Production of Epoxidized Waste Cooking Oil for Road Bitumen

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Abstract. The results of the epoxidation of waste cooking oil (WCO) for its use as a modifying additive for road bitumens are presented. Analysis results and IR spectra of used oil and used epoxidized oil are given. A conclusion was made about the possibility of epoxidation and further use of waste oils as a road bitumen modifier

Keywords – bitumen, epoxidized oil, waste cooking oil, bitumen modification, epoxidation

Introduction

It is known that modifiers of various natures are used to eliminate the shortcomings of road surfaces when obtaining high-quality bitumen. Almost all the top layers of the road surface in the world are made using modified road bitumens. The addition of epoxides, in particular epoxidized oils, to road bitumens, improves their physical and chemical properties, such as adhesion, softening temperature, penetration, ductility, and others[1]. Also, it is a well-known fact that the problem of collection and recovery of waste cooking oil has not been properly resolved in Ukraine to this day. Combining these two problems, we used waste cooking oil for in-situ epoxidation using hydrogen peroxide as an oxygen donor and formic acid as a peroxygen carrier.

Waste cooking oil was placed in a round-bottomed, three-necked flask with a volume of 3 liters, equipped with a stirrer, a reflux condenser, a thermocouple, and a dropper, immersed in a water bath, and heated to a temperature of 70 °C with stirring. A mixture consisting of hydrogen peroxide (60%) and formic acid was gradually dripped into the heated oil. The mixture was dripped at such a rate that the temperature of the reaction mass was equal to 66-68 °C within two hours. After the complete introduction of the mixture of H_2O_2 and formic acid, the reaction mass was kept under stirring for 2.5-3 hours. Acid, peroxide, and water residues were evaporated from the resulting mixture in a vacuum oven at a temperature of 70 °C for 3 hours.

After obtaining the epoxidized waste cooking oil, we conducted several analyzes for the content of epoxy number, and unsaturation and obtained IR spectra. The results are shown in Table 1 and Figure 1. After the analysis of the epoxidized WCO, the road bitumen was modified and analyzed. Bitumen BND 70/100, modification time 60 min, temperature 160 ºC, and additive content 3% wt. were chosen for the experiment.

Table 1

Characteristics of WCO

	Epoxy number,%	Bromine number, g Br/100g
WCO	0.08	45.64
Epoxidized WCO	5.52	0.85

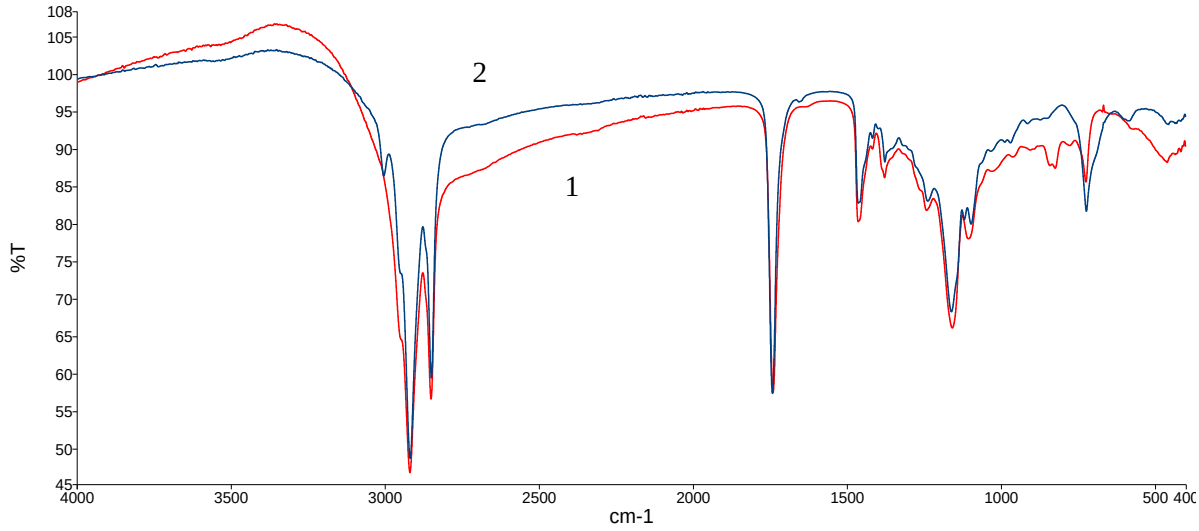

Fig.1. IR-spectra for WCO (1) and epoxidized WCO (2)

Conclusions

During the work, epoxidized waste oil with an epoxy number of 5.52% was obtained. The appearance of bands with frequencies of 1250 cm-1 and 910-920 cm-1 on the IR-spectra by epoxidized waste cooking oil (fig. 1) indicates the presence of epoxy groups in there. Bitumen modification using epoxidized waste oil gave a positive result and improved the quality of the modified bitumen. In particular, an increase in the softening temperature by 2 ºC and adhesion to the stone (up to 4.5 points) with a decrease in penetration by 20 points was recorded. However, the idea of using epoxidized waste oil for bitumen modification requires additional work on the selection of optimal modification conditions and parameters. We plan to expand our research in this direction and perform in-depth analysis to ensure the optimal conditions and parameters of bitumen modification using epoxidized waste oil.

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References

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