Sergey Novikov,
Deputy General director,
Marketing and Strategy, Makorus LLC

Biotechnology is one of the key areas of innovative development of the global economy. The reason for this growth is enormous potential of biotechnology opportunities for solving global mankind problems:

- public health services — biotechnology effectively works towards seeking remedies for the treatment of previously incurable diseases (cancer, AIDS) and advanced vaccines;
- Ecological problem — biofuels use allows to reduce significantly the volumes of human impact on the environment;
- the problem of natural resources depletion — biotechology uses renewable sources of raw materials;
- comestibles problem — increase in agriculture productivity through protection of plants against harmful insects and weeds by using of biological substances and development of food crops with advanced properties.

THE MAIN GLOBAL BIOTECHNOLOGY DEVELOPMENT DIRECTIONS

Sergey Novikov,
deputy general director,
marketing and strategy, Makorus LLC

At fig. 1 main global trends of biotechnologies development are demonstrated.

PRIORITY AREAS OF INDUSTRIAL BIOTECHNOLOGIES DEVELOPMENT IN FOREST BIOMASS PROCESSING SPHERE

At fig. 1 areas of industrial biotechnologies development of forest biomass global processing with the indication of produced goods and semi-finished products are given.

PRODUCTION OF WOOD PELLETS AND BRIQUETTES

Wood pellets and briquettes are produced from renewable natural raw materials and used as a fuel both in industrial scale and in private sphere. Pellets global production amounts grows continuously; currently it is >11 MMT/year. Priority areas in pellets and briquettes production is utilization of timbermill wastes: sawdust, shavings, and infected and dead trees and logging wastes as well. The principle

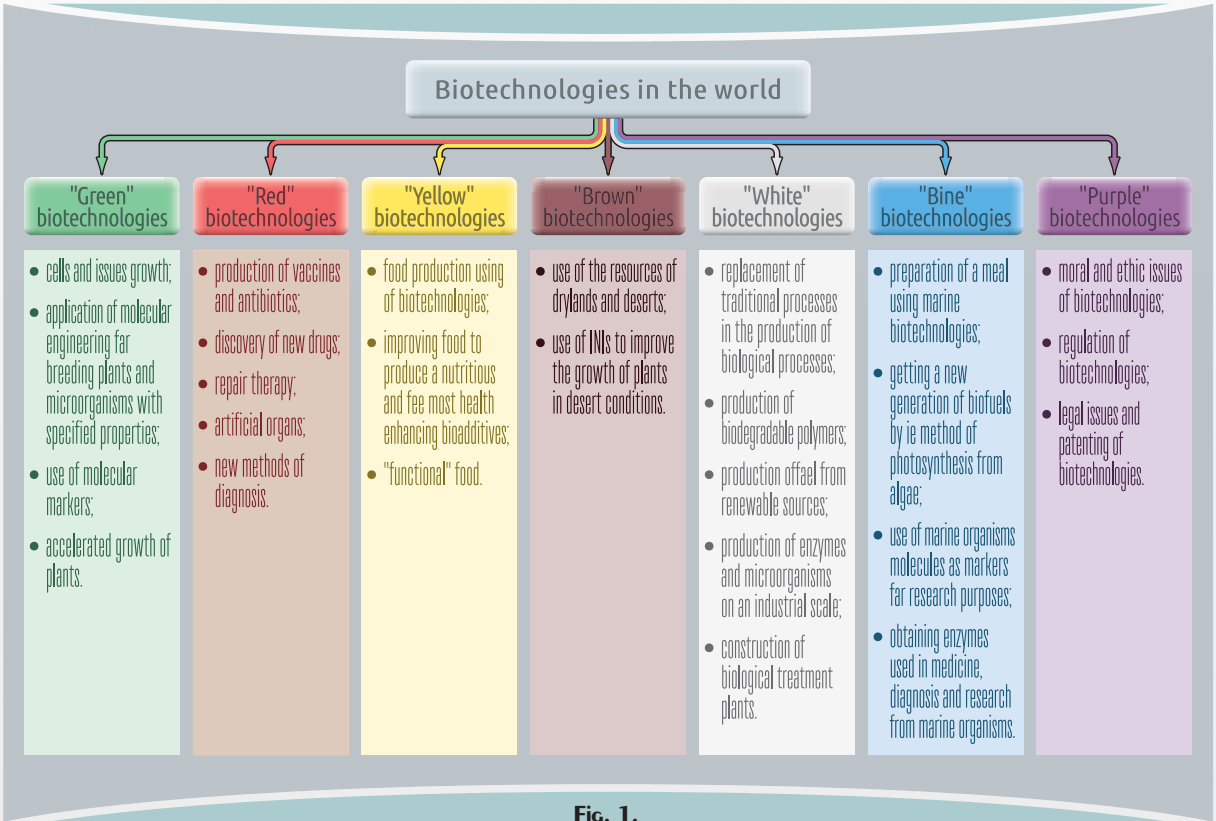

Fig. 1.
Diagram of main global trends in biotechnologies extension

of wood pellets and briquettes production is based on biomass hot pressing under high pressure and punching it through the mold.

