CHAPTER II
BACKGROUND AND LITERATURE REVIEW

2.1 Petroleum Fuels and Alternative Fuels

The petroleum found underground is derived from the remains of plants and animals called fossils. Petroleum has high energy, which can be refined to various fuels such as gasoline, kerosene, diesel, and aircraft fuels, or petrochemicals feedstock. The petrochemical feedstock is used in the manufacture of plastics, cosmetics, and petroleum solvents. Accordingly, due to sharp increases of petroleum fuel consumption and environmental pollutions, alternative fuels are developed to substitute the petroleum fuels. These alternatives include alcohol from corn fermentation, biodiesel from soybean or algae, BTX (benzene, toluene, and xylenes) from coal, and liquid fuels from used tires or agriculture wastes, etc (Lee *et al.*, 2007). The alternative transportation fuels are very interesting since they can reduce in the emissions of toxic chemicals, ozone forming compounds, and other pollutants, as well as greenhouse gases. They include alcohols, gaseous fuels, biodiesel fuels, hydrogen fuels, electricity, and fuels derived from coal, which are substituting alternatives to gasoline and diesel fuels (http://ncseonline.org).

2.2 Hydrodesulfurization

Because of the rapidly increasing demand for light engine fuels, the environmental problems are concerned, especially those from sulfur and the quality of the engine fuels, which are the main problems needed to solve. The sulfur contents in transportation fuels are limited to a minimum concentration. In 2006, the US limited the sulfur contents to be 30 ppm in gasoline and 15 ppm in diesel as same as levels in Europe and Japan. In 2008, the sulfur content in diesel was lower to 10 ppm. In petroleum refinery, the sulfur compounds in feedstock are removed by hydrotreating processes such as hydrodesulfurization (HDS) using a catalyst (Oyama *et al.*, 2008).
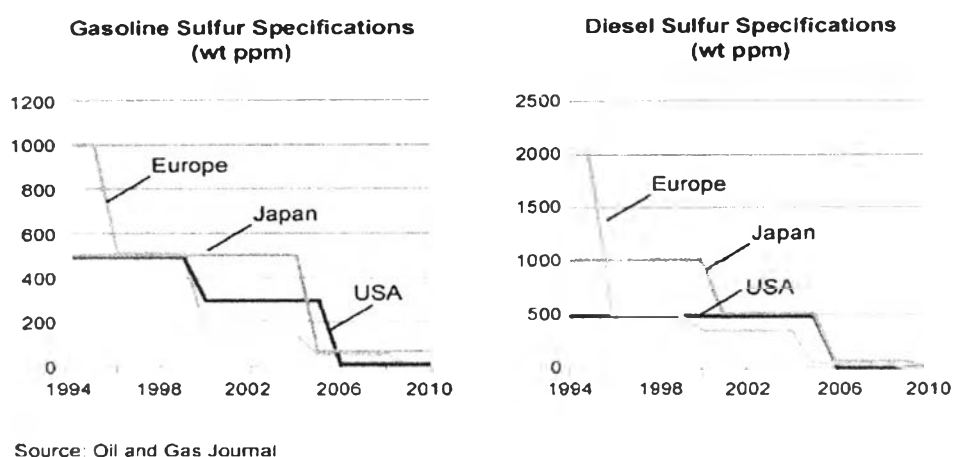
Figure 2.1 Fuel quality specifications (http://www.secinfo.com).

