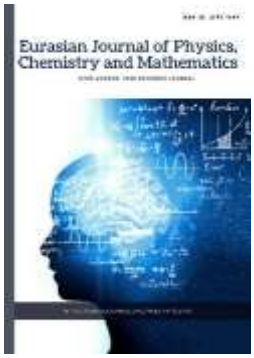

Environmental aspects of bioethanol production methods

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ABSTRACT

To the present day, bioethanol is considered to be a perspective substance, which can serve as fuel for cars and replace petroleum products. Therefore a lot of experiments on ways of bioethanol production, its further use as an organic gasoline substitute are carried out. However in our country these developments are limited and in the basis of the study are such substances as starch and sugar. But it can be assumed that the use of ordinary cane will be more cost-effective and therefore persepective direction of biofuel production.

Keywords: common cane, bioethanol, enzymatic hydrolysis, biofuel., etc

Substantiation of the relevance of the study

In Russia, as in a country whose economy is based on the sale of resources, the development of the issue of biofuel extraction is at a low level. However, the current international situation pushes states to new solutions, including in relation to energy resources.

The relevance of the topic under consideration is confirmed by a large layer of researchers, both in Russia and abroad. And in connection with recent events, foreign teams are conducting more and more exploratory work aimed at switching from petroleum products to biological raw materials. But, as already noted above, biological fuel turns out to be expensive, which does not allow us to completely abandon gasoline.

Thus, the total capital costs (including thermal power plants) for the production of bioethanol in Brazil amount to 117mn US dollars. In the United States, due to the volume of production, the sum is half as much. But, it can be assumed that if we replace sugar cane with ordinary, which in our country is considered as a weed plant, then production costs will significantly decrease, while the mass of ethanol will remain, since the whole plant will be used, and not its individual parts, as it happens in Brazil or in the USA.

Also, the relevance of the study of methods for obtaining ethanol from ordinary cane necessitates the search for alternative and environmentally friendly energy sources, while bioethanol is a promising direction of economic growth, especially since the Russian Federation is a huge state covering a large list of climatic zones where it is possible to grow a variety of crops, including ordinary cane without serious the costs of cultivation and processing.

Introduction

The current situation in the world pushes Western countries to search for alternative

energy sources. In addition, the public is increasingly asking questions about the environment and the coming problems associated with the scarcity of resources. As a result, all countries in the world are, to one degree or another, interested in finding environmentally friendly substitutes for petroleum products, especially gasoline. However, this process is extremely costly and at this stage cannot guarantee high performance because all production options are in the development stage. Moreover, the automobile industry is not ready for a full transition to biofuels, which in turn slows down the process of developing the issue.

The purpose of the study is to consider the method of bioethanol production from ordinary cane.

Objects and methods of research

The main methods of research, which can be specified on the basis of the text of the work, are:

- the method of dialectical materialism (assumes the study, the study of categories (concepts) from the simplest to more complex, based on their development);
- the method of comparison and analogy (based on the works of domestic and foreign authors, it is possible to identify the significance of the search for analogues of combustible fuels and promising in this direction for the Russian Federation);
- analysis and synthesis of the collected information (includes compilation of the found information on the considered problem and making up one's own vision of the perspectives);
- experiment

Results and discussion

More and more foreign researchers are relying on cane processing and obtaining the necessary mass from fast carbohydrates.

L. Canilla, A. C. Chandel, F. A. Fernandez-Antunes, V. L. da Costa Freitas, M. das Graças Almeida Felipe and S. S. da Silva in their work on ethanol fermentation point out that Brazilian sugar-alcohol mills process more than 602 million tons of sugar cane. Sugar cane cake and straw are typically burned in the industry to provide all the energy needed for the sugar and/or alcohol production process. If, instead of recycling, all cane parts were used for ethanol production, much more ethanol would be produced from each hectare of processed sugar cane. The authors note that in general, the biological process of converting lignocellulosic biomass to fuel ethanol includes:

1) pretreatment to remove lignin or hemicellulose to release cellulose;
2) depolymerization of carbohydrate polymers to form free sugars by cellulose;
3) fermentation of hexose and/or pentose sugars to produce ethanol;
4) distillation of ethanol [1]

It can be assumed that if we replace sugarcane with common sugarcane, which in our country is considered a weed plant, the cost of production would be greatly reduced, while the mass of ethanol would be saved, since the whole plant would be used, rather than parts of it, as it is in Brazil or in the United States.