CHEMICO-MECHANICAL PULP PRODUCTION

Reduced demand for newsprint paper, which is the main consumption sphere of the chemico-mechanical pulp and high energy consumption issue of the process have significant impact onto the chemico-mecanical mass production state globally.

In order to remain competitive, the chemico-mecanical pulp manufacturers should improve processes and strive to production integration,as implying extension of products range on main products basis. Little attention has been paid to such plants integration up to now. In process of mechanical pulp production wood raw materials are transformed into the product completely – it limits the possibilities of separate ingredients extraction.

Biotechnologies — one of key trends of global economy innovative development.

An example of industrial biotechnologies implementation in in production of mechanical pulp is incorporation of the prehydrolysis stage before beating with generation of xylite used in food and pharmaceutical industry, or common production of newsprint paper and biocomposites with high value added, which are extremely demanded in construction, automotive industry and as packing materials.

Industrial biotechnologies can be applied for improvement of mechanical pulp production process. Chips treatment with enzymes, for example with laccase, allows to reduces energy consumption costs for beating, to increase the throughput and fibres output, to increase the finished product strength and reduce resin constraints.

PRODUCTS OBTAINED FROM WOOD EXTRACTIVES

Wood and trees bark consist mainly of high molecular weight structurants: cellulose, hemicellulose and lignin. These substances can be extracted