High performance hydrodesulfurization (HDS) catalysts are needed to produce clean engine fuels. From previous works, the conventional CoMo and NiMo/γ-Al$_2$O$_3$ catalysts were used for hydrodesulfurization via the direct desulfurization (DDS). However, the direct desulfurization had insufficient activity for the elimination of most refractory polyaromatic sulfur compounds such as 4,6-dimethyldibenzothiophene (4,6-DMDBT). Many researchers studied new HDS catalysts for eliminating the refractory dibenzothiphene (DBT) compounds by deep HDS through the hydrogenation (HYD) pathway. The noble metals were hydrogenating catalysts used to hydrogenate the aromatic compound and break down the C-S bonds. As shown in Figure 2, the hydrodesulfurization of 4,6-dimethyldibenzo-thiophene (4,6-DMDBT) occurs through two routes. In the first route, the sulfur atoms are directly eliminated via breakdown of the C-S bond that is called the direct desulfurization (DDS) route, whereas in the second route, the 4,6-DMDBT is hydrogenated, followed by hydrogenolysis that is called the hydrogenation (HYD) route (Klimova et al., 2010).
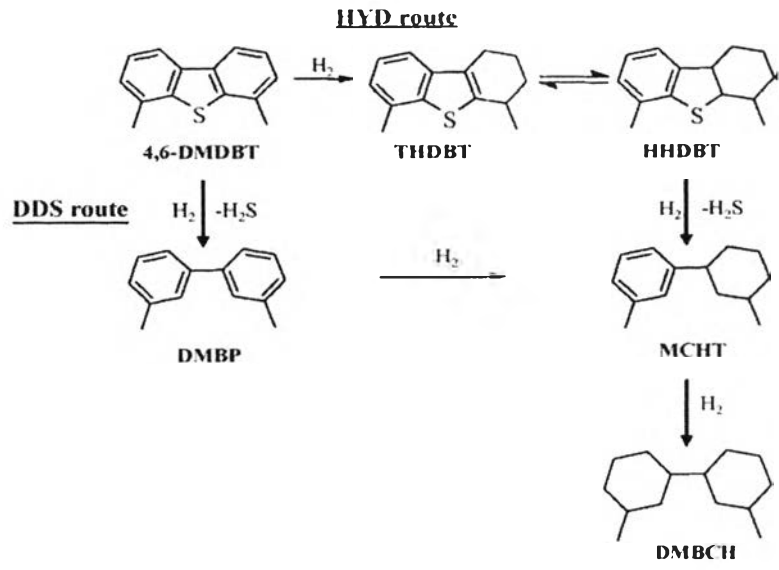
HYD route

4,6-DMDBT THDBT HHDBT

DDS route

DMBP MCHT

DMBCH

Figure 2.2 Reaction network for 4,6-dimethyldibenzothiophene hydrodesulfuriztion (Klimova *et al.*, 2010).

2.3 Alternative Fuels from Waste Tire Pyrolysis

The alternative fuels are needed to substitute petroleum fuels. Accordingly, the waste tires have been produced annually around the world, due to the extremely increased transportations and automobile manufacturing. The alternative fuels produced by the pyrolysis of waste tires are an interesting route. These used tires are non-degradable materials, and the complexity of tires is difficult to recycle, which causes significant environmental problems. Sulfur is used to crosslink the polymer chains for the vulcanization process (Williams *et al.*, 1990). Therefore, tires have chemical, biological, and physical resistant properties that are extremely difficult to be disposed. The pyrolysis of waste tires is receiving more attention from many researchers due to the wide range of products such as gases (C_1-C_6), liquid products (gasoline, kerosene, and gas oil), and solid (carbon residue). Moreover, the pyrolysis of waste tires can produce high value commercial products such as mono-aromatics (BTX), mixed C_4, olefins, and cooking gas. After pyrolysis process, sulfur atoms in the crosslink of waste tire molecular can reform into highly hazardous substances, for

examples, thiophene, benzothiophene, dibenzothiophene and others. These substances are carcinogenic and mutagenic. Therefore, sulfur components have to be removed from fuels.
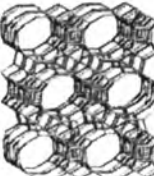
2.4 Zeolites

In industry, catalysts are used in order to produce high selectivity of desirable products and reduce the reaction time in processing. Zeolites are acid catalysts which are used in many chemical processes. One group of zeolites is aluminosilicate type which the performance of each zeolite is governed by pore size, Si/Al ratio, surface area, framework dimension, and etc. Some commercial zeolites, which are mordenite (MOR) and Beta zeolites are studied in this research.

The mordenite zeolite (MOR) has 12-member ring, large pore size about 7.0 x 6.5 Å, and one dimensional structure. MOR has been used in many chemical reactions such as C_5/C_6 paraffin isomerization, aromatics alkylation and transalkylation, xylene isomerization and catalytic NO_x reduction (http://www.sud-chemie.com). Adjaya and Bakhshi (1995) studied the influence of different catalysts on hydrocarbon products from pyrolysis bio-oil. They found that, similar to ZSM-5, H-mordenite (HMOR) produced a higher yield of aromatics than that of aliphatic hydrocarbons. Toluene, xylenes and trimethylbenzenes were those among the main aromatic hydrocarbons in the gasoline range. Moreover, they mentioned that the HMOR zeolite produced a low amount of char and a high amount of gas.

