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ON THE NEED TO DEVELOP TECHNOLOGIES FOR PRODUCING BIOPLASTICS IN KAZAKHSTAN

Abstract. This article is published with a purpose to draw attention to the need to initiate in Kazakhstan the development of technologies for producing bioplastics from Kazakhstan’s own renewable plant resources.

Every year, Kazakhstan generates hundreds of thousands of tons of plastic waste based on synthetic polymers traditionally produced from petrochemical raw material. Among them are bottles, packaging and bags. For example, in 2019 alone, plastic waste amounted to over 480 thousand tons. 15 companies, including two plastic processing plants, are not capable to cope with this amount of garbage. More than 18 million plastic bags are discarded in Kazakhstan every day, contaminating the environment.

Since only about 9% of the plastic produced is recycled, the remaining part either contaminates the environment or is damped where the complete decomposition takes up to 500 years, releasing toxic substances into the soil in the mean time.

The production of bioplastics and bioplastics-based products that will decompose in a short time (few months) will reduce the use of synthetic plastic products the decomposition of which is extremely slowly from 100 up to 500 years. Petroleum-based plastic is a real threat as a source of environmental pollution. Kazakhstan is taking measures to reduce environmental pollution. Starting in 2025 it is planned to introduce a complete ban on the realization of petroleum-based food packaging (bags).

It is necessary to develop technologies for producing biodegradable polymers from renewable biological resources to replace petroleum-based plastic, reduce environmental pollution and increase global sustainability.

There is a need for initiation of the research work on bioplastics in Kazakhstan.

Keywords: bioplastics, natural polymers, natural rubber.

Main part. Problem. Hundreds of thousands of tons of plastic waste based on synthetic polymers traditionally made from raw materials based on petroleum products accumulate in Kazakhstan annually.

These are bottles, packaging and bags. For example, in 2019 alone, plastic waste amounted to over 480 thousand tons. 15 companies, including two plastic processing plants, cannot cope with this amount of garbage. Every day in Kazakhstan, more than 18 million plastic bags are thrown, polluting the environment [1].

Since only about 9% of the plastic produced goes into recycling, the rest either pollutes the environment or settles in landfills, where its complete decomposition can take up to 500 years, and toxic substances will be released into the soil.

The main problem with the use of products made of synthetic polymeric materials is their very slow decomposition under natural conditions (from one hundred to 500 years). Oil based plastic is a real threat as a source of environmental pollution. Kazakhstan is taking measures to reduce environmental pollution.

Thus, the Ministry of Ecology, Geology and Natural Resources of Kazakhstan, the National Chamber of Entrepreneurs "Atameken" and the Association of Environmental Organizations of Kazakhstan concluded a memorandum of cooperation on the introduction of paid use of plastic bags. The main goal of the adopted memorandum is to reduce the use of plastic bags and the production of environmentally friendly types of packaging (biodegradable plastics).

It should be noted that the international community is actively working to reduce the output of synthetic plastic products. To date, more than 40 countries at different stages have introduced a ban on the use of plastic bags. For example, in Germany, Denmark, the Czech Republic, and Uzbekistan, free sale of plastic bags in retail trade is banned, and in the USA, China, Italy, Australia, Pakistan, Georgia, Kenya, a complete ban on the use, sale, production and import of plastic bags has been introduced.

Since 2025, Kazakhstan will introduce a complete ban on the sale of oil-based food packaging (bags) [2].

It is necessary to develop technologies for producing biodegradable polymers from renewable biological resources to replace petroleum-based plastic with them, reduce environmental pollution and increase global sustainability.

The main advantage of bioplastics is its ability to decompose in a short period of time (weeks and months), while the decomposition of synthetic plastic requires hundreds of years [3].

In this regard, research is also being initiated in Kazakhstan aimed at developing technologies for obtaining new bioplastics from Kazakhstan's renewable plant resources.

Biodegradable polymers are polymers that retain performance over a period of consumption and then decompose under the influence of environmental factors into water and carbon dioxide, humic substances and biomass. Thus, a natural cycle of substances is carried out, capable of maintaining the ecological balance in nature [4]

Biodegradable polymers have advantages:

- the possibility of processing, as well as petroleum-based polymers, on standard equipment;
- resistance to decomposition under ordinary conditions;
- fast and complete degradability when specially created or natural
conditions - the absence of problems with waste disposal;
- independence from petrochemical raw materials.

Biodegradable plastics are divided into four groups.

The first group is natural polymers isolated from biomass: starch, cellulose, protein, glycogen, inulin, natural rubber.

The advantage of natural polymers is that the resources of the feedstock are constantly renewable.