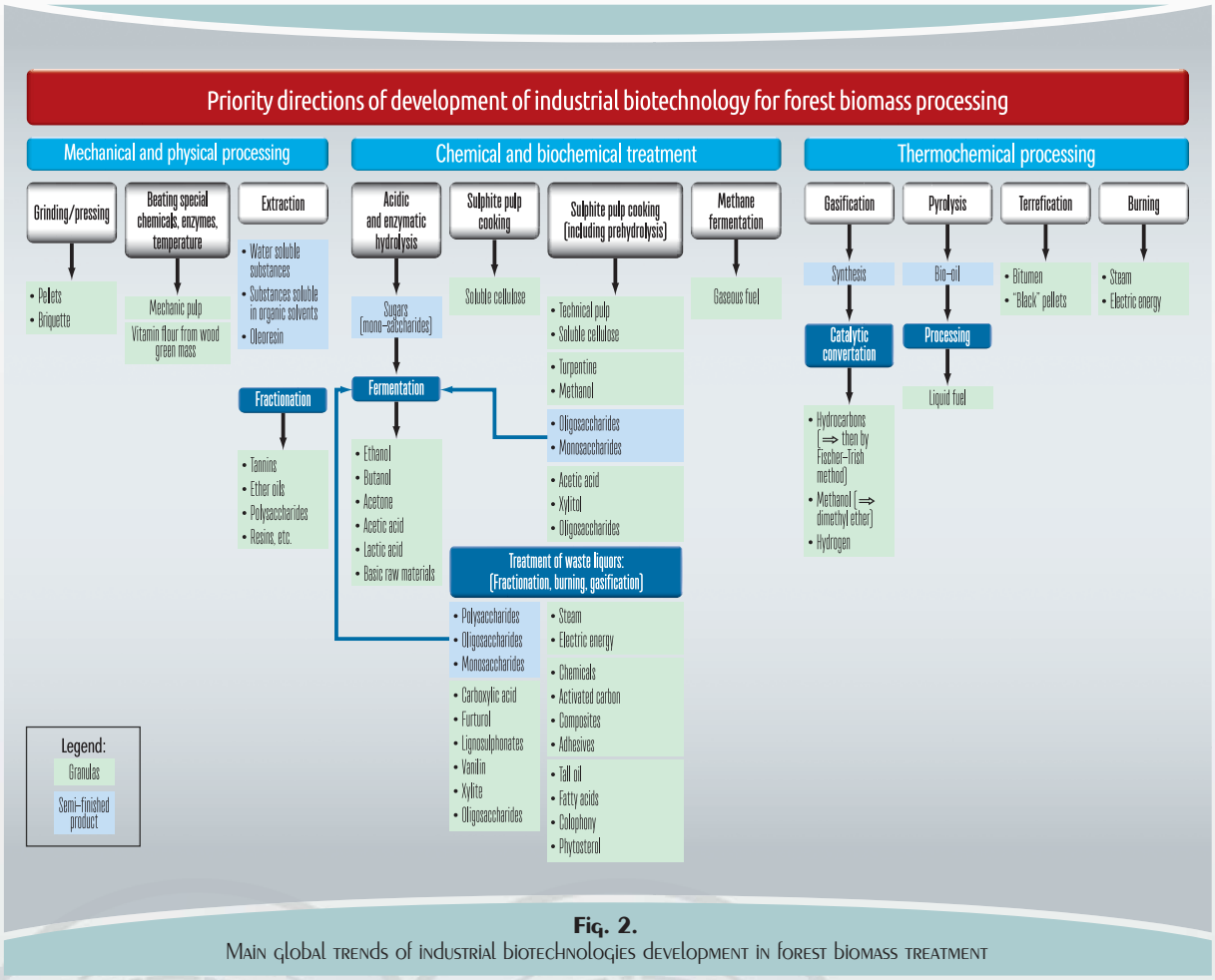

Fig. 2.
Main global trends of industrial biotechnologies development in forest biomass treatment

from wood with organic solvents or with water, which specifies their usual name - extractive substances. The composition of extractives is dependent on the tree species, but in general such compounds can be classified in terpenoids, fats (lipophilic components), polyphenols, water-soluble carbohydrates and inorganic salts (hydrophylic components). Terpenoids are the only group of substances found in softwood solely. Main products on the base of extractive substances currently are: turpentine, rosin, fat acids and sterols, which can be extracted during sulphate pulp production process. Polyphenols are of the utmost interest, namely: lignans, flavonoids, stilbenes and tannins.

Volumes of pellets world production is continuously growing – currently it stands at more than 11 million tons annually.

Research results demonstrated that some of these substances are characterized by biologically active and anti-cancer effect. Polyphenols can be used in functional nutrition, cosmetic products, technical antioxidizers and natural biocides (see fig. 3). At present on an industrial scale an accessory food substance – hydroxymatairesinol traded as HMR iignan. Such product is extracted from spruce knots. Tannins are still widely used as agents for leather tanning and as components of phenolformaldehyde resins. Hydrolyzable tannins are produced generally by extraction from chestnut wood, although their content is high in the tree green mass. Bark and the tree green mass contain significant quantities of condensed tannins which have a high potential for food and pharmaceuticals Other bark components, for example, betulin and suberin in birch bark are of high potential as well.

BIOCHEMICAL METHODS OF BIOFUELS PRODUCTION

For ethanol production from lignocellulose raw

materials the production process preliminary preparation is needed (separation of the cellulose fraction from the hemicellulose fraction by acidic hydrolysis method), as a result convertation of cellulose to glucose in enzymes presence has place.

Currently the sphere of enzymatic hydrolysis of cellulose is developing rapidly. Ethanol obtained from glucose through fermentation, undergoes the distillation stage for final purification. In 2015, three plants for the production of ligno-cellulosic bioethanol were launched in USA: Hugoton (90 MIO litres/year), Nevada (110 MIO litres/year) и г. Emmetsburg (75 MIO litres/year) (source: www.eia.gov/todayinenergy/ detail.cfm?id=17851).

INTEGRATED PRODUCTION OF CELLULOSE FIBERS

Main chemical methods of cellulose fibers production are still sulphate and sulphite digestion. For the past 60 years the sulfate process has been existing as the most versatile and economical method of pulp cooking. During sulphate pulping, about half of wood mass in the form of hemicellulose and lignin dissolves in the cooking liquor, resulting in formation of cellulose fibers with high strength. The dissolved substances of the waste liquor are burned for the purpose of steam and electric energy production, and for chemicals recovery. Basing on the combustion heat values (13,6 MJ/t for hemicellulose) and (27 MJ/t for lignin), it can be concluded that conversion of hemicelluloses into new bioproducts such as polymers and oligomers, the cost of which can exceed 2000 USD/tT, represents the greater economic opportunity than burning of such substances. Because there is an abundance of energy at modern sulfate pulp mills, such plants could become in the future the main suppliers of biofuels.

Joint production of newsprint paper and biocomposites with high added value can serve as an example of industrial biotechnology implementation.

Examples of industrial biotechnologies realization on the base of sulfate pulp production process in industrial scales can be:

Significant quantities of tannins are contained in bark and trees green mass – they possess high potentials for application in food industry and pharmaceutics.

