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MICROWAVE PYROLYSIS OF AUTOMOTIVE PAINT SLUDGE (APS) AT MEDIUM MICROWAVE POWER: EFFECT OF MICROWAVE ABSORBER LOADING

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ABSTRACT

Application of activated carbon as microwave absorber (MWA) in microwave pyrolysis of automotive paint sludge does affect the products yield at medium microwave power. 10%, 15%, 20% and 25% (from APS weight) of MWA have been used in this study. There were three product phase produced which were solid, liquid which is the total of aqueous and oil and gas. The highest amount of aqueous produced was at 25% MWA while the highest oil produced was at 10% MWA. As for solid char produced, there was only slightly difference with the application of MWA instead of without MWA. Gas produced from the microwave pyrolysis process also decreased with the application of MWA instead of the process without MWA.

Keywords: microwave pyrolysis, microwave absorber, pyrolysis, activated carbon, automotive paint sludge.

INTRODUCTION

Mass automotive production nowadays leads to higher amount of waste produced. Based on the statistical report, the production of vehicles is increasing from year to year [1]. By having this higher production of vehicles leads to higher production of waste regardless it is hazardous waste or not. One of the wastes produced by the automotive industry is automotive paint sludge (APS). This automotive paint sludge has been gazetted as hazardous or schedule waste (SW 416) by Malaysian Government [2]. Thus, it must be sent to authorize disposal party such as Kualiti Alam for Malaysia and the handling cost is high since it is categorized as hazardous waste. Even though it is categorized as hazardous waste, this APS contains very valuable constituents that can be recovered [3]. There were many attempts that have been made in order to recover or gain some value and lower the overall processing costs of APS by creating useful products from APS [4-7].

Microwave pyrolysis process has been known to be a good process to recover waste material. This process produces three types of product; solid, liquid (total of aqueous and oil) and gas. Based on previous researches, APS seems to have potential to be recovered by using this technique [8-10]. Microwave pyrolysis technique has filled up the gap of conventional pyrolysis where microwave pyrolysis can deal with high moisture content material and reduce the operating hour, which indirectly help to complete the hydrocarbon chain breakdown [11]. Even though this technique seems better than convectional pyrolysis, APS is a poor microwave energy receptor. However, this problem can be solved by introducing microwave absorber during the microwave pyrolysis process [12-13].

Thus, the aim of this study is to observe the effect of microwave absorber and its loading towards pyrolytic product of APS microwave pyrolysis process.

Background of study: Automotive paint sludge

During painting process, vehicle bodies are placed in a spray booth. This painting process generates waste since vehicle body is sprayed and during this spraying process, there is overspray in which the sprayed paint did not reach the target [14-15]. This over sprayed paint will go to downward to the undersection of spray booth with the help of airflow system (downdraft) provided inside the spray booth. The velocity of downdraft is controlled to be 0.5m/s-1.0 m/s.

The overspray or excess paint will be collected in a water stream at the bottom of spray booth. At the undersection tank, coagulant or paint killer is injected and cause the overspray to coagulate [16]. This coagulated overspray which is known as automotive paint sludge (APS) are then accumulated and collected at the sludge tank [14]. APS contains numerous hazardous component; both organic and inorganic substances like polymer resins, pigments, curing agents, surfactants and other minor formulation ingredients [7, 17]. Even though APS has hazardous component, it also contains useful materials that can be recovered (Table-1 and Table-2).

MATERIALS AND METHODS

Materials

Automotive paint sludge (APS) were collected from one of the famous automotive industry in Malaysia. For each experimental work, only 200g of APS were used. Activated carbon (AC) powder has been used as microwave absorber with four different percentage of

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activated carbon to APS (Table-3). An experimental work without using MWA also carried out as control.

Microwave pyrolysis

APS were placed in a quartz reactor before placing the reactor inside the microwave. Activated carbon was placed inside the silica crucible and this crucible was placed inside the reactor. The whole system was set to be in inert condition by feeding 150ml/min nitrogen for 20 minutes before the microwave pyrolysis process took place. Nitrogen gas was continuously fed to the system until the process completed. 600W of microwave power with 30 minutes radiation time has been used. The arrangement of APS microwave pyrolysis showed in Figure-1. The process was repeated by changing the % of microwave absorber as shown in Table-3, while maintaining the same process condition. The product yield were measured by weighing their weight and compared.

