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Research Article

DEVELOPMENT OF A DEPRESSOR ADDITIVE BASED ON BIODEGRADABLE CHITOSAN FOR DIESEL FUEL

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ABSTRACT

For the first time in scientific research, effective compositions of copolymers based on environmentally friendly aminopolysaccharide chitosan and acrylic acid and styrene were developed and scientifically based. The scientific significance of the research results was explained by the fact that a copolymer was obtained from acrylic and styrene.

KEYWORDS

Cetane, biodiesel, thickening agents, filter, depressant, aminopolysaccharide, chitosan, morpholine.

INTRODUCTION

The global demand for middle distillates, including diesel fuels (DF), is growing at a rapid pace. Requirements for fuel characteristics are also changing rapidly and are constantly becoming more stringent. The criteria for assessing the quality of high-grade diesel fuels include the following indicators: sulfur content, PAHs, cetane number, density, fractional composition.

Diesel engines emit exhaust gases, which has an adverse effect on the environment. Exhaust gases have a negative impact on human health. According to statistics, 8% of mortality is due to unfavorable environmental conditions caused by air pollution [1].

To improve the environmental and operational properties of diesel fuel through the use of biofuel as an additive, it is important in practice. Biodiesel fuel can

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also be obtained from various vegetable oils through the transesterification reaction [2]. Plant raw materials for production can be: sunflower, camelina, rapeseed, corn, microalgae. However, the production and consumption of biodiesel from vegetable oils such as sunflower and corn competes with food production.

Currently, the most promising direction is the use of chitosan synthesized from dead bees Apis Mellifera, which is a biodegradable polymer and its energy characteristics are superior to other raw bioresources [2, 3]. However, diesel fuels are used in a fairly wide ambient temperature range.

As a rule, the use of fuels at positive temperatures does not cause any difficulties. At temperatures below 0°C, difficulties arise due to impaired pumpability of diesel fuel due to its thickening.

In this regard, special attention is paid to the low-temperature properties of diesel fuel, which include the following indicators: cloud point, filterability limit temperature and pour point.

Depressant additives are fundamentally aimed at lowering the pour point of diesel fuels, while the cloud point - an indicator that has long been considered the determining criterion for the suitability of fuels for use in winter - remains virtually unchanged.

In the 1960s, based on numerous performance tests and accumulated experience, it was shown that diesel fuel can be used in engines at temperatures below the cloud point. This circumstance served as the basis for the start of work in the field of synthesis and research of depressant additives for fuels.

The low-temperature characteristics of diesel fuel are determined by their hydrocarbon composition, and primarily by the content of normal paraffins, which have high melting points and are capable of crystallizing from the fuel when the ambient temperature drops and precipitating, thereby disrupting the operation of the fuel filter.

However, diesel fuels are used in a fairly wide ambient temperature range.

Antibacterial additives for diesel fuel - used to destroy bacteria and microalgae that form in fuel during long-term storage in the tank and prevent their development. Antibacterial fuel additives do not change the chemical properties of the fuel.

Anti-wear additives - compensate for the low sulfur content in fuel, increase its lubricating properties and increase engine service life.

Cetane boosting additives improve engine starting, increase engine efficiency and increase the cetane number in diesel fuel. Especially useful in winter. When choosing a cetane booster, you need to know whether it is suitable for the diesel fuel you are using.

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Depressants are used to lower the cloud point and pour point of diesel fuel. Typically used in climatic conditions where temperatures drop to -20-40 °C.

Dispersants - used to prevent the formation of layers in the fuel tank, when light liquid collects at the top and paraffin accumulates at the bottom. Dispersants help convert paraffin into small crystals that are evenly distributed in the fuel throughout the tank, which makes the fuel operate uninterrupted.

Detergent additives are designed to prevent clogging of the engine and remove various deposits from it (carbon deposits, varnish and resinous substances), which worsen the process of fuel combustion and increase the toxicity of exhaust gases.

Multipurpose additives – combine the properties of various types of fuel additives.

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Drawing. Various imported depressant additives for diesel fuels

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Improving the low-temperature properties of biodiesel fuels can be achieved by two different methods:

the first is associated with reducing the content of normal paraffins in fuel using various catalytic hydrogenation processes (catalytic hydrodewaxing, catalytic hydroisomerization, etc.). The second is based on the use of depressant additives.