- Chemrec, Soiander Science Park and Smurfit Kappa (Sweden), started the black liquor gasification

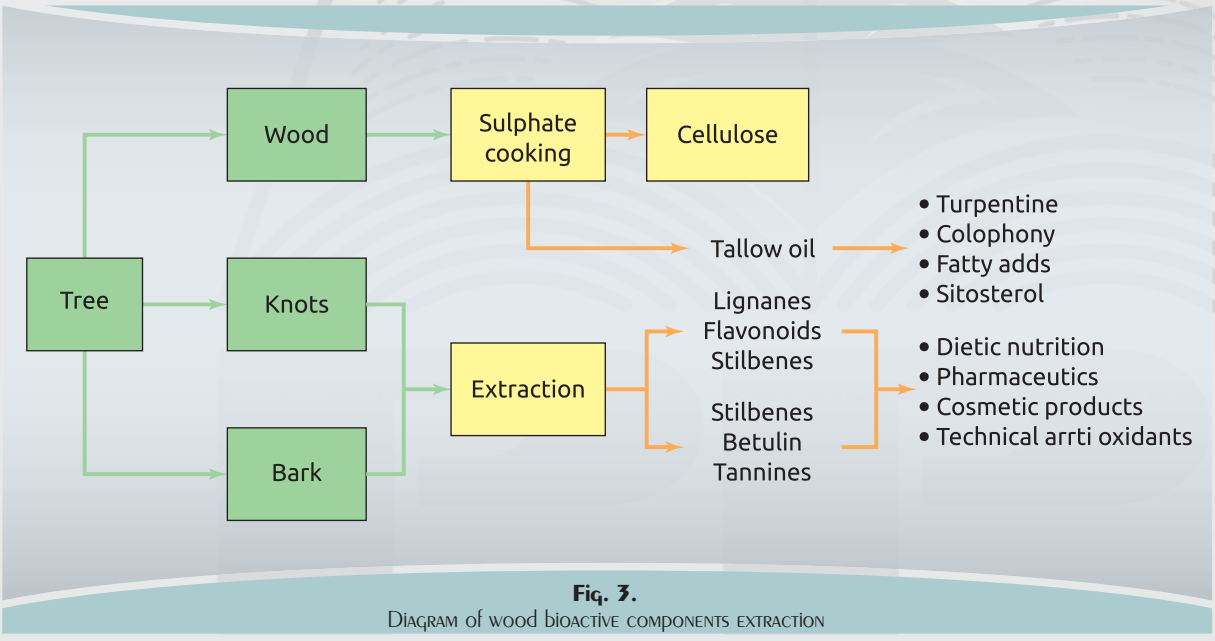

Fig. 3.
Diagram of wood bioactive components extraction

for production of second generation biofuels;

- MeadWestvaco Corporation (USA), manufacturing a range of products from tallow oil, some chemicals and activated carbon on the lignin base along with traditional packaging materials;
- Alberta Pacific Forest Industries (Canada), extracting methanol from gas fraction after digestion stage;

Currently the sphere of enzymatic hydrolysis of cellulose is developing rapidly.

- Metsa Fibre (Finland), started the project of construction of the new plant applying new industrial biotechnologies.

In many countries a significant part of sulphite pulp production mills has been closed due to the obvious advantages of sulfate method, such as the efficiency of the chemicals and energy recovery; savings due to increased production scale, a wider range of raw materials used and high strength characteristics of the pulp fibers. However, the sulphite method of cooking is still widely used for the manufacture of soluble cellulose fibers. Approximately half of the soluble cellulose is being produced from wood by sulphite method. In addition to the high whiteness and the good bleachability of sulphite fibers the advantage of this method is that the waste liquors of the sulphite pulp production can be easily processed into a variety of products, thus ensuring maximum added value of products per ton of raw material. The leading manufacturers implemented industrial biotechnologies on the basis of the sulphite pulp mills, are currently Borregaard (Norway), Lenzing AG (Austria) и Domsjo Fabriker (Sweden).

THERMOCHEMICAL METHODS OF BIOFUELS PRODUCTION

Thermochemical processes are used for biomass transformation under high temperature conditions (500–1500 °C) — pyrolysis reaction and gasification. Such processes can be used for any type of lignocellulosic raw materials.

After refining synthesis gas can be transformed into sulfur-free liquid gas fuel.

Pyroliis and/or torrefication processes can be used for biomass preparation to gasification with the purpose of the transfer material into a homogeneous state for facilitation of feeding into the gasification unit. Gasification of waste liquor sulphate pulp mills is used also.