Table-1. Automotive paint sludge chemical composition.

Raw material composition	Wt %
Xylene	43.0
Solvesso 150	19.8
Toluene	15.0
Ethyl Acetate	5.75
Ester	4.88
Glycol Ether	2.69
Acrylic Resin	1.54
Cellosolve Acetate	1.46
Amino Resin	1.12
Acrylic copolymer	1.12
Naphthalene	0.8
1,2,4 Trimethylbenzene	0.65
Ethylene Glycol Mono Iso Propyl Ether	0.30
Benzotriozote Derivatives	0.28
Acrylic Emulsion	0.28
n-Butyl Alcohol	0.28
Ethylene Glycol Mono Ethylether	0.19
Titanium Dioxide	0.19
Alcohol	0.14
Acrylic Polymer	0.14
Carbon black	0.07
Methanol	0.07
Methyl Alcohol	0.04
Thermosetting acrylic resin	0.03
Polyacrylate	0.03
Phthalocyanine blue	0.03
Quinacridone	0.03
Tri-Ethyl-Amine	0.03
2-Butanone	0.02
Metotate	0.001
Aluminium	0.0003

(Source: Material Safety Data Sheet from PERODUA Manufacturing Sdn. Bhd.)

Table-2. Elemental results of APS from XRF test [3, 6].

Element	Concentration
Na_2O	1.30 wt %
MgO	0.66 wt %
Al_2O_3	18.01 wt %
SiO_2	2.15 wt %
P_2O_5	0.28 wt %
SO_3	6.37 wt %
Cl	600 ppm
K_2O	550 ppm
CaO	2.30 wt %
TiO_2	54.21 wt %
Cr_2O_3	2.44 wt %
Fe_2O_3	0.43 wt %
Cu_2O	600 ppm
Zn	600 ppm
BaO	11.26 wt %
Br	300 ppm
SrO	0.21 wt %
ZrO_2	350 ppm
Bi	750 ppm

*XRF: X-ray fluorescence spectroscopy, Na_2O: sodium oxide, MgO: magnesium oxide, Al_2O_3: aluminium oxide, SiO_2: silicon dioxide, P_2O_5: phosphorus pentoxide, SO_3: sulphur trioxide, Cl: chlorine, K_2O: potassium oxide, CaO: calcium oxide, TiO_2: titanium dioxide, Cr_2O_3: chromium oxide, Fe_2O_3: iron oxide, Cu_2O: copper oxide, Zn: zinc, BaO: barium oxide, Br: bromine, SrO: strontium oxide, ZrO_2: zirconium oxide, Bi: bismuth

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Table-3. % of MWA towards APS.

Sample	% of AC to APS
Sample 1	0
Sample 2	10
Sample 3	15
Sample 4	20
Sample 5	25

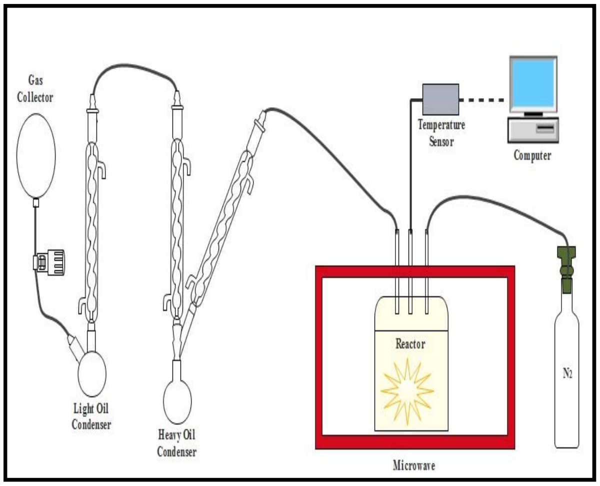

Figure-1. Microwave pyrolysis of automotive paint sludge system.

RESULTS AND DISCUSSIONS

APS microwave pyrolysis product yield

There were three phase of product yield obtained from the microwave pyrolysis of APS; solid, liquid and gas. Figure-2 shows the weight of product in terms of %. The result shows that there is not much different in solid phase for the process regardless with or without MWA. This solid phase is called solid char. Solid char reduced when MWA loading increased from 0% to 10% and increased when the MWA loading increased from 10% to 25%. Sample 1 produced the highest gas with 75.50%, followed by sample 4, sample 3, sample 2 and finally sample 5.