Most refineries do not have sufficient production capacity, so the most relevant way to produce winter and Arctic grades of diesel fuel is the use of depressant additives.

Thus, correctly selected compositions in a concentration of 0.02-0.05% wt. are able to reduce the pour point and PTF of diesel fuels by 20-30°C.

The mechanism of action of depressants is not fully understood. According to one of the main hypotheses, depressant molecules are sorbed on the surface of paraffin crystals and inhibit the growth and adhesion of paraffin molecules, thereby preventing the formation of deposits.

There are three main types of compounds on the basis of which the main effective depressants are obtained: ethylene vinyl acetate copolymers (EVA), polymethyl methacrylates (PMAs) and olefin copolymers.

Copolymerization of methacrylic acid and styrene with basic vinyl monomers, as well as copolymers based on them, are produced on an industrial scale and are widely used in various fields of the national economy is an urgent problem [1-4]. They find application as thickeners, cutting fluids in metalworking, foam plastics, paint coatings, medicines, viscosity, depressant additives, etc. [5-6].

It is well known that compounds containing the morpholine group have a wide range of different properties and can be used in pharmaceuticals, medicine, agriculture, the oil and gas industry, etc.

Based on this, the synthesis of new morpholine-containing copolymers based on methacrylic acid with N-morpholine-3-chloroisopropylacrylate is of theoretical and practical interest.

The purpose of this work is to study the process of copolymerization of N-morpholine-3-chloro-isopropylacrylate with methacrylic acid (MCHIPA:MAA) and to study the influence of the

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nature of this copolymer on the low-temperature properties of diesel fuel (Table 1).

Table 1

The influence of the nature of synthesized copolymers on the low-temperature properties of diesel fuel intended for diesel engines, summer

Concentration of additive,%	Cloud point, °C			Pour point, °C			Filterability limit temperatur, °C		
	MHIPA·MAK								
	30:70	50:50	70:30	30:70	50:50	70:30	30:70	50:50	70:30
0,05	-4	-5	-6	-12	-13	-15	-6	-8	-10
0,1	-5	-6	-7	-14	-16	-17	-7	-10	-11
0,2	-6	-7	-8	-15	-17	-19	-10	-11	-15
0,3	-7	-9	-10	-18	-19	-22	-10	-10	-14
0,4	-6	-8	-8	-18	-18	-20	-8	-9	-13

At the same time, samples of the MHIPA·MAA copolymer containing 30 wt.% MAA in the initial mixture, which made it possible to reduce the cloud point to -12 ℃, have the best low-temperature properties.

We are conducting research on the creation of depressant additives based on bioside based on aminopolysaccharide-chitosan (CH) from dead bees. The synthesis of chitosan from dead bees is carried out at the Department of General Chemistry of TSTU. Next, we developed a composite biodiesel fuel for use as a depressant with the above-mentioned synthetic acrylate copolymer [7].

Diesel fuel containing the copolymer MHIPA MAK and chitosan was subjected to full analysis in accordance

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with the requirements of the current standard for diesel fuel (Table 2).

The density of diesel and biodiesel fuels was determined using hydrometers. The determination of kinematic viscosity consisted of measuring the flow time of a certain volume of the test liquid under the influence of gravity at a constant temperature (Table 2). Table 2 shows the physicochemical characteristics of diesel and biodiesel fuels obtained by us.

Table 2

Physico-chemical characteristics of diesel fuels

№	Indicator	Diesel fuel	Biodiesel fuel
1.	Density at 20°C, kg/m	860	875
2.	Kinematic viscosity at 40 °C, mm2/s	2,5	4,1
3.	Coking ability of 10% residue, %	0,3	0,3
4.	Cetane number	48	56
5.	Sulfated ash content, % (wt.)	0,01	0,01
6.	Water content, mg/kg	200	320
7	Sulfur content, mg/kg	400	less than 10
8	Flash point, °C	50	110

As can be seen from Tables 2 and 3, the kinematic viscosity of biodiesel fuel is much higher, and the sulfur content in diesel fuel is 400 mg/kg, and in our biodiesel, it is less than 10 mg/kg. This shows a high appreciation of the quality of high-grade diesel fuels. Thus, the use of biodiesel fuel from biodegradable polymers such as chitosan will reduce toxic emissions of exhaust gases and improve the performance properties of the fuel.

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