BIO-OIL PRODUCTION

A rapid pyrolysis is a process, representing air-free heating of organic substances to 500-600 °C for 2 seconds generation of organic vapours, which can be condensed for obtaining of liquid substance — bio-oil — biofuel of the 2nd generation, which doesn't overlap with the food products chain. The first plants using such technologies were created by Evergent Technologies/ Ensyn in 1990s, then other companies the company were involved into this process improvement.

Bio-oil can be used as a fuel for boiling stations and for electrical energy generation.

Now, the development process is carried out for technology of producing biodiesel fuel for cars and planes from bio-oils.

Practically all types of wood raw materials can be used for bio-oils production. It is possible to process whether one specific wood type, or several types together in almost any ratio.

The yield of bio-oil from wood is 70–80%, depending on the relative amount of cellulose/ lignin in the raw material and bark impurities.

The schematic diagram of the pyrolysis plant is given at the fig. 5.

7 operating plants on bio-oil production exist currently and 4 projects are in the construction stage (table 1).

PRODUCTION OF «BLACK» PELLETS, BIOCHAR

The energy value of bio-coal (torrefied granulas, pellets) is 25% higher in comparison with conventional «white» wood pellets, that reduces energy units transportation and storage costs by 50%. Torrefied granulas are also water-proof, they are designed to form less dust and reduce ignition and fire risks during transportation and storage. Such pellets can be produced from different types of

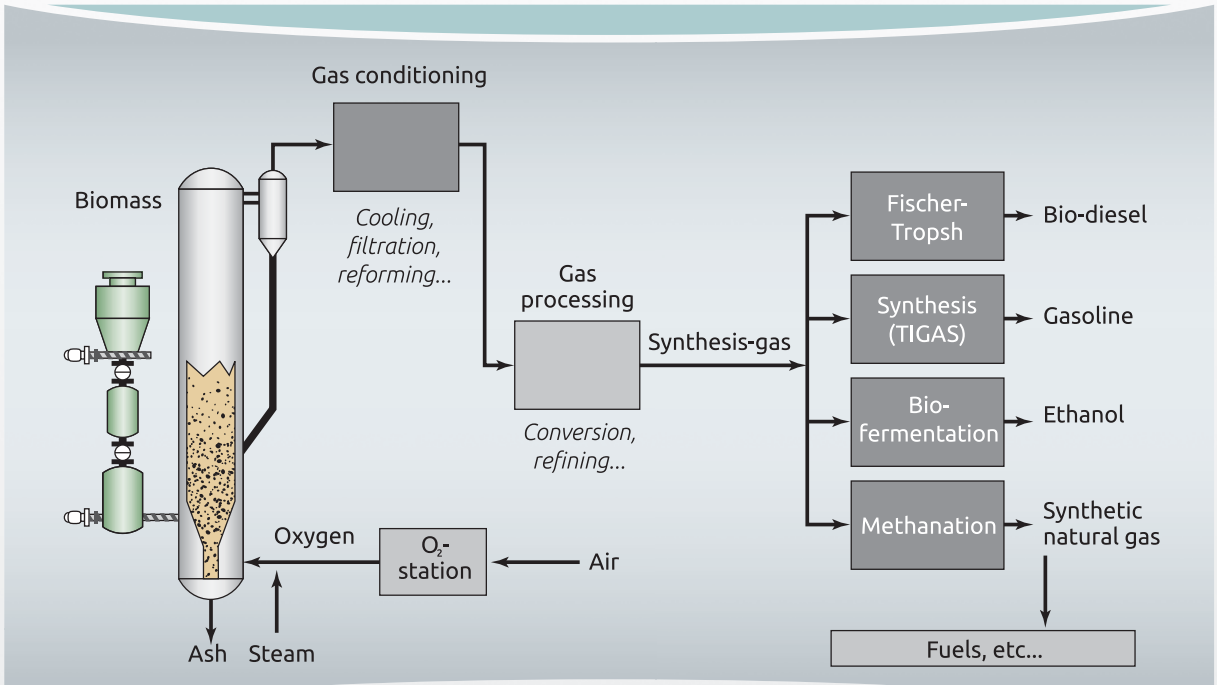

Fig. 4.
Synthesis gas production diagram

biomass and wood wastes, they are reasonable for co-combustion with coal at coal-fired power plants.

Rapid pyrolysis is a process that represents organic materials heating to 500–600 °C without air to generate organic vapors within 2 seconds; the vapors can be condensed to obtain a bio-oil.

Main branches of biotechnological products consumption are directly related to human activity and needs concerning a comfortable and safe living environment ensuring. Following key spheres where biotechnological products are sought-for can be noted: energy sector (1,8%), textiles production (3,8%), pharmaceutics (8–10%), personal hygiene products (4%), packaging materials (4,8%), paint and coatings industry (6%), poultry industry (3,9%) and livestock farming (1,2%).