Without application of activated carbon as MWA, gas phase is the main production of the process. However, application of MWA has switched the major production from gas phase to the liquid phase. Application of 10% AC for sample 2 has drastically shifted liquid yield from 13.15% (sample 1) to 79.61% (sample 2). By comparing sample 2 to sample 4, it is shown that the liquid production has dropped from 79.61% (sample 2) to 48.59% (sample 4) and increase drastically again to 84.91% (sample 5) with the application of 25% AC.

The results showed that higher liquid yield does not promise higher production of oil. It is proven by looking at sample 5 where it produced highest percentage of liquid yield (84.91%) with 170.3g of them were aqueous and only 7.0g of them were oil. However, by comparing all the samples, sample 1 produced the lowest oil (0.04g) and aqueous (26.26g) yield. Highest production of oil owned by sample 2 with 9.9g weight, even though sample 2 produced the second higher of liquid yield.

From visual appearance, the colour of oil produced were darker for sample that undergo microwave pyrolysis process with application of microwave absorber as compared to sample 1 which was done without using AC.

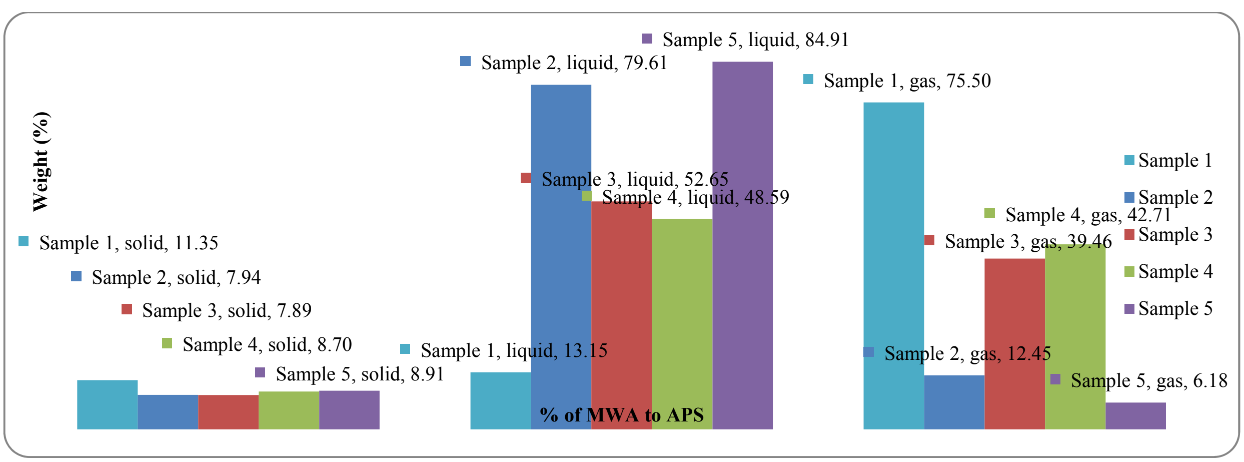

Figure-2. Yield of microwave pyrolysis of APS.

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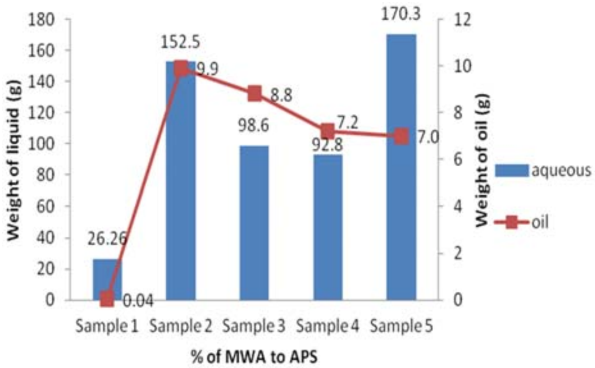

Figure-3. Weight of aqueous and oil product of microwave pyrolysis of APS.

CONCLUSIONS

In a nutshell, application of activated carbon as microwave absorber does affect the yield of liquid and gas. However, there is only slightly difference for solid char produced. The best % of microwave absorber used is 10% in order to produce highest amount of oil.

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