Development of lubricating oils production process by fatty acid methyl esters alcoholysis with ethylene glycol

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Relevance of the research topic.

The relevance of this work is confirmed by the inclusion of the target products—fatty acid esters and polyols — in the "List of Critical Industrial Products in the Chemical Industry of the Russian Federation for 2024 and for the Planning Period of 2025 and 2026" (Order of the Ministry of Industry and Trade of Russia dated February 22, 2024, No. 207, OKPD-2 code 20.14.33). However, while the traditional method for producing fatty acid esters (FAEs) is the direct esterification of distilled fatty acids (FAs) and monohydric aliphatic alcohols, when using polyols, particularly ethylene glycol, this approach is associated with technological difficulties: high boiling points of the reaction mixture and limited solubility of the reagents. An alternative route — the alcoholysis of fatty acid methyl esters (FAMEs) with polyols — equally requires study, since both processes involve a comparable number of process steps.

The raw material aspect makes the work particularly significant. Currently, fatty acid methyl esters obtained from oil and fat raw materials are commercially available on the Russian market. Ethylene glycol, unlike other diols (propylene glycol, 1,3-propanediol, butanediols), is a large-scale product of industrial organic synthesis in Russia. Therefore, the development of a technology for synthesizing esters based on ethylene glycol and FAME represents an import-substituting solution that leverages the existing raw material base. At the same time, analysts note that there is growing interest from Russian oil companies in expanding monoethylene glycol production, which will ultimately strengthen the raw material base for ester production and drive the development of domestic oleochemistry.

The goal of this work.

Development of scientific foundations for the technology of synthesis of ethylene glycol and fatty acids esters of oil and fat origin.

The tasks of the work:

To achieve this goal, the following tasks have been formulated for this dissertation:

1. To study the general physicochemical principles of the alcoholysis of fatty acid methyl esters with ethylene glycol;

2. To develop a kinetic model for the alcoholysis of carboxylic acid methyl esters with ethylene glycol;

3. To examine the possibility of intensifying the alcoholysis process and to determine the conditions that ensure the maximum yield of fatty acid mono- and diesters and ethylene glycol;

4. To develop a process flow chart for the alcoholysis of fatty acid methyl esters with ethylene glycol.

The scientific novelty of the work.

This work provides the first substantiation of the relationship between the structure of the resulting cyclic alkali metal alkoxides and their reactivity during the alcoholysis of methyl esters of carboxylic acids with ethylene glycol.

A kinetic model for the alcoholysis of methyl esters of fatty acids with ethylene glycol in the presence of basic catalysts is proposed for the first time, taking into account the balance of catalyst species.

Theoretical significance of the work.

Development of understanding of the mechanism of base-catalytic alcoholysis of carboxylic acid esters with ethylene glycol. The conjugated endergonic and exergonic reactions associated with the structure formation of alkali metal ethylene glycolates is substantiated. This process must be taken into account when constructing a mathematical model of the process.

Practical significance of the work.

A highly selective method for producing fatty acid ethylene glycol esters has been proposed, which allows for a reduction in the catalyst consumption coefficient.

The main provisions for the defense:

1. Principles of the alcoholysis of fatty acid methyl esters with ethylene glycol catalyzed by base catalysts;

2. Development of a kinetic model of the base-catalytic alcoholysis of carboxylic acid methyl esters with ethylene glycol;

3. Development of a laboratory technology for producing fatty acid esters and ethylene glycol, allowing for a reduction in the catalyst consumption coefficient.