Currently, a narrow range of basic biotech products in Russia are produced by manufacturers of enzyme preparations, by plants producing solid biofuels and by pulp and paper mills. The frontmost products for the forest industry in Russian Federation are:

1) enzyme preparations (forage production), distillery industry, enzymes application in pulp and paper production);
2) lactic acid;
3) bioethanol for fuel blends;
4) liquid biofuels (pyrolysis oil);
5) furfurol;
6) BCTMP (bleached chemical thermo-mechanical pulp);
7) sulphite pulp and lignosulphonates;
8) sulphate pulp;
9) soluble cellulose;
10) by-products of sulphate production:
    - ♦ sulphate turpentine,
    - ♦ crude tall oil,
    - ♦ distilled tall oil,
    - ♦ tall oil fatty acids,
    - ♦ tall oil rosin,
    - ♦ tall oil pit,
    - ♦ phytosterol,
    - ♦ lignin;
11) solid biofuels («white» pellets).

The energy value of bio-coal (torrefied granulas, pellets) is 25% higher in comparison with conventional «white» wood pellets.

As of 2015 the total volume of the Russian biotechnological market (excluding the bioenergy segment) is estimated as no less than 4.3 billion USD and

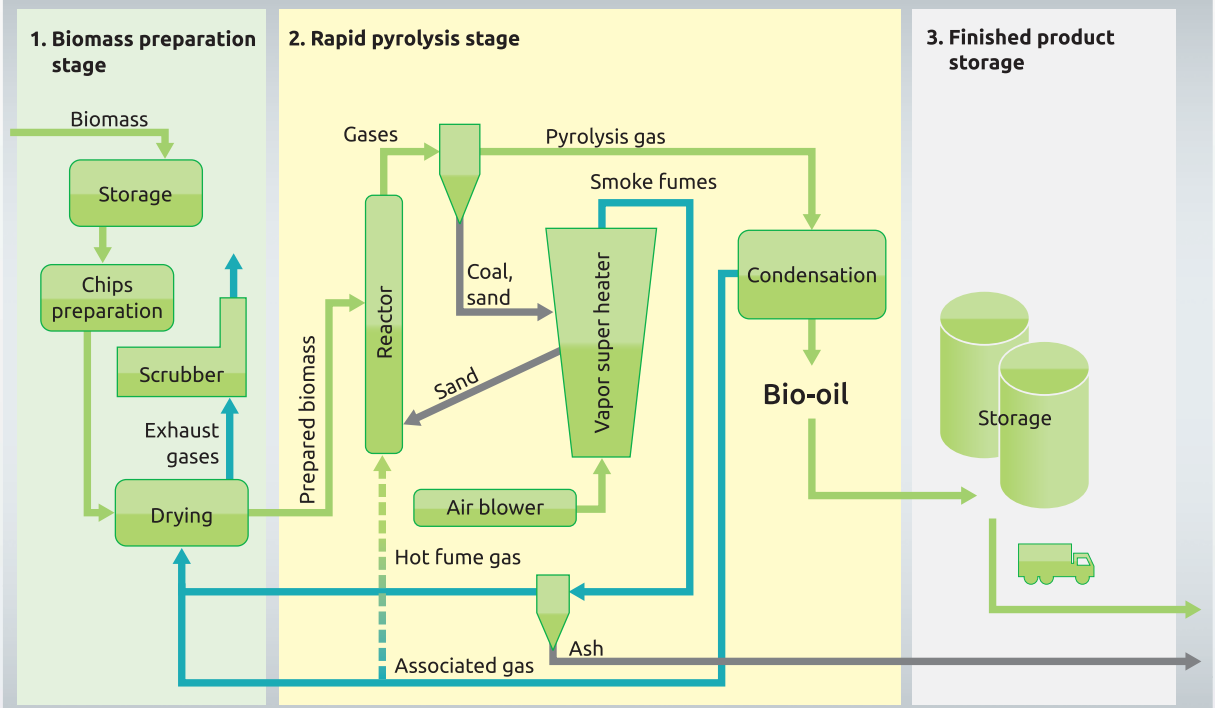

Fig. 5.
Basic diagram of the pyrolysis plant

№	Company	Country	Capacity, t/y	Application sphere	Project status
1	Fortum	Finland	50 000	Fuel	Operation
2	Dynamotive Energy Systems Corporation	Canada	~ 28 000	Fuel, bio-carbon, synthesis gas	Operation
3	Empyro	Netherlands	24 000	Fuel	Operation
4	BioLiq	Germany	4000	Fuel, synthesis gas	Operation
5	Ensyn	Canada	10 000	Fuel	Operation
6	Battelle	USA	360	Fuel	Operation
7	Iowa State University	USA	~ 10	Fuel	Operation
8	Cool Planet	USA	40 000	Fuel, bio-carbon	Construction
9	Renergi	Australia	~ 4700	Fuel	Construction
10	Green Fuel Nordic Oy	Finland	~ 25 000	Fuel	Construction