Table 1

Feasibility study of sugar-based bioethanol production [5]

Parameter	Value	Units
Sugarcane as raw material	165	dry ton/hour
Requires fresh water	310	m 3 / h
Ethanol production	46	m 3 / h
Vinasse produced	370	m 3 / h
Bagasse in the cauldron	74	dry ton/hour
Electricity produced	77	MW el
Live steam, 2.5 bar, for evaporators	210	ton/hour

Steam, 1.7 bar required for distillation	160	ton/hour
Steam, 1.7 bar, extracted after evaporation	170	ton/hour
Total capital costs (including CHP)	117	US$ million

Another team of authors, Santana K., M.A. Faizal, N.A. Zainuddin, M. Fadhil Md Din, Sh. Chelliapan, etc. researchers from the USA, note that corn and potatoes, in much more outperform other lignocellulosic biomass in production, but, such plants as water lettuce and hyacinth have potential due to their cheap price. At the same time, as K. Pankaj and S.K. Maiti, existing internal combustion engines are not ready to run on biofuel, and the conversion to new environmentally friendly modes of transport turns out to be not just a time-consuming process, but also affects the interests of the market. But the market is not ready to give up gasoline cars. Researchers note that it has been proved that catalytic conversion of bioethanol with integration of heat into gasoline hydrocarbons on zeolites is self-sustaining. However, this process also cannot be called cheap and justified, at this stage of economic development in the world.

Russian researchers, F.Sh. Vildanov, F.N. Latypova, R.R. Chanyshev, S.V. Nikolaeva, note that despite the fact that Brazil and the USA are considered the largest suppliers of bioethanol, other countries are also able to find sources that are not expensive to produce and profitable in terms of operation. Moreover that number of bioethanol plants in Western countries is increasing day by day which is connected with refusal of petroleum products and a number of advantages of biological fuel such as low toxicity and practically full absence of CO in combustion products, biodegradability, possibility of increasing efficiency of agricultural resources use, reducing dependence on oil, reducing greenhouse effect. However there are still unresolved issues in the organization of the process of bioethanol production: due to the fact that food is mostly used, while the issue of providing the population with daily necessities is not solved, bioethanol has a very high cost, and dependence on crops only increases it many times over. Therefore, the idea of using alternatives such as common cane is considered attractive and relatively cheap [2]

Bioethanol is a perspective direction of economic growth, especially because the Russian Federation is a huge state, covering a large list of climatic zones where it is possible to grow a variety of crops, including common cane [3]. (Fig.1)

