Application of Plant Biomass Conversion Products for Biofuel Production

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Application of Plant Biomass Conversion Products for Biofuel Production

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Abstract. The problem of energy saving while reducing environmental pollution forces not only to look for ways of more rational use of traditional energy resources but also to find other preferably renewable and inexpensive sources of energy. The reserves of fossil fuels are not unlimited and therefore one of mankind tasks is to find new energy renewable sources to meet the growing needs of modern society and future generations. Particular interest in this regard is plant biomass. This review presents the results of studies of the practical application of plant biomass for biofuel production. Production of bioethanol from plant raw materials (in particular molasses - the waste of sugar production), the use of traditional and non-traditional oilseeds for biofuel production are considered. The most promising approach for the conversion biomass based on the dehydration of carbohydrates into furan derivatives is presented also.

1. Introduction

All natural resources in rough approximation can be divided into renewable and non-renewable. At the moment the situation develops so that the widely used technologies are oriented towards the use of non-renewable. The depletion of fossil hydrocarbons reserves such as oil, natural gas and coal, leads to the need of searching for new sources of energy. Plant biomass containing about 75% of hydrocarbons is a viable alternative non-renewable natural resource that can be recovered in the foreseeable period from the use of solar energy for its growth [1-5]. The development of effective processes for recycling plant raw materials is a priority task of modern chemistry and chemical technology, and the obtained products will satisfy practically all energy needs [6, 7].

Alcohols can be obtained from all plants and used as fuel in pure form or as an additive to the basic hydrocarbon fuel. Bioethanol is the most common fuel that is produced industrially. Annually in the world over 70 million tons of this fuel from vegetable raw materials are produced. One hectare of barley yields 1.5 tons of bioethanol after processing, in the case of wheat more than 2.7 tons, maize 3.8, sugar beet more than 6.2 tons, sugar cane 7.7 tons [8]. But this direction does not apply due to need to sow large areas. More promising raw materials are available for processing, regardless of the time of year, wastes such as biomass of trees (sawdust, branches, waste from sanitary cutting), woodworking industry and sugar production waste. The use of such non-traditional materials makes the raw material base for obtaining ethanol practically inexhaustible [9-11].

2. Materials and Methods

At present the production of ethanol from molasses (waste of sugar production) is relevant both from the point of view of rational nature management and from the point of view of economic efficiency because in the treatment of molasses waste is formed in the form of bards and luthers which can later be used [12]. From grain wheat and corn produce high-quality food alcohol. It cannot be obtained from sugar beet molasses, but this raw is suitable for the production of bioethanol which, according to all technical requirements, corresponds to motor fuel. From 1 ton of wheat grain bioethanol is produced in an amount of 355-360 dm^3, and from 1 ton of molasses 310-315 dm^3 [13]. Also positive moment of using molasses is the net energy output after deducting energy costs for the production of the crop itself and for obtaining fuel (the coefficient of energy efficiency) [14].

Widely studied type of vegetable raw material used to produce the biological component of diesel fuel are oilseeds such as: oil palm, jatropha, soybean, sunflower, rapeseed, saffron milk cap, mustard, and coleseed. The advantages of vegetable oils as diesel fuel are their mobility, renewability, higher heat content, lower sulfur and aromatic content, biodegradability [15-19]. However the widespread use of these agricultural food crops to produce fuel can lead to a problem of food shortages and a rise in the cost of the final product. The solution to this problem can be the production of biofuels from non-food oleaginous plants, such as indow and moloch [20], safflower oil, which is obtained by pressing out safflower seeds (a plant of the family Asteraceae) [21].

Another promising approach to processing biomass is based on the dehydration of carbohydrates into furan derivatives [5, 6, 22] and the most promising is 5-hydroxymethylfurfural (HMF). It is obtained from mono-, di- and polysaccharides, such as fructose, glucose, sucrose, inulin, starch, cellulose and others. The main precursor of HMF is usually considered fructose (first hydrolysis of polysaccharides to glucose and / or fructose, then glucose reversibly isomerizes into fructose, which loses 3 water molecules to form HMF) [5, 23, 24]. HMF is a key reagent or "connection-platform" for obtaining a variety of useful products, such as polymers, pharmaceuticals, food additives, solvents and fuels [25, 26].

One of the most studied derivatives of HMF which is considered as a component of motor fuels is 2,5-dimethylfuran (DMF) [27-29]. It has a high calorific value (31.5 MJ L^{-1}), an acceptable boiling point (92-94^{0}C) and a high octane rating (119 according to the research method) [5, 27, 30]. According to kinematic parameters and combustion characteristics DMF is comparable and by some parameters it exceeds gasolines and it does not mix with water, which is an advantage over ethanol and butanol, which are also considered as biofuels [29]. DMF can serve as the starting compound for the preparation of 2,5-dimethyltetrahydrofuran (DMTHF) which also has a high calorific value (31 MJ L^{-1}), has a boiling point (90 ^{0}C) and is stable during long-term storage which allows it to be considered as a promising motor fuel [30].

Widely used such as motor fuels can have various ethers and esters that are derived from HMF and 2,5-bis(hydroxymethyl)furan derivatives of HMF (BHMF) [1]. As components of diesel fuel and aviation kerosene linear hydrocarbons (also derived from HMF) can be used [31-33].

Hydrolysis of HMF leads to the formation of levulinic acid which is another important "compound-platform". Techniques for the synthesis of alkyl esters (components of motor fuels) from it are discribed [26, 34]. For example, the addition of ethyl ester of levulinic acid to diesel fuel reduces its freezing point and reduces soot formation [31]. Another of its derivatives - γ-valerolactone (GVL) - promotes an increase of octane rating of gasoline [35, 36].

3. Conclusion

The production of biofuels from different types of biomass is an important strategic direction for the development of the economies of Europe, Brazil, the USA, etc. The resource potential of biomass in Russia for the needs of bioenergy taking into account its renewability is practically inexhaustible. This allows us to conclude that the use of plant raw materials for biofuels production in Russia is promising as an alternative to the use of non-renewable natural resources.

4. References

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