Table. 1.
Projects for biomass production based on wood raw materials

more than 2.7 times higher in comparison with 2005 figures (the actual growth rate was +2.7 billion USD, CAGR was 13%). The market size dynamics, including forecast indicators in horizon of 2020, is given in Fig. 6.

On the basis of the commodity market structure, the major role in volumes grow played segments of the biomedicine, food and agricultural biotechnologies, provided up to 96% of the total increase. The sector of industrial biotechnologies due to minor changes in volumes didn't have any significant impact on the overall dynamics of the market.

According to 2005–2015 results the Biomedicin Segment has become a key driver of market growth (+ 1.9 billion USD, which corresponds to a 66% share in the structure of growth for the overall market). A major role in volumes increase played the biopharmaceutical sector (+ 1.5 billion USD, or 80% increase in the segment).

The segment of agricultural biotechnology (+0.6 billion USD, the share of the overall volume growth ~21%). The key drivers of growth were sectors of veterinary drugs and feed components (overall growth +0.58 billion USD, or 96% of the growth for the segment).

As of 2015 the total volume of the Russian biotechnological market (excluding the bioenergy segment) is estimated as no less than 4.3 billion USD.

The segment of food biotechnologies demonstrated growth of +0.27 billion USD, or 9% of the total increase. The most significant segments, defining the increase, are stabilizers, flavorings, including flavor and smell enhancers (+0,24 billion USD / share 86%).

The analysis confirmed the presence of demand in both domestic and foreign markets. For implementation of bio-technological products manufacturing in Russia. It is necessary, that future products meet and/or exceed the existing analogs and advanced development results abroad. The first direction of biotechnological products manufacturing is imports phase-out, which is evaluated at the moment as