The beta zeolite (Beta) has higher Si/Al ratio (13.5) than the other zeolites (MOR = 9.5 and Y = 7.5), which leads to lower acidity than the other zeolites. Beta has three-dimensional 12-member ring channel as same as the Y zeolite. The dimension of zeolite can control the molecular diffusion in a zeolite framework; for example, the diffusion in one dimensional structure is slower than in the three dimensional one.

Table 2.1 Structure of commercial zeolites (http://www.ucl.ac.uk/nanogrowth/) (http://tjchemist.en.ecplaza.net/catalog.asp)

Zeolite	Dimensional	Pore size	Si/Al ratio
Mordenite (MOR)	1D	7.0 x 6.5 Å	9.5
Beta	3D	7.6 x 6.4 Å	13.5

2.5 Pyrolysis of Waste Tires

A huge number of waste tires is generated annually around the world. Many researchers have studied on the variety of techniques to produce valuable products from waste tires. The pyrolysis is one of many techniques that can produce high calorific value products to substitute conventional fuels. The pyrolysis of waste tires have been investigated and developed; either on thermal pyrolysis or catalytic pyrolysis, using bifunctional or bimetallic catalysts.

2.5.1 Thermal Pyrolysis of Waste Tires

At the beginning of pyrolysis study, several researchers studied the thermal degradation of waste tires via pyrolysis process. The main purpose of most research works was to produce a high quality and quantity of pyrolytic products. Aylón *et al.,* (2006) studied the gas emission from tires pyrolysis. They used two fixed bed reactors in series; the first one was tire pyrolysis reactor, and the second one was the combustion of tire pyrolytic gas. The pyrolysis gas was produced from the first reactor, and then pre-mixed with the oxygen for combustion in the second

reactor. The gas emissions from the two reactors were analyzed by gas chromatographs. They mentioned that the pyrolysis gases from the first reactor consisted of CO_2, CO, H_2, H_2S and light hydrocarbons. On the other hand, the gases from combustion reaction in the second reactor consisted of CO_2, SO_2, NO_2, metal (As, Sb, Hg, Pb, Sn etc.) vapors, HF, HCl, dioxins and furans. As a result, the combustion of tire pyrolysis gas (the second reactor) produced emitted gas pollutants higher than the tire pyrolysis (the first reactor).

Zabaniotou and Stavropoulos (2003) studied the effect of pyrolysis temperature on the char, gas, and volatile products by varying the temperature in the range of 390-890 °C. They found that the thermal cracking activity increased with increasing pyrolysis temperature, leading to increased gas yields and decreased liquid yields. Moreover, they tried to improve the reactivity and the specific area of pyrolytic residual char by combustion, CO_2 gasification, stream gasification, and active carbon preparation. They concluded that the pyrolytic char from stream gasification had much higher reactivity than that from CO_2 gasification. They also determined the surface area of pyrolytic char by both CO_2 and stream gasification, which was 600 $m^2 g^{-1}$ as compared with those of commercial activated carbons that was in the range of 800 and 1,100 $m^2 g^{-1}$.

Several researchers studied the effect of pyrolysis temperature on pyrolytic products. In 2001, Rodriguez *et al.*, studied the effect of the tire pyrolysis temperatures at 300 °C, 400 °C, 500 °C, 600 °C, and 700 °C carried out in an autoclave reactor on pyrolysis yields. The result showed that the optimum temperature of tire pyrolysis was 500 °C. The tire pyrolysis was incomplete at below 500 °C, and no influence of temperature in product yields was found above 500 °C. Moreover, the tire decomposition by pyrolysis was completed at 500 °C, and gave the same products yields as high temperatures. The elemental composition (H/C atomic ratio) and gross calorific value (G.C.V.) of tire pyrolysis liquids were analyzed at different temperatures. They found no significant influence of pyrolysis temperature on the elemental composition of pyrolysis liquid, H/C atomic ratio, and also on G.C.V. In addition, they mentioned that at lower temperatures, the tire structure was cracked, and free-radical aliphatics were generated, while at higher temperatures, the recombination reaction of free-radical aliphatics were occurred,

