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Catalytic conversion of bioethanol in to hydrocarbon fuel

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Introduction

Due to the increase in global consumption of hydrocarbon-based fuels and the decline in crude oil reserves, there is an ongoing research in finding an alternative to the traditional source of hydrocarbons, crude oil. In the last decade, as a result of the problems raised by global warming and the agreement reached by many countries at the Kyoto convention (in 1997 of December in addition Framework Convention on Climate Change, UN FCCC) which limits the volume of carbon dioxide given off to the atmosphere, there has been a significant interest in renewable energy sources.

The use of crude oil, coal, and natural gas cannot reduce CO_2 emission, as carbon in these materials gives off carbon dioxide on combustion. The only known way of absorbing atmospheric CO_2 is photosynthesis, where carbon dioxide is converted to carbohydrates in plants. If processed, the latter can give a vast number of important products, one of which is bio-ethanol. Bio-ethanol can be produced by fermentation of starch or sugar found in the sap and fruit of plants. Industrial wastes are also raw materials for bio-ethanol production. In many countries, bio-ethanol is used as fuel for internal combustion engines in its pure form and also as a mixture with gasoline. However, in Russia and other countries with predominantly cold climate, the use of ethanol as a fuel is hindered by many factors: high hygroscopic nature of ethanol, social factors, absence of legislative acts on ethanol as fuel.

A promising way of processing bio-ethanol into different hydrocarbons is conversion over zeolite catalysts. An example of such process is the production of butadiene and synthetic rubber from ethanol over $MgO\text{-}SiO_2$, $ZnO\text{-}Al_2O_3$ catalyst using the Lebedev's method.[1] As a result of the discovery of large crude oil deposits; ethanol was forced out of this process by cheaper cracking products. However, with the increase in crude oil prices, the process of obtaining 1, 3-butadiene from bio-ethanol seems more promising.

We have developed a technology which allows for obtaining a wide range of hydrocarbons from the conversion of ethanol over zeolite catalysts.[2] Our results showed that ethanol conversion is 100% over all synthesized catalysts, yet the process selectivity can be managed. Depending on the reaction conditions, nature of the doping oxides and metals, and also the presence of a binder, the reaction equilibrium could be shifted towards the formation of ethylene, olefins, alkanes, or aromatic compounds (toluene, xylenes, etc.) which are important petrochemical products, formation mechanism over zeolites of this compounds was determine (Figure 1). The octane number of obtained liquid product is 98 (research method); considering the absence of sulfur and nitrogen as well as the low content of benzene, this product can be used as high-octane, ecologically clean motor fuel in class with the Euro-4 or 5 standards, as opposed to the oil-derived fuels. After the catalytic conversion of bio-ethanol the obtained hydrocarbon fraction was hydrogenised over Pt-based catalysts at 360°C and 10 MPa in order to obtain naphthenes, the important components of jet fuel. During hydrogenation, the total content of aromatic hydrocarbons decreased from 51 % to 12 - 21 % depending on the process depth. Again, the absence of benzene ensures the high ecological standard of produced fuel. Accordingly, the liquid product of hydrogenation can be used as jet or motor fuel. The analysis of obtained liquid fractions showed that they comply to the industrial standards for synthetic bio-fuels intended for the use with gas-turbine aviation engines.

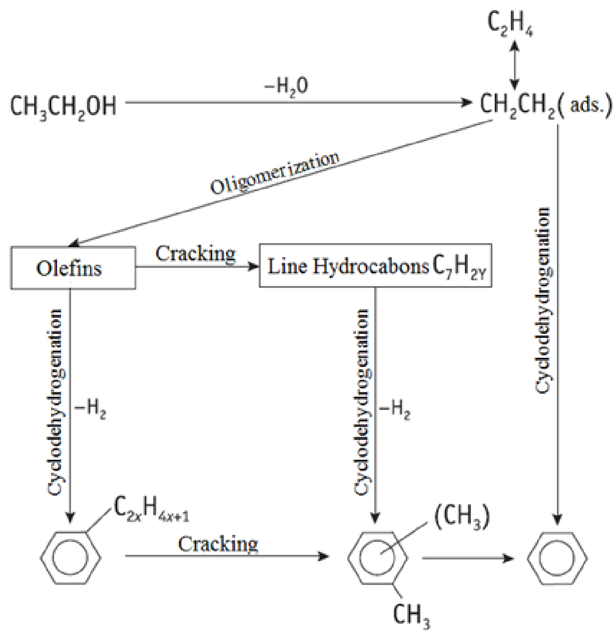

Figure 1 Diagram of ethanol conversion over zeolites.

Conclusion

Thus, for the first time in Russia the samples of synthetic liquid fuel suitable for use in gas-turbine aviation engines were obtained from biomass.[3] The developed technology of two-stage ethanol conversion allows to obtain bio-fuel with controlled characteristics; hence, it can be recommended for industrial implementation. Another possible way of converting ethanol is its steam reforming to hydrogen-containing gas which could be used in fuel cells for producing eco-friendly electrical energy.[4]

Catalytic conversion of ethanol is viable alternative to the traditional process of crude oil refining; the process is capable of making headway for the production of synthetic fuels and raw materials for petrochemical industry, at the same time providing the opportunity to curb the incremental rise of anthropogenic CO_2 in the atmosphere.

Acknowledgement

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Conflict of interest

The authors declare there is no conflict of interest.

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