The second group consists of polymers produced by microorganisms during their life (PHA polyhydroxyalkanoates - derivatives of polyoxybutyric acid). The most promising polymer of this group at present is poly-3-hydroxybutyrate, or polyhydroxybutyrate (PHB). In nature, this polymer is synthesized by certain types of microorganisms and plays the role of an intracellular energy reserve, like glycogen and polyphosphates in other microorganisms. Polymer located in the cytoplasm of microorganism cells in the form of granules and usually accounts for more than 40% of their weight in the dry state [5].

Since PHA is biodegradable and does not harm living tissues, it is often used in medicine as absorbable suture threads, dressings and tampons, plates and rods in orthopedics [6, 7].

The third group includes polymers artificially synthesized from natural monomers, for example, PLA polylactides.

Products made of polylactide (PLA), a transparent thermoplastic that is a product of polycondensation of lactic acid, decompose in compost within one months and a little longer in seawater. An important advantage of a submarine is the possibility of processing it on traditional equipment. Disposable dishes, films, fibers, and implants for medicine are formed from PLA [8].

The main producer of polylactides is the company RURAC (Netherlands).

When you add the appropriate plasticizer, the PLA becomes elastic and can compete in properties with polyethylene (PE), polypropylene (PP) or plasticized polyvinyl chloride. The service life of the polymer increases with a decrease in the size of the monomer unit in its composition, as well as after orientation drawing, causing an increase in the modulus of elasticity and thermal stability of the submarine. By fermenting corn dextrose, the American company Cargill Inc. mastered the production of submarines under the Eco-Pla trademark, sheets of which are comparable in impact resistance to polystyrene (PS). Films have high strength, transparency, gloss, low coefficient of friction and good weldability.

However, the PLA is not without flaws, the main of which is the ability to swelling and dissolution during prolonged contact with water. Moreover, the higher the temperature, the faster these processes occur. Another drawback holding back the widespread adoption of PLA as a polymer domestic and general technical purpose, is its high cost [6].

The fourth group consists of traditional synthetic plastics with biodegradable additives introduced into them.

Currently relevant task is the creation of compositions (mixtures) from synthetic (obtained mainly from oil) and natural (organic and inorganic) materials - BSPM, in which the continuous (matrix) phase is a synthetic polymer.

The first stage of biodegradation is the formation of microcracks and the subsequent destruction of products into fragments. The mechanism of these processes is based on photodegradation of system components under the influence of ultraviolet (UV) radiation with the formation of radicals, which, in turn, activate photooxidative processes in PM [9].

Then the fragments are exposed to microorganisms, enzymes [6].

Synthetic polymers, that is, based on petroleum products, include: polyethylene, phenol-formaldehyde polymers, synthetic fibers, synthetic rubbers [10].

The problem of replacing plastic based on synthetic polymers with bioplastics is an international problem. Thus, according to global market forecasts, in 2020 bioplastics will make up 5% of all plastics produced, and in 2030 - 40% of all plastics produced. Ceresana predicts that by 2020 the global bioplastics market will be $ 5.8 billion [11].

Currently, bioplastics account for approximately 1% of 335 million tons of plastics produced annually.

According to the latest data from the European Bioplastics Institute and the nova-Institute Research Institute (Hürth, Germany), which are leading organizations in the field of biopolymer research, global bioplastics production capacity will increase from approximately 2.11 million tons in 2018. up to approximately 2.62 million tons in 2023 [12].

The disadvantages of biopolymers should also be noted:

- high cost (so far an average of 2-5 euros per 1 kg) ;.
- many of the bioplastics are inferior to conventional plastics in mechanical properties, i.e. they are not strong and tough;
- many of the bioplastics are inferior to petroleum-based plastics in their barrier properties to oxygen, carbon dioxide and water vapor, which can adversely affect a packaged food product.

At the same time, numerous publications indicate an ongoing search for promising developments in the production of biodegradable materials [13].

Thus, research is needed to address the disadvantages of biodegradable polymeric materials.

For example, it is necessary to modify the technology for bioplastics based on the natural polymer of starch. The main sources of starch are crops - potatoes, corn, wheat, barley.

Starch is fully biodegradable, renewable and has a low cost [14].

Starch is an inexpensive and affordable substance that decomposes under various conditions the environment. Its production exceeds current market needs.

USA and Europe. The leading manufacturers of starch-based biopolymers are: the Italian company Novamont, the Dutch company Rodenburg Polymers [15]. Overproduction of potato, a source of starch, was also noted in Kazakhstan [16].

Starch $(C_6H_{10}O_5)_n$ is a mixture of amylose polysaccharides and amylopectin,

monomer of which is alpha glucose. Amylose is a linear polymer, amylopectin is a branched polymer. The content of amylose and amylopectin in starch varies and largely depends on the source of starch [17].

The good compatibility of starch with plasticizers is of great interest for the production of bioplastics.

Plasticizers are substances that are introduced into the composition of polymeric materials to give (or increase) elasticity or plasticity, to improve technological and operational properties.

