# Utilization of Contaminated Food Plastic Bag Waste for Fuel Oil Production through Pyrolysis Process

Woraratana Pattaraprakorn and Pornrapeepat Bhasaputra

***Abstract*—** *Plastic waste, the second portion of municipal wastes in Thailand, has a potential to the utilization of wastes. Though recycle is a preferable method to utilize wastes, some types of plastic such as food-containing plastic bag, supermarket bag, are improper to this application because of contaminated substances. This research focuses on the conversion of plastic waste to fuel oil by pyrolysis process. A food-containing plastic bag, made of polypropylene, is uses as a representative of plastic waste while kaolin is a catalyst of this system. The substances such as water, soybean oil, coconut milk, soybean milk, clear soup and curry soup are simulated contaminants with plastic waste. The suitable amount of catalyst for pyrolysis has 10% wt because the larger amount of catalyst is not significant to increase the yield of oil. When amount of contaminant increases the pyrolysis oil continuously decreases. The ranking effects from the most to the least of contaminants to the production of oil are soybean milk, clear soup, curry soup, coconut milk, soybean oil and water. The reduction of oil yield is up to 51% in case that soybean milk of 13 ml is contaminated with this plastic. Moreover, the pyrolysis liquid is separated into 2 layers, from IR Spectrum confirmed that, the upper layer is the pyrolysis oil. The major portion of pyrolysis oil is the diesel about 69% and the second large portion is gasoline about 24%. According to gas chromatography technique, distributions of C-number of pyrolysis oil from plastic waste with and without contaminant are different depending on type of contaminant which might be related with the quality of pyrolysis oil. Finally, in order to do the most effective pyrolysis of the food-containing plastic bag, the food stuff should be removed as much as possible.***

***Keywords*— Pyrolysis, plastic waste, liquid fuel.**

## 1. INTRODUCTION

The amount of municipal wastes still increases countinuously due to population growth and high standard of living. In 2008, the volume of the municipal wastes in Thailand was approximately 15.03 million ton per year or 41,064 ton per day (excluding the number of municipal wastes before they were disposed to the garbage bin)[1]. The composition in the municipal wastes consists of food waste at 63.57 % and following by plastic at 16.83% as shown in Fig.1. Plastic waste is the second portion of total municipal wastes and especially of residential and school/university (Fig.2). Though food waste is the major portion of the solid wastes, the typical management is used as animal feed or fermented to be fertilizers with the assumption that the municipal wastes are separated originally. Otherwise, the mixed wastes are dumped into sanitary landfill by local government.

The problem for plastic waste that cannot be degraded by microorganism to be soil is different with food waste; therefore, larger landfill areas with longer time are required[2-3]. Pyrolysis technology; a reaction at higher temperature under insufficient oxygen; is an alternative process for demolishing the plastic waste by transforming it into fuel oil. The liquid product may be different rely on the various kinds of plastic. Advantages of pyrolysis process are not only the reduction of waste but also the regeneration of oil from the waste.

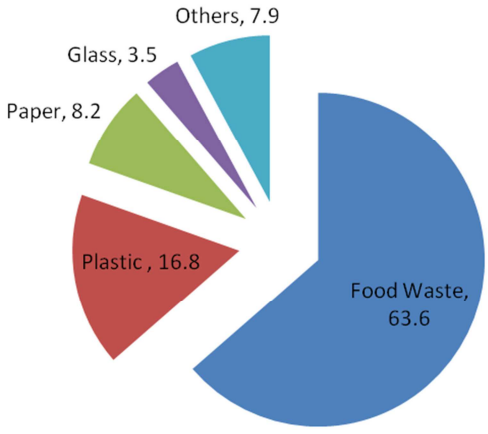


**Fig. 1. The Compositions of Municiple Wastes in Thailand**

However the recycle of plastic is the most preferable method, some limitations have to be concerned. Most of recycle plastic wastes have to be dry material, high density, not rotten or bad smell after keeping which usually are drinking water, goods container, etc. The other types of plastic waste are always disposed in landfill. One example of plastic waste which is not appropriate to recycle is a food-containing bag. Life style of people in urban area always buys already cooked food for dinner. Example is illustrated in Fig.3. They do not have time to

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prepare food by themselves. Plastic waste after use is mixed with municipal wastes.