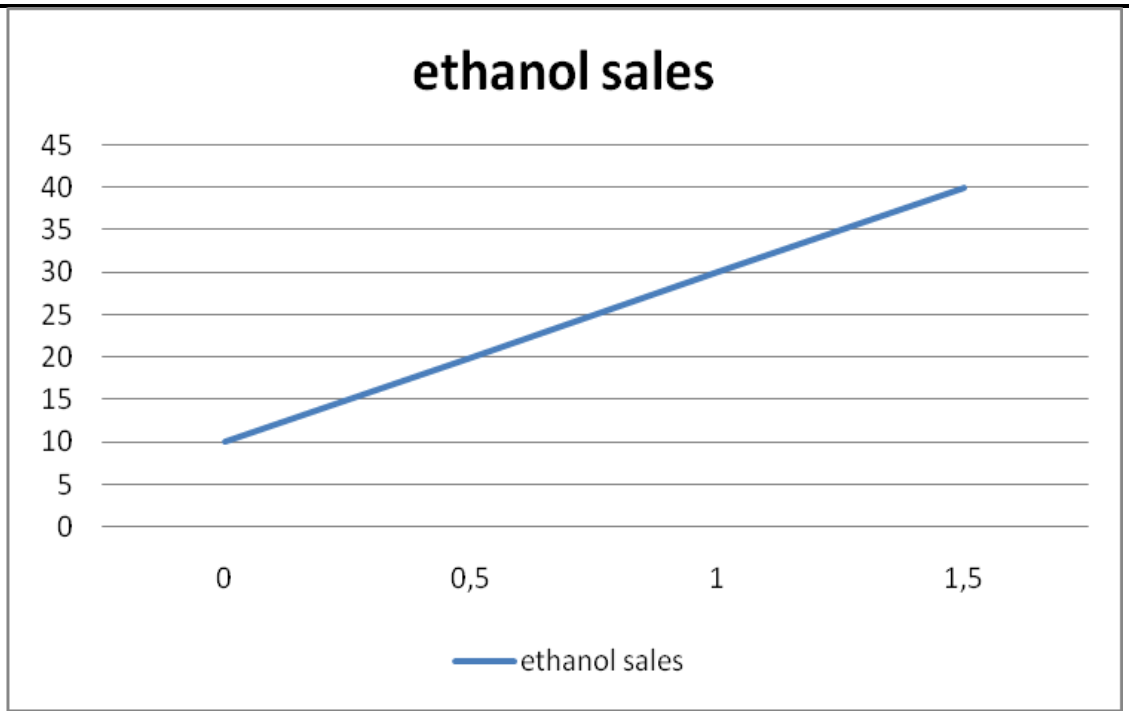

Fig.1. The impact of the price of ethanol sales on the domestic economy of the country

Figure 1 shows that the interest in biofuels has a positive impact on the economy of the country, so the issue of its production in our country should be developed and improved. Especially when you consider that, domestic authors note that bioethanol is quite promising fuel, but there is no absolutely ready-to-use basis for it, so it goes in combination with gasoline.

Yu.A. Zhukova, M.V. Naidanova, O.Ya. Mezenova note that in domestic practice starch rather than sucrose is used to produce ethanol. However, it is the sugars that make it possible to increase the quality of the produced fuel.

G.Z. Dzhakhangirova, N.A. Akbarova, and N.A. Agzamova argue that the circumstances surrounding exhaustible energy sources require mankind to find an alternative. Such could be bioethanol, but, according to the authors, hydrolysis does not give a sufficient product in relation to the cost of obtaining it. Researchers want to propose another way of bioethanol production, arguing that fermentation can give higher productivity and quality of the product [3].

A.Z. Midov continues the topic of the prospects of bioethanol development in Russia, and notes that despite the fact that Russia lags far behind Brazil and the United States in bioethanol production, still market needs and international relations require new industrial solutions from the country. Bioethanol is a promising direction for economic growth, especially since Russia is a huge country, covering a large list of climatic zones where it is possible to grow a variety of crops, including ordinary cane.

Consequently, domestic authors point out that bioethanol is quite promising fuel, but there is absolutely no ready-to-use basis for it, so it goes in combination with gasoline. But for our country this direction turned out not to be as demanded as European and Pacific countries.

The hypothesis that common cane could serve as the basis for a cheaper biofuel analogue is based on the following points:

1)it is one of the most common cereal plants in the world that is not used in the food industry;

2)it is considered a weed because it spreads quickly by dispersing seeds over large areas than can harm cultivated plants;

3)A perennial plant, reaching 4-5 meters in height and 2 cm in thickness; easily adapts to different conditions and survives in places unsuitable, for other plants [4]

Potential uses of haulm include:
1) as fodder for animals such as muskrat, nutria, as well as young shoots forage for cattle;
2) drainage of wetlands, the formation of peat bogs;
3) production of paper, household items and decor.

Physically, common cane consists of four main fractions: fiber, insoluble solids, soluble solids, and water. The soluble solids fraction, which can be dissolved in water, consists mainly of starch, sucrose, and other chemical components (Figure 1)