A review of the literature indicates that the final properties of starch bioplastics can be improved by using various plasticizers, fillers, and also by changing the source of starch [18].

That is, further, new studies of starchy bioplastics compositions are needed.

Composite material is a multicomponent material, consisting, as a rule, of a plastic base (matrix), supplemented with fillers with high strength, rigidity, etc. By varying the composition of the plastic base and filler, their ratio, they get a wide range of materials with the necessary properties.

Promising technologies aimed at the inclusion of latex rubber plants (milk juice with colloidal rubber particles) in the composition of starchy bioplastics to increase its elasticity and strength. Due to its plasticity, elasticity, affordability and low cost, natural rubber is a promising agent for improving various bioplastics.

Similar work was carried out in Thailand and the USA with PHBV (Poly (3-hydroxybutyrate-co-3-hydroxyvalerate), as a result, the plasticity and hardness of this bioplastics were improved [19,20].

Natural rubber is a high molecular weight hydrocarbon (C5H8) n, a cis polymer of isoprene; contained in the latex of the tropical tree of Hevea (Hevea brasiliensis), in the roots of the Kazakhstan Dandelion kok-sagyz (Taraxacum kok-saghyz) and other rubbery plants [21].

The most widespread use of natural rubber is the production of rubber [22].

However, a new application of natural rubber is currently being discovered - the inclusion of natural rubber in bioplastics to improve its performance [20].

Conclusion. Oil-based plastic is a real threat as a source of environmental pollution in Kazakhstan. In this regard, research is also being initiated in Kazakhstan aimed at developing technologies for obtaining new bioplastics from Kazakhstan's renewable plant resources.

It is necessary to develop technologies for producing bioplastics from natural polymers that are biodegradable for several months to replace synthetic plastic with them.

The critical points, alternative ways of implementing the bioplastics problem in Kazakhstan are as follows.

It is necessary to strengthen the strength and elasticity of bioplastics.

Promising solutions. Choose the best composition, such as starch and adequate plasticizers and additives. A promising way to improve the strength and ductility of bioplastics is to include natural rubber in its composition.

It is necessary to reduce the cost of bioplastics, to ensure import substitution. Cheaper bioplastics can be achieved by using cheap ingredients. Use of waste, waste or untreated materials is possible.

It is necessary to narrow the gap between bioplastics research and the market through the collaboration of scientists with commercial enterprises producing and selling bioplastics.

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ҚАЗАҚСТАНДА БИОПЛАСТИКТІ АЛУ ТЕХНОЛОГИЯСЫН ӘЗІРЛЕУ ҚАЖЕТТІЛІГІ ТУРАЛЫ

Аннотация. Ұсынылған аналитикалық шолу Қазақстанға жекеменшік қазақтандық жаңартылатын өсімдік ресурстарынан биопластик алу технологиясын әзірлеуді бастау қажеттілігіне назар аудару мақсатында жарияланды.

Жыл сайын Қазақстанда мұнай өнімдері негізінде шикізаттан дәстүрлі дайындалған синтетикалық полимерлер арқылы жүздеген мың тонна пластик қалдықтар жиналады. Бұл қалдықтар – бөтелке, қаптама және пакеттер. Мысалы, 2019 жылғы пластик қоқысы 480 мың тоннадан асты. 15 компания, оның ішінде пластикті қайта өңдейтін екі зауыт қоқыс мөлшерін игере алмайды. Қазақстанда күн сайын қоршаған ортаны ластайтын 18 миллионнан астам пластикалық пакет шығарылады.

Қайталама өңдеуге өндірілетін пластиктің 9%-ға жуығы ғана келіп түсетіндіктен, қалған бөлігі қоршаған ортаны ластайды немесе қоқыс тастайтын жерде тұрады, онда толық ыдырау үдерісі 500 жылға дейін созылуы мүмкін, бұл ретте топыраққа улы заттар бөлінеді.

Қазақстанда биопластика өндірісін және соның негізінде қысқа мерзімде (айларда) ыдырайтын бұйымдарды өндіру ұйымдары синтетикалық пластиктен жасалған бұйымдарды пайдалануды 100-ден 500 жылға дейін өте баяу ыдырату жағдайын қысқарта алады. Мұнай өнімдерінің негізінде пластик қоршаған ортаны ластаудың көзі ретінде нақты қауіп-қатерлерді келтіреді. Қазақстанда қоршаған ортаны ластану мөлшерін қысқарту жөнінде шаралар қабылдануда. Осылайша 2025 жылдан бастап мұнай негізіндегі тағамдық қаптаманы (пакеттерді) сатуға толық тыйым салу жоспарланып отыр. Жаңартылатын биологиялық ресурстардан биологиялық ыдырайтын полимерлерді мұнай негізіндегі пластиктерді ауыстыру, қоршаған ортаның ластануын азайту және жаһандық тұрақтылықты арттыру үшін айырып алу технологияларын әзірлеу қажет.

