



DEVELOPMENT OF ANTI-KNOCK ADDITIVES FOR AUTOMOTIVE GASOLINE

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Abstract: *The efficient and reliable operation of modern automobile engines directly depends on the quality of the gasoline used in the fuel system. One of the main technological characteristics of gasoline is its knock resistance, that is, its resistance to self-ignition under high compression ratios. The knock process leads to a decrease in engine power, incomplete combustion of fuel, energy loss, as well as damage to the piston, valves, and cylinder walls. Therefore, the production of gasoline characterized by a high octane number is of special importance for extending the service life of engines and ensuring compliance with environmental regulations. The present study investigated the effect of various oxygenate blends (MTBE and IBA) on the octane number of automotive gasoline. The effectiveness of these oxygenates was increased due to the emergence of a synergistic effect when they were blended. A synergistic effect was observed with the combined action of a two-component mixture of MTBE and IBS in ratios of 20–80 and 80–20 wt.%, respectively, resulting in an increase in the octane number of gasoline fractions to 1.3–2.0 units compared to that of individual oxygenates.*

Keywords : *automotive gasoline, additives, oxygenates, octane number, synergistic effect.*

INTRODUCTION

The modern, intensive development and improvement of equipment that uses petroleum products as fuel places strict demands on their operational and environmental characteristics. Despite an increase in production volume and the expansion of the range of environmentally friendly gasoline, the demand for it is not being fully met today [1-3]. This is because domestic production of components and additives for automotive gasoline does not meet more than half of the total demand. Under conditions of limited imports, ensuring the production of automotive gasoline is of particular importance.

Traditional technologies for producing high-octane gasoline components based on processes (reforming, catalytic cracking, alkylation, isomerization) are basic, but require significant investments for their implementation, and the current pace of construction and modernization of secondary oil refining plants is currently insufficient. Moreover, the inclusion of components obtained as a result of these secondary processes in gasoline increases the content of combustion by-products in the exhaust gases [4].

A promising innovative direction for expanding the raw material base for motor gasoline is the search for new ways to recycle waste and by-products of petrochemistry and oil refining, which are a source of valuable hydrocarbons. Using these technologies to produce new gasoline components will reduce exhaust gas emissions and increase production volumes and product margins [5-7].

It should be noted that the characteristics of gasoline fuels can be improved by using various substances or their mixtures. Additives, detergents, and components are of

great importance for improving the operational characteristics of fuels. They improve the fuels' anti-knock properties, suppress the knock process, improve gasoline vaporization, and reduce the amount of harmful substances in exhaust gases [8-10]. The purpose of the present study is to investigate the effect of the composition of oxygenates added to automotive gasoline on the increase in its octane number. For this study, we have selected isobutanol (IBA) and methyl tert-butyl ether (MTBE) as the oxygenates.

EXPERIMENTAL PART

In this research work, methyl tert-butyl ether (MTBE), isobutyl alcohol (IBA) and a model fuel mixture (light straight-run gasoline, catalytic cracking gasoline and isomerate) were used as research objects. The study used standard determination methods for the analysis of primary and target products.

In the initial sample and the reaction products, the mass fraction of the components was determined by gas-liquid chromatography on a "Tsvet-800" gas chromatograph with a thermal conductivity detector. The temperature of the detector thermostat was 220°C, the temperature of the column was 110°C, and helium was used as the carrier gas at a flow rate of 50 cm³/min. A 6 m × 3 mm column was packed with the sorbent. The sorbent was diatomaceous earth impregnated with Triton-100 liquid phase. The mass concentration of the components was calculated by the internal standard method.

The octane number was determined by the Research Method (RM) according to GOST 8226 and by the Engine Method (EM) according to GOST 511, using a standard single-cylinder engine from a WIT-85 type apparatus.

Gas-liquid chromatographic analysis (GLC) of the samples was performed on a SHIMADZU "GC-2014" gas chromatograph using GsBP-1msc capillary columns. Column characteristics: length 30 m and internal diameter 0.25 mm with applied stationary phase 100% dimethylpolysiloxane, column temperature was changed at a rate of 5°C/min from 40 to 300°C, FID detector, temperature on the detector 300°C, evaporator temperature 300°C, carrier gas helium.

