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Preparation and physicochemical characterization of cracking oil from waste plastics

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Abstract

The aim of this paper is to systematically explore the preparation process of waste plastic cracking oil from municipal solid waste and its physicochemical properties, and to study the composition and properties of waste plastic crack-ing oil in depth through characterization techniques such as organic elemental analysis (EA), capillary viscometer, flash point and ignition temperature test, so as to provide theoretical basis and technical support for the resource utilization of low value waste plastics in municipal solid waste.

Keywords

Municipal solid waste; Waste Plastic Cracking Oil; Physical and chemical properties

1. Introduction

Plastics have become an indispensable part of modern society by virtue of their multifunctional properties such as strong toughness, corrosion resistance and ease of processing, and are widely used in various industries, such as food packaging, hardware, electronic products and construction. With the rapid development of society, human demand for plastic preparation increases year by year, the global plastic production reached 400 million tons in 2022, and is expected to reach 1.124 billion tons in 2050 [1]. China's plastic production accounted for 30% of the world's total production, is the first country of plastic production. As of August 2024, China's plastic production was as high as 48.31 million tons [2]. However, the large-scale application of plastic products has produced a large number of waste plastics, the quality of light and difficult to degrade waste plastics if not effectively recycled and treated will cause pollution to the environment, a serious threat to the ecosystem and even human health [3]. According to statistics, China's annual production of waste plastics is about 60 million tons, but the recycling rate is less than 30%, much lower than the global average recycling rate of 50% [4]. Existing waste plastics are mainly incinerated, filled and recycled in three ways, but incineration and landfill are difficult to meet the requirements of environmentally sound treatment, and also produce secondary pollution to the environment [5-7]. Therefore, pyrolysis technology, which can improve the recycling rate of waste plastics and has the advantages of significant economic and environmental benefits, has received wide attention. Therefore, pyrolysis technology, which can improve the recycling rate of waste plastics and has the advantages of significant economic and environmental benefits, has received wide attention.

2. Raw materials and test methods

2.1. raw materials

The waste plastics used in this study were obtained through separate collection of municipal solid waste and were recycled and baled as shown in Figure 1. The waste plastics obtained from collection were pretreated to remove impurities such as metals, sediment, etc., to avoid equipment corrosion and coking which affects the quality of waste plastic cracking oil. The waste plastics are plastic films, which are mainly compounded from PE.

Fig.1 Waste plastic in urban construction solid waste

2.2. Test Methods

After thermal cracking of PE, the yield of PEO and cracked carbon was determined by weight difference.

3. Preparation of cracking oil from waste plastics

The PEO prepared in this study was subjected to high-temperature thermal cracking of PE film by a solid high-pressure cracking equipment provided by Hunan Yunzhong Technology Recycling Co. In order to clarify the effects of thermal cracking temperature, heating rate and residence time on PEO yield and chemical composition of PE during thermal cracking, different process parameters were used to implement the cracking. Among them, the thermal cracking temperatures were 450°C, 500°C and 550°C, the heating rates were 2050°C/min, 3550°C/min and 50°C/min, and the residence times were 40 min, 80 min and 120 min, respectively, and a total of 15 sets of tests were conducted. The prepared finished PEO heavy oil is shown in Fig. 2.

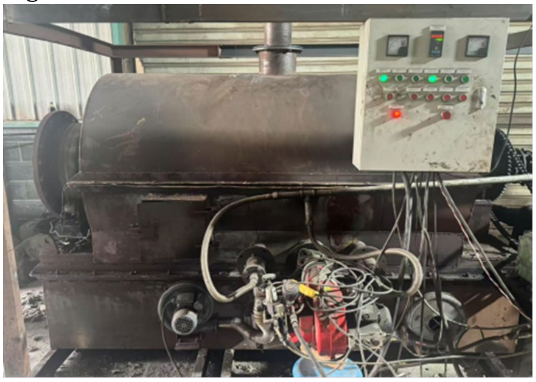

Fig.2 PEO pyrolysis equipment

3.1. Physical properties of waste plastic cracking oil

The physical properties of PEOs, such as pH, viscosity, density, ignition temperature and water content, were tested at room temperature with a physical appearance similar to that of an oil-wax. Since the differences in some physical properties (e.g., pH, viscosity and density) of the 15 PEOs obtained under different cracking conditions were negligible, the average values of pH, viscosity and density of the 15 PEOs were calculated.

3.2. Chemical composition of waste plastic cracking oil

The most abundant chemical component in the PEO was a common medium molecular weight alkane $C9H18$ (n-nonane), which is often used as one of the components of diesel fuel, and it was identified at 2 different residence times respectively, with a combined area share as high as 15.685%, and the presence of this component may have a significant effect on the energy density and viscosity of the sample. Meanwhile, the presence of the more common light hydrocarbon $C5H12$ (n-pentane) in the PEO, with an area share of 3.046%, and its low boiling point property implies that this PEO has certain volatility and combustion characteristics, which can be used as a fuel.$C6H12$ (cyclohexane) was identified at 2 different residence times, respectively, and its area share of the PEO was 4.98%, and the presence of this chemical constituent means that the PEO has cyclic hydrocarbon compounds, which can be used as solvents or intermediates for petrochemicals.The PEO was not fractionated and refined during the thermal cracking process of the waste PEO, so it may contain some heavy hydrocarbon compounds, such as -$C12H24$ (dodecane), which was identified at the residence times of 8.037 min, 8.775 min, and 9.722 min, respectively, with the sum of the proportions being 1.089%, this compound has higher viscosity and lower volatility, so that the PEO viscosity increases and volatility decreases.In addition to the presence of hydrocarbons in the PEO, there is also a small amount of oxygenated alcohols, which are mainly found in biomass fuels or some organic solvents, such as - C10H18O (decanol), the proportion of which is 0.153%.

4. Conclusion

In this paper, PEO was prepared from municipal solid waste PE film by thermal cracking process, and the effects of different cracking process parameters on PEO yield were analyzed, and the physical properties and chemical composition of PEO were investigated, and the following conclusions were obtained:

(1)The thermal cracking temperature has the greatest effect on the yield of PEO, and the effect of heating rate and residence time is smaller. Comprehensively comparing the yield of PEO under different conditions, the thermal cracking temperature of 500 °C, the heating rate of 20 °C/min and the residence time of 80 min were proposed for the preparation of PEO.

(2) The average pH value of PEO is 5.9, PEO is mainly composed of three elements, C, H and O, containing a small amount of N and no S. The content of C is the highest, followed by H and O. The content of medium molecular weight alkane C9H18 (n-nonane) is the highest in PEO, and its chemical components are mainly hydrocarbons (alkanes, olefins, cyclic compounds and aromatic hydrocarbons), which accounts for more than 80% of the total.

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