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Study on Pyrolysis Characteristics of Micro-emulsified Diesel Fuel

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Abstract

In order to understand the effect of moisture on the pyrolysis process of micro-emulsified diesel fuel, the pyrolysis characteristics of micro-emulsified diesel fuel were analyzed by thermogravimetric analysis. Thermogravimetric experiments on micro-emulsified diesel fuel with various water contents (0%, 5%, 10%, 15%) and heating rates (10℃/min, 30℃/min, 50℃/min) were conducted. The results showed that the samples were evaporated slowly in the initial stage of the pyrolysis process. Then the water was evaporated and the pyrolysis was accelerated. In the later stage, the samples were pyrolyzed deeply and the loss of weight was greatest. The pyrolysis gradually stopped in the last stage. In addition, the loss of thermogravimetric weight for micro-emulsified diesel fuel tended to lower temperature area with the increasing of water content. Moisture can slow down the pyrolysis process of micro-emulsified diesel fuel. With the increasing of heating rate, the evaporation hysteresis occurred and the effect of pyrolysis was getting better.

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Keywords: micro-emulsified diesel fuel, thermal analysis, thermogravimetry, pyrolysis characteristics

1. Introduction

The composition of micro-emulsified diesel fuel is a chemically stabilized system of water, crude oil and surfactant. Pyrolysis process often contains many associated chemical reactions and the reaction process is very complex. In addition, the thermal stability of micro-emulsified diesel fuel during the pyrolysis process is closely related to its composition [1]. A lot of researches on pyrolysis characteristics of various kinds of oils have been studied. Wang Zhong [2] measured the volatilization, oxidation process parameters of particle matter varied with the methanol/biodiesel blending ratio by the TGA/DSCI thermal analyzer. He found that the pyrolysis properties of the particles are enhanced with the increasing of the methanol ratio. Hu Huihui [3] studied the effect of di-tertiary-butyl peroxide (DTBP) on pyrolysis characteristics of biodiesel from swill-cooked dirty oil. She found that DTBP could effectively promote the combustion of fuel and made biodiesel better flammability. The physicochemical properties of micro-emulsion are relatively stable, and the viscosity of micro-emulsified fuel is consistent with undiluted fuel oil [4]. Chen Xiu [5] found the micro-explosion law of biodiesel and simulated the micro-explosion model. In the thermogravimetric analysis of diesel oil, Huo Mengjia [6] investigated the pyrolysis characteristic of biodiesel by the thermogravimetric coupled with the Fourier transform infrared spectroscopy, where the composition of the released gas was also determined. Li Li [7] conducted thermogravimetric studies on the bio-oil under various atmospheres and at various heating rates. Wang Xuechun [8] found that the pyrolysis of methyl linoleate was simple two step decomposition. Compared with nitrogen atmosphere, it had a relatively worse stability of pyrolysis at oxygen atmosphere. Murugan [9] studied the kinetic parameters of oil shale in nitrogen and air atmosphere by thermogravimetric analysis. Mothe [10] studied the pyrolysis characteristics of heavy oil in N_2 atmosphere and the overflow

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of heavy oil components using TG-DSC-FTIR. By using thermal analysis to study various kinds of oils, experts from home and abroad have obtained a lot of scientific research achievements, but the pyrolysis characteristics of micro-emulsified diesel fuel have not been studied systematically.

In this paper, the pyrolysis characteristics of micro-emulsified diesel fuel were analyzed by thermogravimetric analysis to understand the effect of various water contents and heating rates on the pyrolysis process. It was aimed to constantly optimize the ratio of micro-emulsified diesel fuel and make it have better flame retardant and explosion suppression performance.

2. Experiment

2.1. Experimental samples

Four samples of micro-emulsified diesel fuel were used in this experiment and the water contents were 0%, 5%, 10% and 15% respectively. Related parameters are shown in Table 1.

Table 1. The related parameters of micro-emulsified diesel fuel

Sample No	Water content/%	Density/g·mL^{-1}	Kinematic viscosity/ mm^{-2}·s^{-1}
Sample No.1	0	0.8210	5.850
Sample No.2	5	0.8235	6.477
Sample No.3	10	0.8180	7.390
Sample No.4	15	0.8199	10.208

2.2. Experimental method

In this paper, the method of thermogravimetric analysis was adopted to measure the quality change of micro-emulsified diesel fuel during the pyrolysis process, and investigate the influence of various water contents on the pyrolysis process.

(1) Preparation of experimental samples

A quantity of sample was removed from the pre-configured sample, then placed into the sample box and sealed well.

(2) Calibration of the instrument

At the beginning of the experiment, the thermogravimetric analyzer of TG-209-F3 should be corrected all aspects to control the experimental error in the minimum range and ensure the accuracy of the experimental data.

(3) Sample weighing

The appropriate crucible was selected by tweezer, and then the mouth of crucible should be sealed with foil. The sealed crucible was put on the electronic balance of BT25S to be weighed, and then the weighing result should be cleared.10mg~15mg samples were taken to the crucible by spoon and the crucible should be sealed with foil again. Finally, the sealed crucible was put on the electronic balance to be weighed again and the number was the net weight of the experimental sample.

(4) Thermogravimetric test

The foil sealing crucible was poked a hole by toothpick before the test. The crucible after handling was gently placed on the thermal balance of the thermogravimetric analyzer. The experiment parameters were set on the computer and the experiment was performed. The temperature range of this experiment was from 30℃ to 550℃ and the atmosphere was nitrogen. Therefore, the samples were difficult to be oxidized during the pyrolysis process and the loss of weight for the samples only depended on evaporation and pyrolysis at high temperature. The heating rates were 10℃/min, 30℃/min and 50℃/min. When the heating rate was set to 10℃/min, the thermogravimetric experiment took about 50 minutes. It took about 17 minutes when the heating rate was 30℃/min and 10 minutes when rate was 50℃/min. Each group of experiments should be cooled for half an hour after completing thermogravimetric analysis.

3. Experimental results and analysis

3.1. The pyrolysis process of micro-emulsified diesel fuel

The curves of TG-DTG for sample No.1, 2, 3 and 4 at the heating rate of 10℃/min are shown in Fig. 1. It can be seen from Fig. 1 that samples of various water contents exhibited similar pyrolysis processes at the same heating rate.