followed by cyclization. It can be concluded that the yield of aromatic compounds increased with increasing the pyrolysis temperature. Similar results have been reported by other workers. For example, Cunliffe *et al.*, (1998) studied the batch pyrolysis of scrap tires at the temperatures between 450 °C and 600 °C. They mentioned that the total polycyclic aromatic hydrocarbons (PAH) in pyrolytic oils increased with increasing the pyrolysis temperature. Moreover, they concluded that the PAH was generated via the Diels-Alder reactions which are the secondary reactions of pyrolysis process. The Diels-Alder reactions occur, followed by alkane dehydrogenation to alkenes or dienes, then the cyclization of alkene or dienes, and finally aromatization.

Williams and Taylor (1993) determined the concentration of PAH by first using liquid chromatography to separate pyrolytic oil, followed by gas chromatography-mass spectrometry. They found that the PAH in the tire pyrolysis oil contained chrysene, benzofluoranthene, benzo[e]pyrene, and benzo[a]pyrene that are carcinogenic whereas phenanthrene, methylphenanthrenes and fluoranthene that are mutagenic. In addition, they mentioned that the PAH increased with the increasing temperature of reactor, and especially the highest PAH concentration was obtained without N_2 purge in the reactor. Díez *et al.*, (2004) studied the influence of three final temperatures (350 °C, 450 °C, and 550 °C) on the yields of the pyrolysis products. The results showed that at a higher temperature, the concentration of sulfur in carbon residues was lower than at the low temperature because the C-S bond favored to break down at a high temperature, and then probably formed hydrogen sulphide (H_2S) in the gas phase.

2.5.2 Catalytic Pyrolysis of Waste Tires

Many researchers studied the products of waste tires pyrolysis such as gases, oils, and residue char with high calorific values. The waste tire pyrolysis products can be used, especially as chemical feedstocks such as benzene, toluene, ethylbenzene and xylenes (BTEX), and limonene, which can be further processed to a high commercial value of products such as cosmetics, solvents and fabric. Catalysts were used in the pyrolysis of waste tires in order to obtain more desirable and higher value products.

Williams and Brindle (2002) studied the influence of pore size and acidity of zeolite catalysts on the yield and compositions of waste tire pyrolysis products. They found that ZSM-5 catalyst produced lower aromatic hydrocarbons, especially benzene, toluene, m-, p- and o-xylenes than Y-zeolite because ZSM-5 catalyst had smaller pore size. Moreover, the propane and propene gases were produced by ZSM-5 catalyst much higher than Y-catalyst. They mentioned that the smaller pore size of ZSM-5 restricted the large molecule of an aromatic compound, and cracked heavy hydrocarbons into light hydrocarbons. In case of Si:Al ratio, the lower Si:Al ratio of Y-zeolite (Si:Al ratio= 5.4) produced higher aromatic content in oil than the higher ratio of ZSM-5 (Si:Al ratio= 40) due to higher hydrogen transfer and surface activity. In 2008, Olazar *et al.* studied the effect of HBeta, HY, and ZSM-5 zeolites on the pyrolysis of tire products. They found that the HY zeolite produced higher yields of aromatic C_{10-} and tar by the condensation and alkylation of aromatic reaction than other zeolites due to the high total acidity and large pore size. In addition, the high total acidity of HY enhanced hydrogen transfer capacity, which caused the production of heavy aromatic hydrocarbons. The ZSM-5 zeolite produced the higher yields of gas and liquid, especially single-ring aromatics (BTX) due to the strong acid site and smaller pore size. In addition, the strong acid enhanced the cracking activity to produce olefins, followed by the Diels-Alder condensation of olefins to single-ring aromatics (BTX).