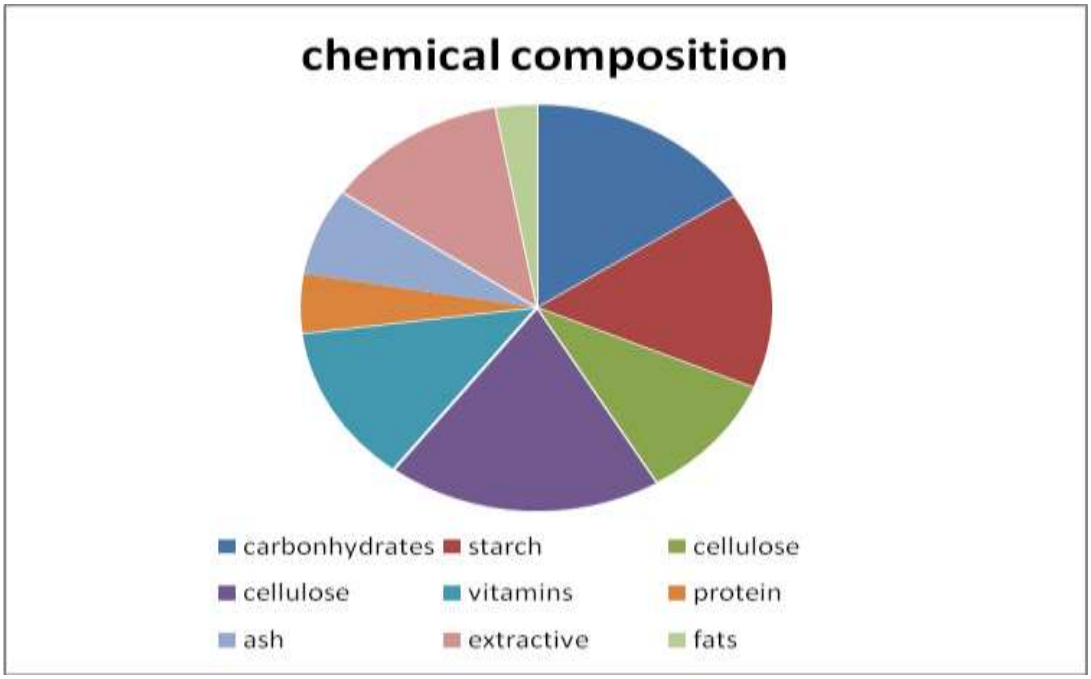

Fig .2. Chemical composition (% wt./wt., in terms of dry weight) of common cane

At the same time, the young shoots are rich in sugar, the stems in fiber, and the leaves in ascorbic acid. Therefore, it is necessary to use young shoots to obtain ethanol [5].

There are three types of processes for producing ethanol from common cane.

The first process is called separate (or sequential) hydrolysis and fermentation, where lignocellulosic material hydrolysis and ethanol fermentation are done separately. Leaves and stems are pretreated, subjected to enzymatic hydrolysis, and sugars are extracted. The reduced sugar solution (hexose sugars) is then digested with the appropriate microorganisms into ethanol.

The other two types of processes are called simultaneous saccharification and fermentation and simultaneous saccharification and cofermentation, where enzymatic hydrolysis and fermentation of the released sugars into ethanol occur simultaneously, making the overall process short. In this process, glucose (from hydrolyzed cellulose) is fermented separately from pentoses (from hydrolysate) in a separate reactor, whereas in the cofermentation process xylose and glucose are fermented together in one reactor.

Ethanol production from lignocellulosic biomass (second generation) includes biomass pretreatment, enzymatic cellulose hydrolysis, fermentation of hexose/pentose sugars, and ethanol recovery.

However, there is a possibility of the release of byproducts, in order to avoid it, factors such as temperature, reaction time and acid concentration must be taken into account. To do this, we will use an equation including temperature and reaction time, indicating the severity of the pretreatment with a combined severity factor (CSF):

$$CSF = t_{exp}\left[\frac{(T-T_{ref})}{14.75}\right],$$

Where t - residence time (min);
T - temperature (C),
Tref is the reference temperature, usually set to 100 C.
Pretreatment of lignocellulosic biomass should:
1) increase the available surface area and decrystallize the cellulose,
2) partially depolymerize the cellulose;
3) dissolve hemicellulose and/or lignin;
4) modify the structure of lignin;
5) maximize the enzymatic digestibility of pretreated material;
6) minimize loss of sugars;
7) minimize capital and operating costs.

After pulping or pyrolysis to break the crystallinity of the pulp, we turn to enzymatic hydrolysis. Enzymatic hydrolysis is the ideal approach to break down cellulose to reducing sugars because mild reaction conditions can be used (pH 4.8 to 5.0 and temperature 45 to 50°C), it causes no corrosion problems in the reactors and results in little byproduct formation at high sugar yields. (Figure3)

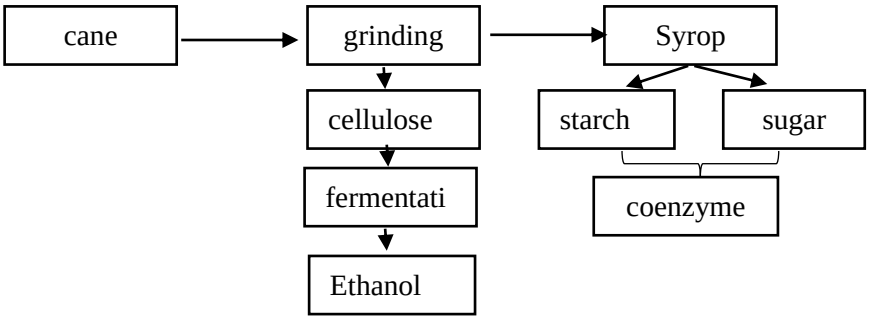

Fig.3. Model for producing ethanol from common cane

To overcome the inhibition of the final product and to shorten the time, hydrolysis and fermentation can be combined, so-called simultaneous saccharification and fermentation or simultaneous saccharification and cofermentation.