RESULTS AND DISCUSSION

The use of oxygenates as additives to improve the properties of automotive gasoline is considered a global trend. It is known that MTBE and butyl alcohols are considered effective oxygenates. MTBE has a low boiling point and a high saturated vapor pressure, which causes it to evaporate during fuel storage in the summer, leading to a loss of knock resistance and a deterioration of the performance characteristics of gasoline. Compared to MTBE, butyl alcohols have several advantages. In particular, they have low vapor pressure and low toxicity, but their production volume is not as high. Although alcohols, as anti-knock additives, meet the environmental requirements for automotive gasoline, the increased alcohol content in gasoline leads to excessive fuel consumption due to their lower heating value (table 1).

In a number of studies [2-4], it has been shown that the effectiveness of these oxygenates can be increased due to the emergence of a synergistic effect during their mixing. Taking the foregoing into account, iso-butyl alcohol (IBA) and methyl tert-butyl ether (MTBE) were selected by us as the oxygenates for the study.

Individual oxygenate samples and their mixtures were added to the model fuel blend at 10% (w/w). This amount increases the volume of light gasoline fractions, which positively affects the fuel's initial properties. In the two-component mixture, the MTBE/IBA ratio was varied in 10% (w/w) steps. In the resulting fuel compositions, the octane number was measured by engine and research methods, and the increase in ON was calculated (table 2).

Table 1

Main physicochemical properties of MTBE and IBS

№	Indicator names	MTBE	IBA
1	Density at 20°C, kg/m ³	746	802
2	Boiling point, °C	55	107.7
3	Octane number by research method	118	108
4	Saturated vapor pressure, kPa, at 38°C	61	8.5
5	Solubility in water, %(w/v)	1.3	8.5
6	Maximum permissible content in gasoline, %(vol.)	15	10
7	Combustion heat, kJ/g	38220	35520
8	Mass fraction of sulfur, mg/kg	110	1

Table 2

Dependence of the increase in the octane number of a model fuel mixture on the composition of a two-component mixture

№	Additive	Increase in octane number	
		By engine method	By research method
1	IBS	5.3	6.9
2	MTBE	5.9	6.2
3	MTBE : IBS = 90 : 10	5.9	6.3
4	MTBE : IBS = 80 : 20	6.0	7.3
5	MTBE : IBS = 70 : 30	6.6	7.6
6	MTBE : IBS = 60 : 40	6.8	7.8
7	MTBE : IBS = 50 : 50	6.9	7.9
8	MTBE : IBS = 40 : 60	6.9	8.0
9	MTBE : IBS = 30 : 70	7.0	8.2
10	MTBE : IBS = 20 : 80	6.6	8.0
11	MTBE : IBS = 10 : 90	5.5	7.0

It has been shown by us that to a model fuel mixture containing 10% (w/w) of MTBE and IBA, in a ratio of 20:80 and 80:20% (w/w), respectively at ratios of 20:80 and 80:20 (by weight) to the model fuel mixture, respectively, the addition of MTBE and IBA blends to the fuel mixture provides a greater increase in octane number compared to the use of individual oxygenates (6.2 and 6.9 for MTBE and IBA, respectively). The addition of MTBE and IBA to the model fuel blend in a two-component mixture at ratios of 20:80 and 80:20% (wt.), respectively, provides a greater increase in the octane number compared to the use of individual oxygenates (6.2 and 6.9 for MTBE and IBA, respectively). The study of the effect of the MTBE/IBA ratio in the two-component mixture on the anti-knock activity of the fuel blend revealed a

synergistic effect on the octane number for IBA content in the range from 20% (wt.) to 80% (wt.).

The observed synergistic effect of the binary mixtures under investigation can be explained by the fact that the boiling point and molecular -mass characteristics result in their being drawn into all narrow petrol fractions, which leads to a uniform increase and distribution of knock resistance across all fuel fractions.

Thus, a synergistic effect was observed with the combined action of the two-component mixture of MTBE and IBA at ratios of 20:80 and 80:20%, respectively (w/w) ratio, a synergistic effect was observed, which is manifested by an increase in the octane number of the petrol fractions by 1.3–2.0 units compared to the individual oxygenates.

CONCLUSION

As a result of research into the complementarity and synergism of oxygenates (methyl tert-butyl ether (MTBE) and isobutyl alcohol (IBA)), new components and additives for motor gasolines have been developed using commercially available domestic raw materials.

A synergistic effect was observed with the combined action of a two-component mixture of MTBE and IBS in ratios of 20–80 and 80–20 wt.%, respectively, resulting in an increase in the octane number of gasoline fractions to 1.3–2.0 units compared to that of individual oxygenates.

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