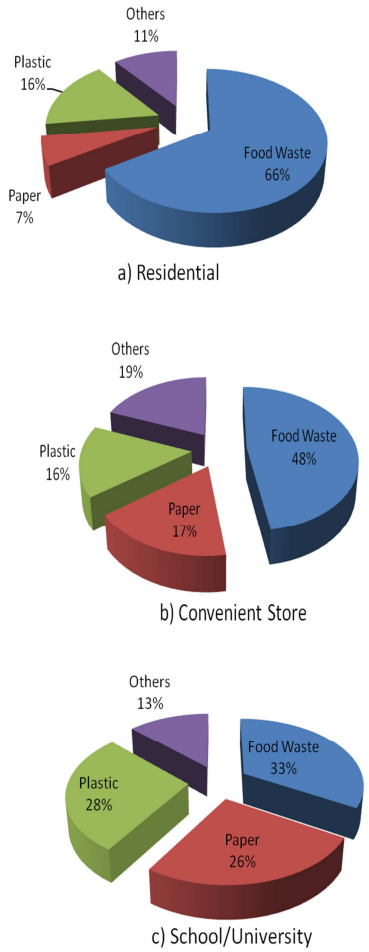


**Fig. 2. Composition of Municipal Wastes Related with Type of Producer**

**Fig. 3. Picture of Already Cooked Food for Working Life Style**

The food-containing bag is made of polypropylene, which has a potential to convert into fuel oil [4-5] but the contaminant from food might affect to the production of oil. Therefore, the purposes of this study are to study the effect of contaminant into pyrolysis process in order to produce fuel oil. The result of this study can evaluate the potential of plastic waste with food contaminant and also suggest the way to manage the food-containing bag for pyrolysis process.

## 2. MATERIALS AND METHODS

Plastic waste used in this research is a food-container bag, made of polypropylene (PP). Contaminant substances are water, soybean oil, soybean milk, coconut milk, clear soup and curry soup. These plastics are cut to size approximately 2 × 2 cm. In addition to, Kaolin clay (Kaolin ACROS #21174) is used as a catalyst and nitrogen gas with purity of 99.99% is used as a carrier gas in pyrolysis process.

All the experiments were carried out in the autoclave reactor type MMJ-100 (100 ml). For thermal degradation, ten grams of sample were heated in this autoclave from room temperature to 450 °C and hold at 450°C for 15 min. Nitrogen gas was connected to the autoclave for removing air before the reaction started. After that, the temperature was decreased to room temperature. In case of considering amount of catalyst and contaminant, it was mixed before heating process. Schematic diagram of the autoclave reactor is shown in Fig.4. The product was condensed, collected and analyzed while percentage of oil yield was measured and the composition and properties of oil were analyzed by thermal gravimetric analysis (TGA), Fourier Transform Infrared Spectrometer (FTIR) and Gas Chromatography (GC)[6].

