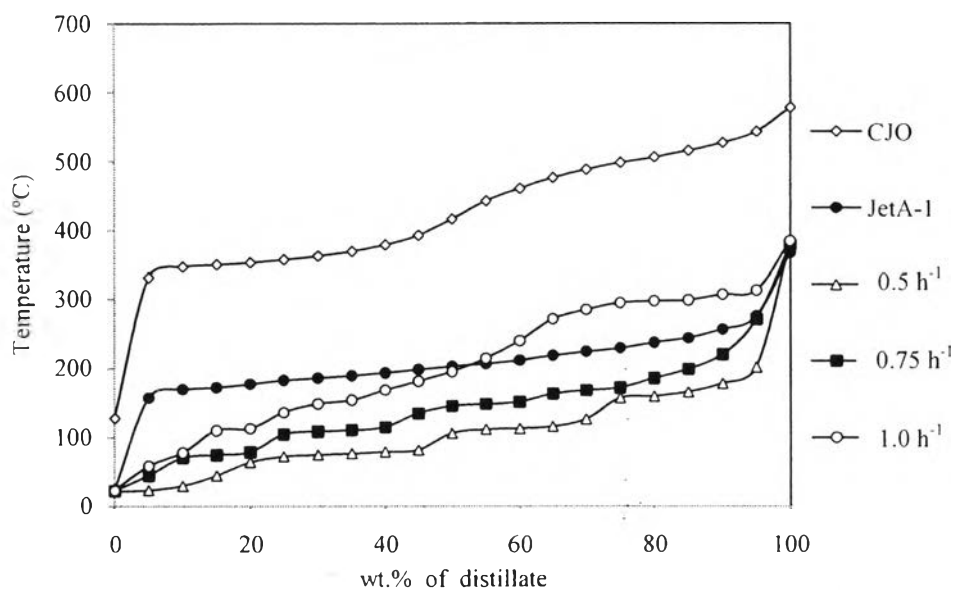


Figure 4.17 Distillation curves of liquid products obtained over Pt/H-Y catalysts at different liquid hourly space velocity. (Reaction condition: 375 °C, 600 psig, H_2 /feed molar ratio of 38.5, and TOS of 8 h).

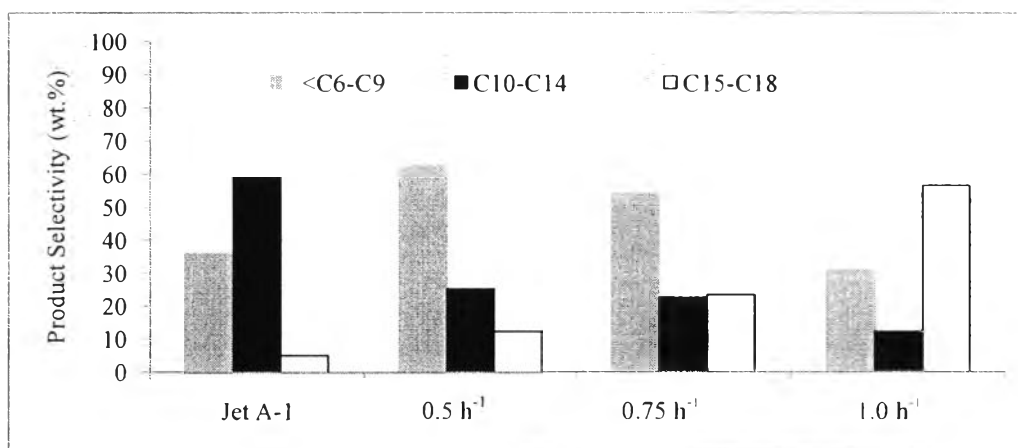


Figure 4.18 Product distribution of liquid products obtained over Pt/H-Y catalysts at different liquid hourly space velocity. (Reaction condition: 375 °C, 600 psig, H_2 /feed molar ratio of 38.5, and TOS of 8 h).

4.3.3 Effect of Pressure

To study the effect of the liquid hourly space velocity on product selectivity, the deoxygenation of jatropha oil was conducted at 375°C, LHSV: 0.5 h⁻¹, and H₂/feed molar ratio of 38.5. The pressure was varied from 500 psig to 600 psig. Figure 4.19 shows distillation curves of liquid products obtained over Pt/H-Y catalysts at different pressure. The results show that higher pressure led to lighter hydrocarbon range.