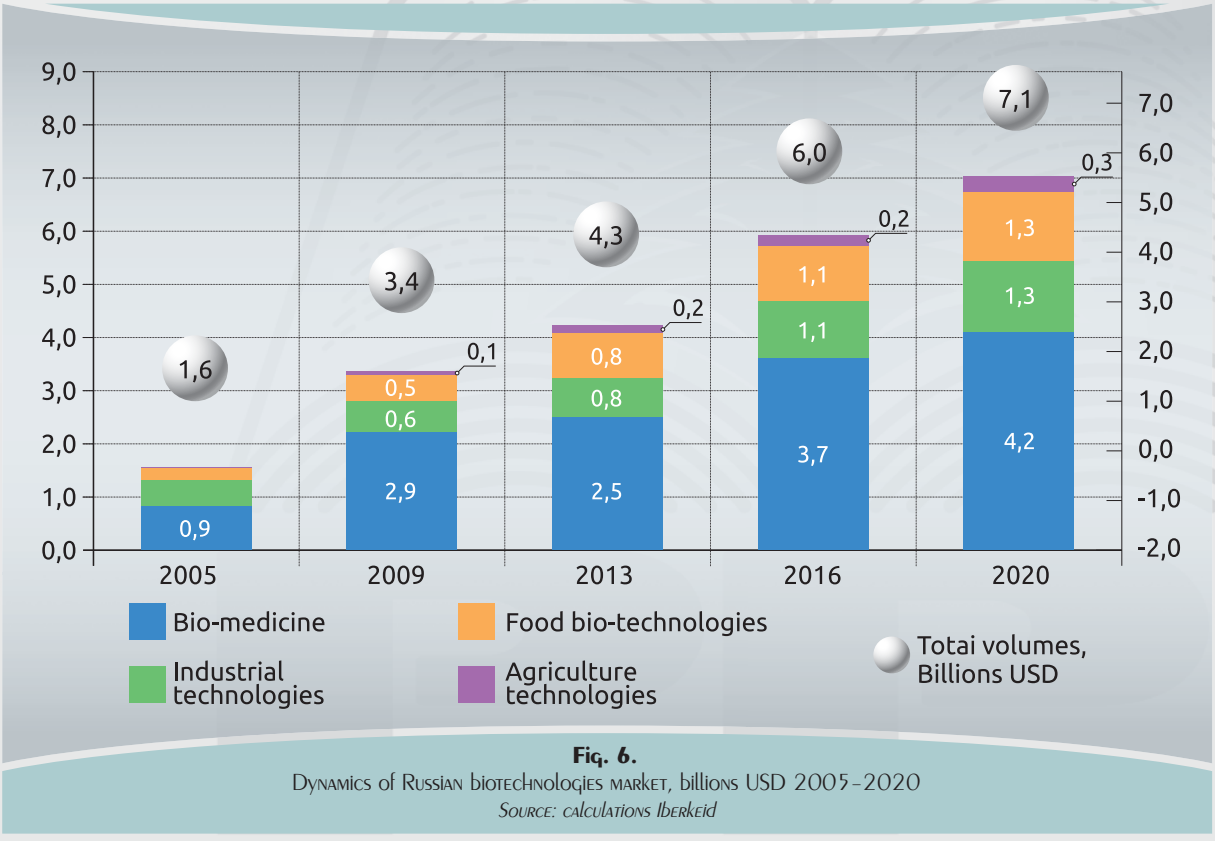

Fig. 6.
Dynamics of Russian biotechnologies market, billions USD 2005–2020
Source: calculations Iberkeid

USD 1947 million, including biotech products and higher added value products: food and feed additives (576 975 million USD, respectively). In the consumption structure 80% are feed additives (50%) and nutrient additives (30%). The share of lesin, methionine, amino acids, enzymes accounts for 20% of the total imports volume (USD 395 million). The increase in the cost of imported biotech products with reduced amounts for some items should be noted.

Analysis of the feasibility of biotechnological products sails at foreign markets from the demand point of view has shown that Russia has the potentials to sale wide range of biotech products and products related with biotechnology.

With regard to nutrition and feed additives, the undisputed leader in the import is Germany with imports 1763 KT, the Netherlands (158 KT) — the leading importers in the segment of amino acids, vitamin E, lactic acid, sterols and Inositols, enzymatic preparations. The import leaders' volume in these segments 3 times exceeds the import volume of Russia. In the energy segment the UK is a net importer with imports of 2944 KT of pellets and bio-diesels, at the dissolving pulp market China holds the leading positions (846 KT).

A leader at biotechnologies market in the CIS is Russia. Ukraine is the leader in the share of biotechnologies in the country's gross domestic product (GDP) — that proves Russia's potential with regard to increasing the share of biotechnologies in the country's GDP. The Russian Federation posesses the richest forest resources. The forest potential of Russia is the largest of all world countries. Timber reserves in Russia make up more than 20% of the world figures. At the current logging of 203 million m3 per year (according to the Federal forestry Agency), forest and industrial wastes volumes are estimated as not less than 30% of timber volumes. This biomass provides a competitive raw material base for the development of industrial biotechnology in the forestry.

For biotechnologies effective development it is important to implement the raft of measures: to create a competences system in the field of biotechnology, to arrange the system of selection and funding of scientific research in the biotechnology sphere (including attracting private capital to the development of biotechnology in the framework of Public Private Partnership = PPP), to develop a system of cooperation between science and business for fast implementation of technologies in finished projects at the market; to reduce costs of industry players for regulation, including taxation; to encourage the development of biotechnology equipment manufacturers; to develop transparent rules for all participants at the biotechnologies market; to protect intellectual property with patents, to establish tax incentives; to encourage the consumption of biotechnology products; to make available the venture capital funding; to lobby for the interests of the timber industry cluster on the political level and at international markets. PPI

For implementation of bio-technological products manufacturing in Russia it is necessary that future products meet and/or exceed the existing analogs and advanced development results abroad.

iNFOLINE

PROFILE

Sergey Faritovich Novikov was born in Tashkent on 11.10.1973. In 1995 he graduated from the Petrozavodsk State University with a degree in «industrial and civil construction». In 1999 he entered the PhD programme of this University in the field of «Technology and management in construction». In 2013 hold the MBA degree.

Since 2000 he has been an specialist in marketing and business development of large plants in Russia dealing in pulp and paper industry and forestry. In 2014 he became the staff member of MAKORUS JSC — deputy general director in marketing and strategy.

For the business proficiency and the ability to achieve goals, solve his tasks he was much accounted of by the company's management and colleagues. All of his projects he carried out with great responsibility and at the highest level. Shortly before his departure from the life Sergey F. began to write the article, publication of which, unfortunately, he did not live to see.

The bright memory of Sergei Novikov will remain forever in our hearts. We mourn and express our deepest condolences to his family and friends!

Team members of MAKORUS JSC