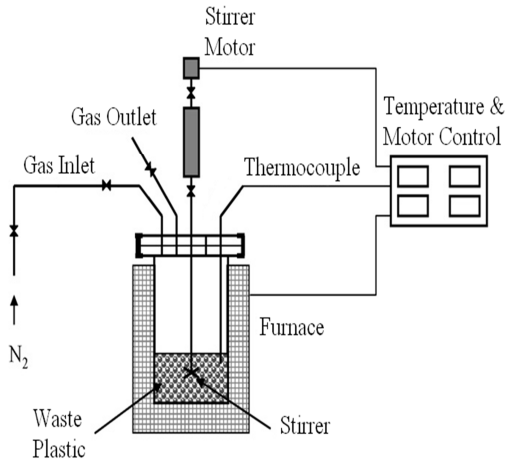


**Fig. 4. Schematic Diagram of Autoclave Reactor.**

## 3. RESULTS AND DISCUSSION

### *3.1 The Appropriated Amount of Catalyst*

In order to identify an appropriate amount of catalyst for pyrolysis the plastic waste into oil, the amounts of catalyst are varied from 0 to 5 grams. Pyrolysis oil without using catalyst is lower than that with using catalyst between 26.1-28.4%. Thus catalyst enhances the yield of pyrolysis oil. According to the result of catalyst amount, the oil yields slightly increase with increment of catalyst as shown in Fig.5. Moreover pyrolysis oil with different amounts of catalyst reveals the similar composition as similar to [7]. Thus the amount of catalyst doesnot affect to the composition and amount of pyrolysis oil. The major composition of pyrolysis oil analyzed by TGA is diesel about 69% and the second portion is gasoline about 27%. Then one gram of catalyst or 10% wt of catalyst is chosen for the next section.

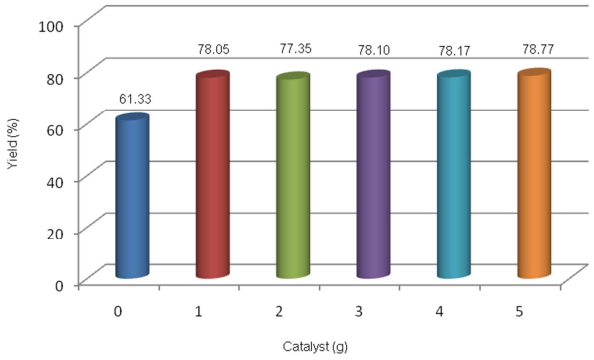


**Fig. 5. Yield of Pyrolysis Oil with Different Catalyst Amount**

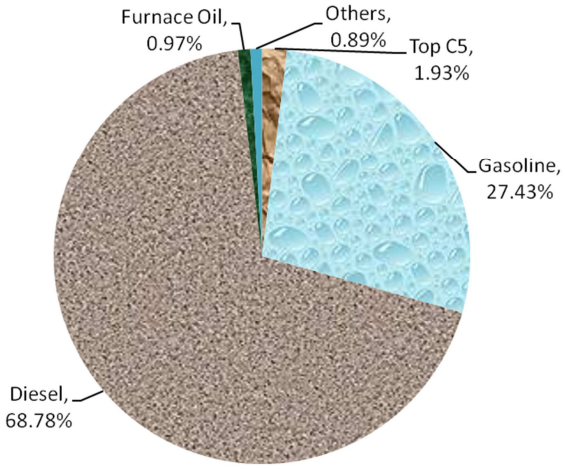


**Fig. 6. Composition of Pyrolysis Oil with 10% wt Kaolin as Catalyst and without Contaminant Analyzed by TGA**

### *3.2 Effect of Contaminant to Yield of Pyrolysis Oil*

Using a food-containing bag in everyday life, the remaining food stuff is the contaminant with the plastic waste. This is the important issue to prohibit the possibility of recycle. In this section, the simulated contaminants are performed with different types and amounts of contaminants. The plastic waste with contaminant is pyrolyzed with 10%wt of catalyst and collected the pyrolysis liquid which is separated into 2 layers as illustrated in Fig.7. In this section, yield of pyrolysis oil is defined to be the upper layer due that the density of oil is lower than water or aqueous solution which the confirmation will be done later.