From a previous work, Choosuton *et al.*, (2007) studied the effect of catalysts on the product distribution of waste tire pyrolysis products. They mentioned that the high acid strength of beta zeolite gave lower saturated hydrocarbons and higher di-aromatic hydrocarbons in oils due to the higher cracking activity of acid site. The lower acid strength of MOR and USY zeolites generated the larger saturated hydrocarbon than the beta zeolite. They found that the KL base catalyst produced the higher amount of mono-aromatics due to low cracking activity. Some bifunctional catalysts such as noble metals (Pt, Pd, and Ru) supported on zeolites (beta, MOR, and USY) and basic catalyst (KL) were also studied, which are reviewed in the next section.

2.5.3 Bifunctional Catalysts for Waste Tire Pyrolysis

The process activities of the waste tire pyrolysis can be improved by using bifunctional catalysts. Choosuton *et al.*, (2007) suggested that the hydrogenation activity of noble metals can improve the ring-opening and cracking activity. They found that Ru/HMOR gave the highest cracking activity because it produced the highest gas production such as methane, ethylene, and propylene. The Pd/HBeta produced a high quantity of gasoline range with a good quality of gasoline due to the low aromatic content in gasoline. Dũng *et al.*, (2009) studied the effect of bifunctional catalysts on polar-aromatic reduction in the pyrolysis of waste tire. The polar-aromatic reduction activity of the bifunctional catalysts, Pt supported on acidic zeolite (HMOR and HBeta), were compared. They found that the Pt/HBeta showed the higher acitivity than Pt/HMOR due to the stronger acid sites of HBeta that enhanced the cracking of aromatic intermediate. In addition, the Pt/HBeta gave smaller carbon distribution than Pt/HMOR. They mentioned that the good hydrogenation activity of Pt could prevent the polar-aromatic formation. In 2010, Dũng *et al.,* used Ru/SBA-1 catalyst in the pyrolysis of waste tire. They used inactive mesoporous SBA-1 support in order to study the roles of ruthenium. They reported that Ru had high hydrogenolysis activity to produce a high amount of light hydrocarbons and increase poly- and polar-aromatic reduction.

2.5.3.1 Noble Metal Catalysts

Noble metals consist of ruthenium (Ru), rhodium (Rh), palladium (Pd), silver (Ag), rhenium (Re), iridium (Ir), platinum (Pt), and gold (Au), and etc. The noble metals have the high activity on hydrogenation/dehydrogenation and ring-opening reactions. Many researchers used noble metals as bifunctional catalysts in several chemical reactions. For example, Juszczyk and Karpiński (2001) studied the effect of Pd and Re supported on alumina as monometallic and bimetallic (Pd-Re) catalysts on the hydrocarbonconversion of n-hexane, 2,2-dimetylbutane and methylcyclopentane reactions. The results showed that Re/Al$_2$O$_3$ catalyst gave the highest C<6 (hydrogenolysis products) selectivity and the lowest activation energy for all reactions. For bimetallic catalysts, the C<6 (hydrogenolysis products) selectivity increased, and the isomerization selectivity decreased with increasing the Re content. They mentioned that the hydrogenolysis reaction was

occurred over rhenium (Re), whereas the isomerization reaction was occurred over palladium.

Aboul-Gheit *et al.,* (2005) studied the effect of catalysts containing Pt, Pd, Ir, and Re supported on H-ZSM-5 on the hydroconversion of cyclohexane (CH). The results showed that Pd/H-ZSM-5 gave the highest hydrogenating activity for cyclohexene (CHE) conversion to cyclohexane (CHA) and also for metylcyclopentenes to metylcyclopentane. On the other hand, similarly to unloaded H-ZSM-5, Re/H-ZSM-5 gave the lowest hydrogenating activity. The hydrogenating activity followed the order: Pd > Pt > Ir > Re ≥ unloaded H-ZSM-5. Moreover, the aromatic products consisting of benzene, toluene, and xylenes were obtained from the hydroconversion of CHE. Benzene was produced from CHE dehydrogenation, while toluene and xylenes were produced from alkylation of benzene. The alkylation of benzene was enhanced by hydrocracking and hydrogenolysis which required the balance between hydrogenation activity (metal sites) and cracking activity (acid sites). The results showed that unloaded H-ZSM-5 gave high toluene and xylenes products because H-ZSM-5 had the highest acid sites and acid strength, resulting in the improved cracking activity. Loiha *et al.,* (2008) studied the influence of a bimetallic catalyst of noble metals (Pd-Pt) on the hydrogenation of toluene. They concluded that the bimetallic catalyst showed higher stability at high temperatures than the monometallic catalysts. Moreover, the bimetallic catalyst provided the high selectivity of hydrogenation product (Methylcyclohexane, MCH).