Three classes of cellulolytic enzymes (cellulases) are required for enzymatic hydrolysis of the cellulose fraction:
1) endo-β-1,4-glucanases, which attack areas of low crystallinity in the cellulose fiber, creating free chain endings;
2) cellobiohydrolases or exoglucanases, which further degrade the molecule by removing cellobiose links from the free chain ends;
3) β-glucosidases, which hydrolyze cellobiose to form glucose.

Several enzymes, such as xylanase, b-xylosidase, glucuronidase, acetyl esterase, galactomannanase, and glucomannanase, are required to break down hemicellulose. Cellulase enzymes, when acting together with xylanases on delignified SB/SS, show a better yield due to the synergistic action of the enzymes [6] (Fig. 4)

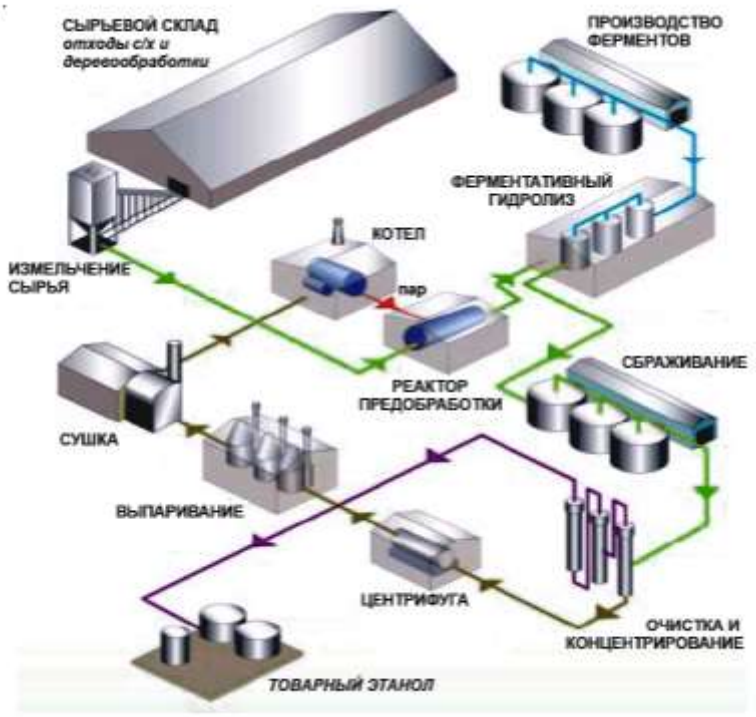

Fig.4. Ethanol production using enzymes

Both bacteria and fungi can produce cellulases to hydrolyze cellulosic materials.

Although the price of enzymes has decreased because of intensive research to improve their production, the loading of enzymes during cellulose hydrolysis must be minimized because it also increases the cost of cellulosic ethanol production.

A number of methods such as evaporation, neutralization, use of membranes, ion exchange resins and activated carbon are used to detoxify hydrolysates to produce ethanol.

Next, with the help of yeast, we move on to ethanol fermentation.

Conclusion

Of course, the above method is not the only one, but it is considered one of the most optimal and not costly. The latter circumstance is especially important, since the main task facing researchers today is the search for minimizing the cost of bioethanol production. As soon as the cost of biofuel will equal or even become less than the cost of non-renewable fuel sources, we can talk about the beginning of a new stage in the economic and environmental conditions of interaction between countries. Therefore, Russia should not be inferior to other countries of the world in the development of biofuels. And with vast territories and different climatic zones, the project of bioethanol production from common cane can be realized in various territories of the country, where there are water bodies and warm air (20º). And if we take into account the fact that in our country this plant is considered as a weed, we can assume that its use will be the most profitable in comparison with developments based on corn, potatoes and other crops.

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