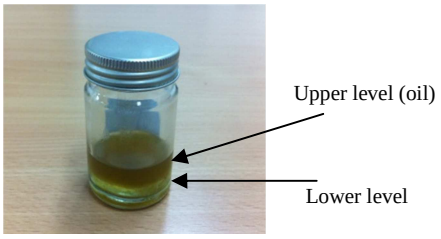


**Fig. 7. Layers of Pyrolysis Liquid from Plastic Waste with Contaminant**

Firstly, each type of contaminant is mixed with plastic sample to evaluate the effect of contaminant. The yields of oil from pyrolysis of plastic waste with different types and amounts of contaminant are summarized in Fig.8. With the same amount of contaminant at 7 ml, oil yields of the plastic waste with contaminant of water, soybean oil, coconut milk and soybean milk are 65.48%, 70.97%, 60.30% and 51.48%, respectively. When the amounts of contaminant are higher, the oil yields become lower. Types of contaminant also affect to the conversion of plastic to oil. The ranking of contaminant from the most to the least effect to yield of pyrolysis oil are soybean milk, coconut milk, soybean oil and water. From this study, thirteen milliliters of soybean milk reduce the yield of oil are up to 51%. Secondly, the mixed contaminant with the ratio of 1:1 are also determined the effect of contaminant. Mixture of soybean milk with water is also the most effect to the yield of pyrolysis oil (Fig.9). As a result, more than one type of contaminant much affect to the pyrolysis process. Thirdly, the actual contaminants in a food containing bag are also investigated. According to Thai's life style, two types of already cooked food are clear soup and curry soup. Main portion of clear soup is water while main portion of curry soup is coconut milk. As a result, the clear soup has more effect with the production of pyrolysis oil than water and a mixture of water with soybean oil. On the contrary that, curry soup has less effect with the production of pyrolysis oil than coconut milk and a mixture of water with coconut milk.

