UNIVERSITI TEKNOLOGI MARA

PYROLYTIC OIL FROM AUTOMOTIVE PAINT SLUDGE VIA ACTIVATED CARBON ASSISTED MICROWAVE PYROLYSIS

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ABSTRACT

Abundance of automotive paint sludge (APS), SW416 led to disposal problem due to its nature that contains high moisture content and limitation of landfill. APS contains valuable components that could be recovered. Microwave pyrolysis technique was applied to treat and convert the APS into pyrolytic oil which later can be upgraded into alternative fuel. Previously, APS was converted into pyrolytic oil using the same technique with addition of catalyst. However, APS pyrolytic oil obtained has low yield and high carcinogenic compounds of nitrogenated and polycyclic aromatic hydrocarbon (PAH). Application of activated carbon (AC) as microwave absorber in this study enhances pyrolytic oil yield. Microwave pyrolysis of APS was carried out at three microwave powers of 500, 600, and 700 W at three different radiation time of 30, 40, and 50 minutes. Response surface methodology (RSM) has been used to determine process parameters of microwave power and radiation time that gave highest pyrolytic oil yield. The behavior of pyrolytic oil yield over radiation time at optimum condition was evaluated by using first-order and second-order kinetic model. APS pyrolytic oil obtained at optimum condition also been evaluated for its fuel properties in terms of calorific value (CV), density, viscosity, chemical bonding and compounds. In the presence of AC, increment of microwave power from 500 W to 600 W led to increment of pyrolytic oil yield from 1.01% to 2.08%, 1.70% to 3.90%, and 1.83% to 4.52% for the process at 30, 40, and 50 minutes, respectively. Further increment of microwave power to 700 led to reduction of pyrolytic oil yield to 2.36%, 2.63%, and 2.93% for the process at 30, 40 and 50 minutes, respectively. Pyrolytic oil yield increased with radiation time regardless of microwave power and application of AC. It was found that process with the presence of AC at 600 W and 50 minutes gave the highest pyrolytic oil yield of 4.52%. Based on the model developed using RSM, it was suggested that the best operating condition for microwave pyrolysis of APS process was 620 W with 50 minutes with predicted yield of 4.27%. The experiment of APS microwave pyrolysis at optimum conditions is carried out resulting 4.69% pyrolytic oil yield which slightly higher than the predicted. Suggested model is valid to be used to predict pyrolytic oil yield from microwave pyrolysis of APS since it has value of Prob>F below than 0.05 and high value of R^2 (0.9243) and F-value (36.6125). The behavior of optimized pyrolytic oil production can be represented by second-order kinetic model because it has high value of R^2 and low value of RMSE as compared to first-order kinetic model regardless of application of AC. The optimized oil has the calorific value of 39.04 kJ/kg, viscosity of 4.14 cSt and density of 836 kg/m^3. The physical properties lie within the range of commercialized liquid fuel. Aliphatic and monoaromatic compounds traced in pyrolytic oil obtained from this study were high. Meanwhile, polycyclic aromatic hydrocarbon (PAH) and nitrogenated compounds were reduced significantly and oxygenated compound was slightly reduced as compared to the process with the absence of AC. Therefore, this study has not only contributed to future reduction or eliminating automotive paint sludge waste, but also generates new alternative fuel.

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CHAPTER ONE
INTRODUCTION

In this chapter, information on background of study, scopes and limitations of study, objectives, and significance of study are presented. Also provided in this chapter is the overview of worlds' waste production and microwave pyrolysis process assisted microwave absorber.

1.1 Research Background

Solid waste production has extremely increased from year to year. It is expected that in the year of 2025 global solid waste production will be increasing to 2.2 billion tons per year and if the worlds' business continues as usual, the production rate of solid waste will be more than triple from today, to exceed 6 billion tons per year by 2100 [1]. One of the sources of wastes that contribute to accumulation of wastes materials is produced from automotive industry such as paint sludge, scrap tires waste, and automotive shredder waste. Surprisingly, almost 50 million tons of automotive waste has been generated every year from the high production of the automotive industry [2]. Currently, more than 50% of vehicles' weight is recycled because of high disposal fees which resulting from limited land available for landfilling [3].

It was reported that the world automotive production had almost achieved 98 million in the year 2017, indicating an increment of 11% as compared to the year 2013 [4]. Production of automotive for the past 5 and 10 years is shown in Figure 1.1. Statistically, 75% of the total automotive production accounts for the production of cars. Car production showed obvious increasing trend from the year 2008 to the year 2017. In Malaysia, high consumers demand has led to high car production hence, its sales increased. For example, Perusahaan Otomobil Kedua Malaysia (PERODUA) has contributed more than 30% from the total car sold in Malaysia for the past few years (Figure 1.2). All cars sold by PERODUA have been manufactured locally.