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DEVELOPMENT OF TECHNOLOGY FOR PRODUCTION OF MOTOR FUEL ADDITIVES BASED ON INDUSTRY-RELATED WASTES OF CAPROLACTAM PRODUCTION

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РАЗРАБОТКА ТЕХНОЛОГИЙ ПОЛУЧЕНИЯ ТОПЛИВНЫХ ПРИСАДОК ИЗ ТЕХНОГЕННЫХ ОТХОДОВ ПРОИЗВОДСТВ КАПРОЛАКТАМА

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Currently the issues of alternative use of chemical wastes, which have significant impact on environment are of vital importance. The article is devoted to evaluation of prospects of technologies to produce motor fuel additives from industry-related wastes of caprolactam production as well as their market implementation. Caprolactam producing facilities produce a lot of wates releasing up to 40 mln. m^3 of effluent gases per year, when utilized. The article presents the research of the methods of processing of alcohol fraction of caprolactam (AFC) production, containing valuable amyl alcohols.

Keywords: fuel additives, caprolactam, fraction of caprolactam.

Enterprises of chemical industry annually generate hundreds of thousands of tons of waste that have negative impact on the environment and reduce the technical and economic characteristics of production processes. Industrial enterprises store, bury or burn significant part of the waste. This entails significant economic losses for production and also has a negative impact on the environmental situation. Increasing the energy and resource efficiency of modern chemical industries through development of technologies for processing of man-made waste is an important scientific and technical task.

Caprolactam is one of the large-tonnage products of the nitrogen industry; the world production of it exceeds 4 million tons per year. In Russia there are 4 productions of this product, with a total capacity of more than 400,000 tons per year [1]. In production of caprolactam, 0.5 tons of waste is generated per 1 ton of product, the most part of waste is utilized by incineration, despite the fact that it contains the significant amount of valuable substances. In this regard, the urgent task is to develop technologies for processing waste products of caprolactam production into valuable chemical products. The aim of the work was to study the conditions for processing the alcohol fraction of caprolactam in various chemical products.

The by-product "Spirituous fraction of caprolactam" (SFC) (Figure 1) contains the significant number of components; Table 1 shows the approximate ratio of them. The most valuable substances are C4-C5 alcohols, which are widely used in industry. It should be noted that amyl alcohols are not produced in our country, and therefore their use is extremely limited. Separation of SFC by classical rectification into individual components is difficult due to the close boiling temperatures of the constituents.

Fig. 1. Alcohol fraction of caprolactam in a flask

The authors considered the following main directions of SFC processing.

1. Rectification with production of narrow fractions of alcohols, mainly amyl alcohol, using effective "Inzhekhim" nozzles.
2. Etherification of amyl alcohols with acetic acid to produce detergent fuel additives.
3. Dehydration to produce olefins.
4. SFC processing into a blended plasticizer for polyvinyl chloride.

Table 1

The ratio of the components of the alcohol fraction of caprolactam

Component name	Mass fraction,%
Cyclohexane	0,4428
Cyclohexene	2,3718
Isopropyl alcohol	0,4663
Propyl alcohol	2,0991
Water	0,0015
Isobutyl alcohol	5,9081
Isoamyl alcohol	7,7813
Amyl alcohol	60,3822
Cyclopentanol	11,4211
Cyclohexanol	0,5808
Cyclohexanone	0,1825

Scientists of chemical laboratories of Tomsk State University have conducted a series of laboratory experiments and showed that the greatest yield and purity of the product is observed when esterifying with SFA acetic acid followed by rectification of the mixture of products. At the same time, a mixture consisting of amyl and isoamyl esters of acetic acid is formed, which are effective fuel additives used as detergents.

Detergent fuel additives are added to both gasoline and diesel. Their action is mostly aimed in large part at cleaning the fuel system of the car. Such additives increase the solubility of resins in diesel fuel or in gasoline, so that the resins do not set in the fuel system. The use of detergent additives reduces deposits in the carburetor and inlet valves, reduces fuel consumption, and reduces CO and hydrocarbons in the exhaust gases. This, in turn, makes it possible to increase the reliability of the fuel equipment, increase the service life, and reduce the cost of maintenance of the car. Detergent additives are also able to decrease formation of carbon in the combustion chamber, thereby reducing engine requirements for the octane number of gasoline.

At present, enterprises of the Russian Federation release antioxidant, octane-increasing and cetane-increasing fuel additives. At the same time, production of key fuel additives, such as depressant-dispersing, anti-static, lubrication, anti-foaming, washing, is absent. Large international companies BASF,

Clariant, Innospec and Afton Chemical import all these additives to our country. There are no Russian suppliers of this product.

The cost of imported detergents varies from 0.25 to 9.8 million rubles per ton. According to preliminary estimates, the cost of domestic additive, developed in this work, will not exceed 0.2 million rubles per ton. One of the advantages of the developed fuel additive is use of the by-products of caprolactam production as a raw material, which is the reason for the low price for the products.

During the further research, the Engineering Chemical Technology Center of Tomsk State University (TSU) will carry out research work on selecting the most efficient catalytic esterification system for alcohols contained in SFC, will carry out detailed optimization of the process conditions, and will develop a new composition of a fuel additive to be used in industry.

The developer will choose Catalytic systems from among Russian catalysts. Scientists of the Laboratory of Organic Synthesis of TSU will optimize the conditions of the esterification process. Industrial partners of TSU plan to develop and test 5–7 compositions of detergent fuel additives and to choose one composition for further scaling based on the results of these tests. LLC "Engineering Chemical Technology Center" will facilitate the testing.

Reference

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