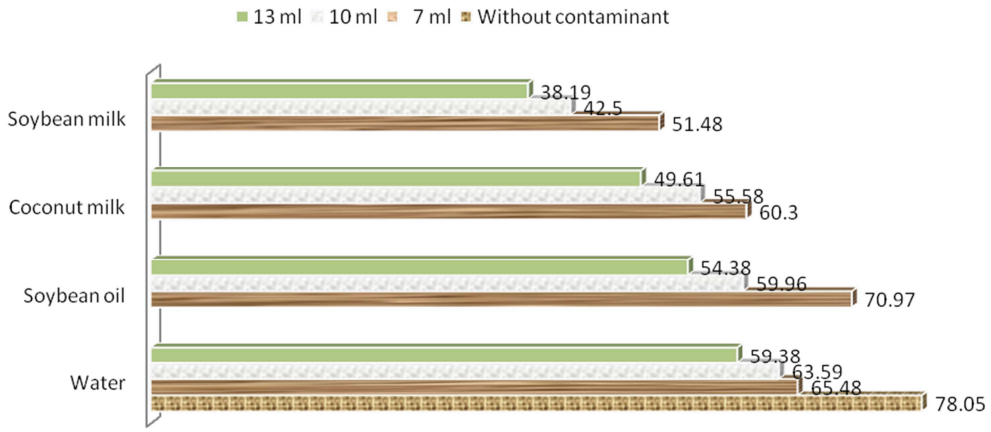


**Fig. 8. Oil Yield from Pyrolysis of Plastic Waste with Different Types and Amounts of Contaminant**

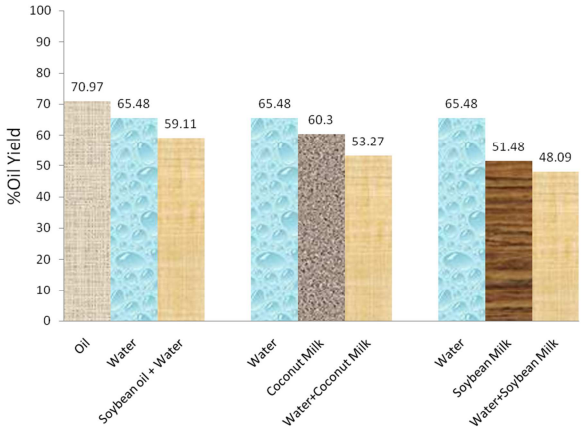


**Fig. 9. Oil Yield from Pyrolysis of Plastic Waste with Mixtures of Contaminants at 7 mL**

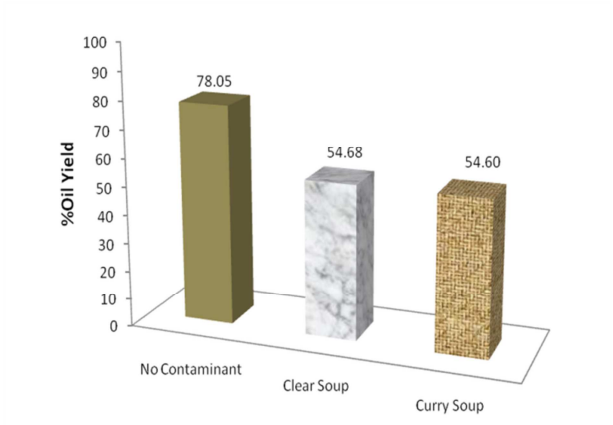


**Fig. 10. Oil Yield from Pyrolysis of Plastic Waste with Real Contaminants at 7 mL**

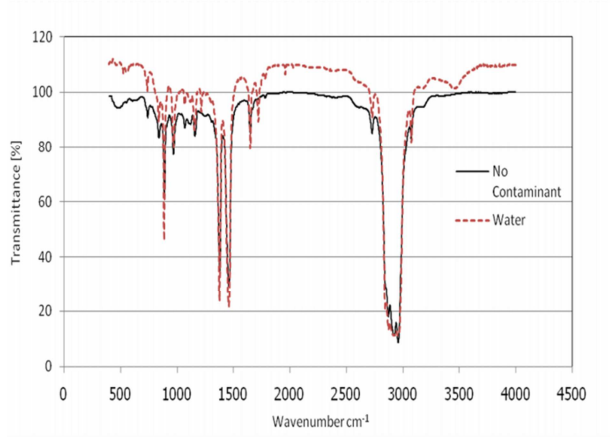


**Fig. 11. IR Spectrum of Pyrolysis Oil with and without Contaminant.**

### *3.3 Effect of Contaminant to Properties of Pyrolysis Oil*

Not only yields of pyrolysis oil are investigated, but the properties of oil are also analyzed. By using FTIR technique, the comparison of spectrum with and without contaminant is made. Both IR spectrums are slightly different as illustrated in Fig.12. However IR spectrum can be identified two levels of pyrolysis liquid. IR spectrum of liquid at upper level when contaminant is water is represented as the dashed line in Fig.11 while IR spectrum of liquid at the lower level is shown in Fig.12. This can be verified that upper level of pyrolysis is the pyrolysis oil.