The product distributions of liquid products at the three different pressures are given in Figure 4.20. The result showed that hydrocarbons in jet fuel range increases with increasing reaction pressure but when pressure increased to 600 psig hydrocarbon in jet fuel range decreased. From this result, the optimum reaction pressure is 550 psig.

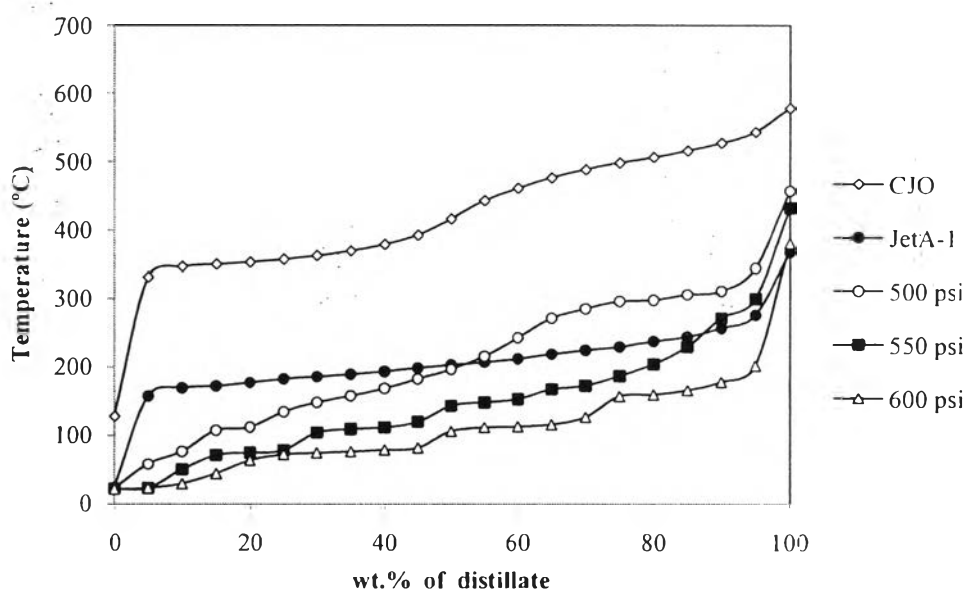


Figure 4.19 Distillation curves of liquid products obtained over Pt/H-Y catalysts at different liquid hourly space velocity. (Reaction condition: 375 °C, LHSV: 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).

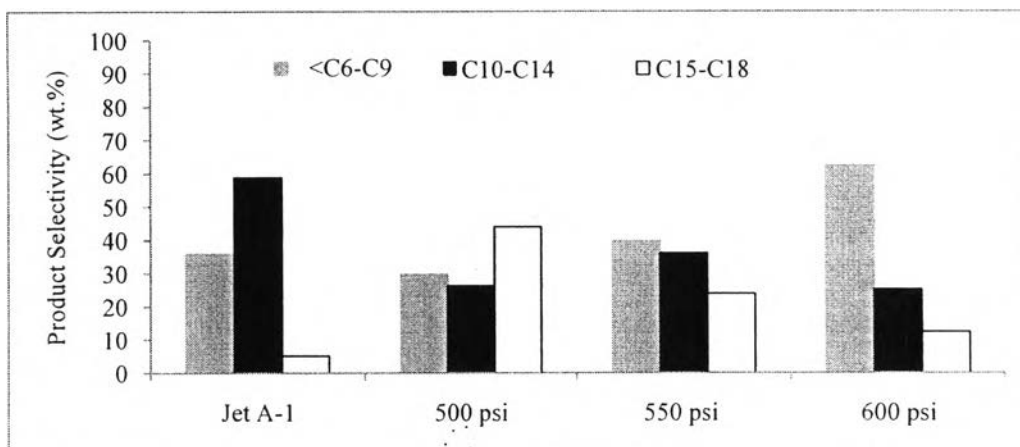


Figure 4.20 Product distribution of liquid products obtained over Pt/H-Y catalysts at different liquid hourly space velocity. (Reaction condition: 375 °C, LHSV: 0.5 h⁻¹, H₂/feed molar ratio of 38.5, and TOS of 8 h).