Guo *et al.,* (2005) investigated the dehydrogenation and aromatization of propane over Re/HZSM-5 and Ga/HZSM-5. As a result, Re/HZSM-5 gave the highest conversion of propane when compared with Ga/HZSM-5 and HZSM-5 because the high dispersion of Re metal over HZSM-5 could enhance propane dehydrogenation and aromatization. The aromatization of olefins to aromatics required the strong acid sites. They found that the yield of aromatics with using Re/HZSM-5 was lower than Ga/HZSM-5 because the amount of Brønsted acid sites of Re/HZSM-5 was lower than thar of Ga/HZSM-5.

The aromatic compounds in gasoline are restricted because of the environmental concern. Some researchers have used noble metals for the

aromatics reduction of gasoline. In 2006, Castaño et al., studied the effect of noble metals as bifunctional catalysts on the hydrodearomatization of pyrolysis gasoline (PyGas). They used both noble metals (Pd, Pt and Ir) and non-noble metal (Ni) in their study. In case of hydrodearomatization under mild ring-opening (MRO) condition, the Pt/HY catalyst showed the highest conversion of ring-opening (RO) and hydrogenation (HYD). They mentioned that the hydrogenation and hydrogenolysis activity of metal sites was dominant under MRO condition. In case of hydrodearomatization under severe ring-opening (SRO) condition, the cracking reaction of acid sites was dominant. The Ir/HY showed the highest conversion of RO and HYD because the Ir/HY had the highest strong acidity compared with the other catalysts. On the other hand, the Ni/HY catalyst showed the lowest RO and HYD conversion due to the lowest strong acidity and low hydrogenation activity of Ni metal. However, the Ni/HY catalyst provided the highest aromatic yields because Ni metal showed the dehydrogenation activity.

The good hydrogenation activity of noble metals supported on zeolite catalyst does not only enhance the activity of aromatic reduction, but also enhances the activity of hydrodesulfurization. Navarro et al., (1999) studied the dibenzothiophene (DBT) hydrodesulfurization (HDS) activity over noble metals (Pt, Pd, Ru, and Ir) and semi-noble metal (Ni) supported on HY zeolite. They found that the reaction rate of the HDS of DBT followed the order: Ir > Pt > Pd > Ru >> Ni > HY. Ishihara et al., (2005) also studied the HDS of dibenzothiophene (DBT) over different noble metal (Ru, Rh, Pt, and Pd) catalysts and bimetallic noble metals (Ru-Rh and Pt-Pd) supported on alumina. They concluded that the bimetallic enhanced the HDS activity, and increased the conversion of polyaromatic sulfur compounds such as dibenzothiophene (DBT), 4- methyl dibenzothiophene (MDBT), and 4,6-dimethyl dibenzothiphene (4,6-DMDBT). They mentioned that 4,6-dimethyl benzothiophene favored to be desulfurized by hydrogenation of noble metals due to the steric effect of methyl group while dibenzothiophene (DBT) was desulfurized by direct desulfurization.

Pinket et al., (2009) studied the catalytic pyrolysis of waste tire over Rh Ni and Co and their bimetallic catalysts. They mentioned that the presence of high percentage loading of Ni supported on KL zeolite for waste tire

pyrolysis showed the increase of gas yield especially olefins and cooking gas and mono-aromatics concentration. Additionally, non-noble metal Ni catalyst (20%Ni/KL) exhibited the carbon number (14.8) as similar as that of noble metal (Rh) catalyst (1%Rh/KL) (14.4).