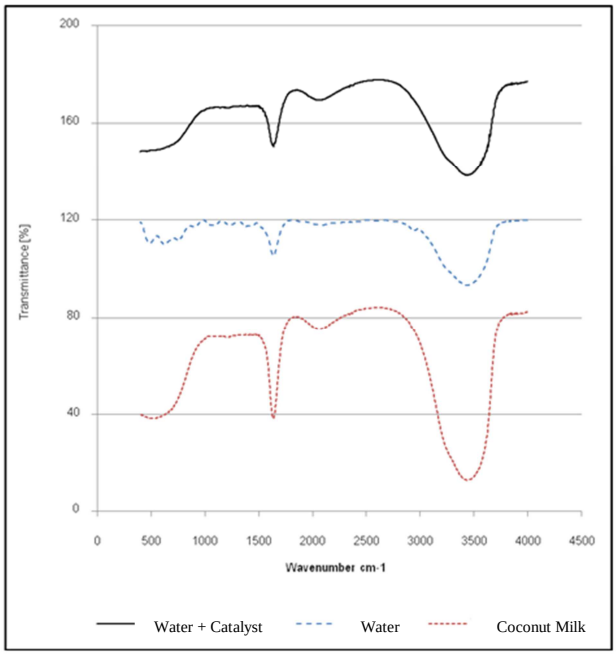


**Fig.12. IR Spectrum of Pyrolysis in the Lower Level**

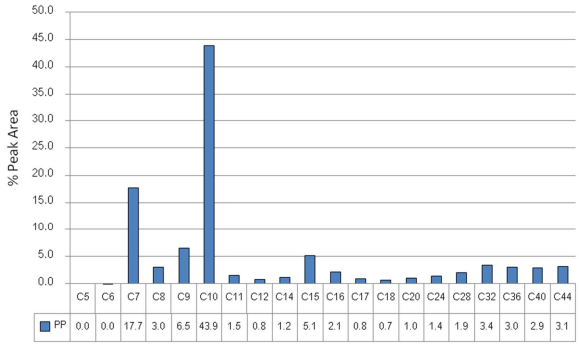


**Fig. 13. Pyrolysis Oil without Contaminant Characterized by C-number (%Area)**

In addition, pyrolysis oil is analyzed by GC using column of Rtx-2887 which can identify Carbon number C5-C44 by using percentage of peak areas. In case of pyrolysis oil from plastic waste without contaminant. The first and second portions of C-number are C-10 and C7 with 43.9% and 17.7%, respectively as shown in Fig.13. When the plastic waste contaminates with food, the distributions of C-number change. If the contaminant is water, the first and the second portions of C-number are C-15 and C-17, respectively. It seems to be the molecules of product are larger. While the contaminant is coconut milk, the first and the second portions of C-number are C-7 and C-9, respectively. The molecule of oil product becomes smaller. Refer to the result, the contaminant might affect to the distribution of C-number of pyrolysis oil. However it depends on type of contaminant.

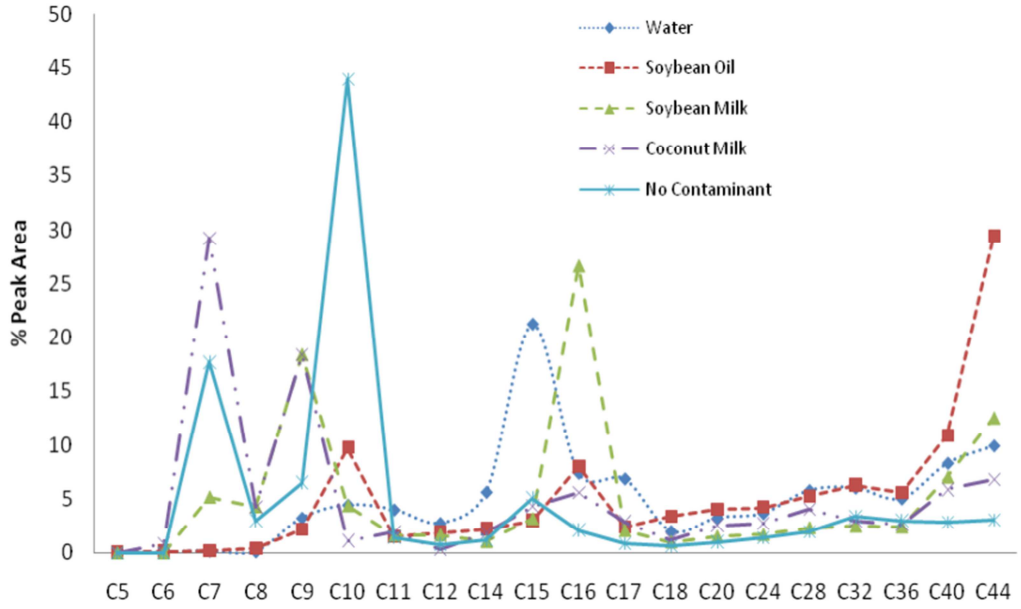


**Fig. 14. Pyrolysis Oil with Contaminant Characterized by C-number (%Area)**

## 4. CONCLUSIONS

The utilization of contaminated food plastic bag waste for fuel oil production through pyrolysis process is evaluated. Kaolin clay, used as catalyst, is important to enhance the fuel oil yield though the catalyst amount has slightly affect to the oil yield. The catalyst at 10% is the suitable amount for the pyrolysis of the food plastic bag. Liquid yield from pyrolysis process of contaminated food plastic bag is segregrate into 2 layers which the upper layer refers to the pyrolysis oil. The contaminant in the plastic bag decrease oil yield with the larger contaminant amount, the lower oil yield. The contaminant with the worst effect to the pyrolysis process is soybean milk which can be found in the everyday life. Mixtures of simulated contaminants are consistent with the real contaminants (clear soup and curry soup) which the pyrolysis oil yields are about 50%. In addition that, types of contaminant affect to C-number distribution in pyrolysis oil. The major portions of C-number from pyrolysis oil without contaminant are C7 and C10 while those from pyrolysis oil with contaminant are more different patterns. However, the pyrolysis of plastic bag contaminated with food stuff still has a potential to generate fuel oil with the appropriate management. The financial analysis should be considered in the further study. Thus, the contaminant has to be removed as much as possible prior to pyrolysis process.

## ACKNOWLEDGEMENT

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