2.5.3.2 Non-noble Metal Catalysts

Since non-noble metals have low cost, many researchers tried to use non-noble metals instead of noble metals. Non-noble metals such as Ni, Mo and Co were widely used in hydrotreating process. Fúnez *et al.*, (2008) studied the effect of Pt and/or Ni over H-beta zeolite catalysts on the hydroisomerisation of C7-C8 from naphtha stream. When they used the Pt/H-beta catalyst, the conversion of paraffins was higher than that of the others because Pt had an ability to promote hydrogenation activity. For bimetallic catalysts, when the Ni content was increasing, the multibranced isomers of paraffins were increased. In addition, they mentioned that the Ni containing catalysts could enhance the isomerization reaction. Eswaramoorthi *et al.*,(2003) studied the effect of Ni content in bimetallic Ni-Pt supported on β-zeolite and mordenite zeolite on the hydroisomerisation of *n*-heptane. They found that the 0.3 wt% Ni-0.1 wt% Pt/Hβ and 0.1 wt% Ni-0.1 wt% Pt/HMOR were the optimum ratios for the isomerization of *n*-heptane. They mentioned that β-zeolite based catalyst showed the higher conversion of isomerization and the higher selectivity of multibranched isomers than the MOR zeolite. Moreover, the MOR zeolite gave the higher cracking activity due to the larger pore size than β-zeolite. They explained that the added Ni could block the pore of MOR zeolite and decrease isomerization activity because of the one dimension pore structure of MOR zeolite. In contrast, the β-zeolite has three dimensional, when Ni blocked one of pore dimension, the reaction could occur over the other dimensions.

Another non-noble metal is iron (Fe), which is widely used in industrial processes such as Fischer – Tropsch synthesis and selective catalytic reduction (SCR) of NO$_x$ and etc. He *et al.*, (2009) studied the activity of selective catalytic reduction (SCR) of NO with ammonia over Fe/Beta catalyst. They investigated the effect of iron loading (0.5-7 wt%) over beta zeolite on the SCR activity. They found that 2.5 wt% Fe/Beta was the optimum loading of Fe because of high NO conversion. The higher loading than 2.5 wt% did not significantly affect the

NO conversion. They indicated that 2.5 wt% Fe/Beta showed the higher SCR activity than 2.5 wt% Fe/ZSM-5 due to the higher surface area.

For Fischer-Tropsch synthesis, the non-noble metal catalysts, namely cobalt (Co) and iron (Fe), have been conventionally used. Pour *et al.*, (2004) investigated the effect of iron and iron-HZSM-5 catalysts. The result showed that the iron-HZSM-5 catalyst could enhance the cracking and the oligamerization of light olefins activity due to the acid sites and shape selectivity of ZSM-5 zeolite. In addition, the acidity of HZSM-5 zeolite could improve the hydrogen transfer activity and enhance the aromatization of olefin. In 2009, Ma *et al.*, studied the effect of bimetallic Fe-Co/SiO$_2$ catalyst on Fischer-Tropsch synthesis (FTS). The result showed that the light hydrocarbons (CO$_2$, C$_1$ and C$_2$-C$_4$) favored to be generated on Fe/SiO$_2$ catalyst. In contrast, C$_{5+}$ fraction was generated on Co/SiO$_2$ at a higher amount than on Fe/SiO$_2$. They also indicated that the CO conversion of FTS increased with increasing cobalt content. Similar to Tavasoli *et al.*, (2009) studied the effect of bimetallic Co and Fe catalysts supported on carbon nanotubes (CNT) on FTS. They found that the light hydrocarbons (CO$_2$ and C$_1$-C$_4$) increased, and C$_{5+}$ decreased with increasing Fe content. They mentioned that Fe/CNT had the higher selectivity of olefin than Co/CNT.

As mentioned above, the performances of noble metals and non-noble metals, which were widely used in an industrial scale in several research works have been reported. Noble metals supported on acidic zeolites are active catalysts for hydrocracking and hydrogenation, and can also enhance the deep hydrodesulfurization reaction via hydrogenation pathway. The Co and Fe non-noble metals have been reported as selective catalysts for Fischer-Tropsch synthesis and selective catalytic reduction (SCR). The aims of this research were to investigate and compare the performance of noble metals and non-noble metals on the pyrolysis of waste tire process. The percentage of loaded noble metals (Pd and Ru) was fixed at 1% by weight, and that of non-noble metals (Ni and Fe) was varied as 5%, 10% and 20% by weight. All catalysts were prepared by using incipient wetness impregnation technique