Биоалуантүрлілік пластиктер төрт топқа бөлінеді.

Бірінші топ – биомассадан бөлінген табиғи полимерлер: крахмал, целлюлоза, ақуыз, гликоген, инулин, табиғи каучук. Табиғи полимерлердің артықшылығы – бастапқы шикізат ресурстары үнемі жаңарып отырады.

Екінші топ – өмір сүру барысында микроорганизмдер өндіретін полимерлер (полигидроксиалканоаттар PHA – полиоксимай қышқылының туындылары). Қазіргі уақытта осы топтың ең перспективті полимері поли-3-оксибутират немесе полигидроксибутират (ПГБ) болып саналады. Табиғатта бұл полимер микроорганизмдердің кейбір түрлерімен синтезделген және басқа микроорганизмдердегі гликоген мен полифосфат сияқты жасушаішілік энергетикалық резерв рөлін атқарады. Полимер микроағзалар жасушаларының цитоплазмасында түйіршіктер түрінде болады және әдетте құрғақ күйінде олардың салмағының 40%-дан астамын құрайды.

PHA биологиялық ыдырайтын және тірі тіндерге зиян келтірмейтіндіктен оны медицинада жиі соратын тігістік жіптер, таңғыштар мен тампондар, пластиналар мен ортопедиядағы өзек ретінде пайдаланады.

Үшінші топ – табиғи мономерлерден жасанды синтезделген полимерлер, мысалы, PLA полилактидтер.

Полилактидтен (АЖЖ) жасалған бұйымдар – сүт қышқылының поликонденсациясының өнімі – мөлдір термопласт бір ай ішінде компоста және теңіз суында одан біраз ұзағырақ ыдырайды. АЖЖ-ның маңызды артықшылығы оны дәстүрлі жабдықта қайта өңдеу мүмкіндігі болып саналады. ПЛ-дан бірреттік ыдыс, пленка, талшықтар, медицина үшін имплантаттар қалыптасады.

Төртінші топ – дәстүрлі синтетикалық пластиктер, оларға енгізілген биологиялық бұзғыш қоспалар.

Синтетикалық (негізінен мұнайдан алынған) және табиғи материалдардан жасалған қоспалар жасалады, оларда үздіксіз матрицалық фаза синтетикалық полимер болып саналады.

Синтетикалық полимерлерге мыналар жатады: полиэтилен, феноло-формальдегидті полимерлер, синтетикалық талшықтар, синтетикалық каучуктар.

Қазақстанда биопластиканың ғылыми-зерттеу жұмыстарына бастамашылық жасау қажет.

Түйін сөздер: биопластик, табиғи полимерлер, табиғи каучук.

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О НЕОБХОДИМОСТИ РАЗРАБОТОК ТЕХНОЛОГИЙ ПОЛУЧЕНИЯ БИОПЛАСТИКА В КАЗАХСТАНЕ

Аннотация. Настоящий аналитический обзор публикуется с целью обратить внимание на необходимость инициации в Казахстане разработок технологий получения биопластика из собственных, казахстанских возобновляемых растительных ресурсов.

Ежегодно в Казахстане скапливаются сотни тысяч тонн пластиковых отходов на основе синтетических полимеров, традиционно изготовленных из сырья на основе нефтепродуктов. Это бутылки, упаковки и пакеты. К примеру, только в 2019 году мусор пластика составил свыше 480 тысяч тонн. 15 компаний, в том числе два завода по переработке пластика не справляются с этим количеством мусора. Каждый день в Казахстане выбрасывается более 18 млн пластиковых пакетов, загрязняя окружающую среду.

Поскольку во вторичную переработку поступает лишь около 9% производимого пластика, остальная часть либо загрязняет окружающую среду, либо оседает на свалках, где его полное разложение может занять до 500 лет, при этом в почву будут выделяться токсичные вещества.

Организация в Казахстане производства биопластика и на его основе изделий, разлагаемых в короткий срок (месяцы), обеспечит сокращение использования изделий из синтетического пластика, разлагаемых крайне медленно от 100 до 500 лет. Пластик на основе нефтепродуктов составляет реальную угрозу как источник загрязнения окружающей среды. В Казахстане принимаются меры по сокращению загрязнений окружающей среды. Так, планируется с 2025 года ввести полный запрет на реализацию пищевой упаковки (пакетов) на основе нефти. Необходима разработка технологий получения биоразлагаемых полимеров из возобновляемых биологических ресурсов для замены ими пластика на нефтяной основе, уменьшения загрязнения окружающей среды и повышения глобальной устойчивости.

Биоразлагаемые пластики делятся на четыре группы.

Первая группа – это природные полимеры, выделенные из биомассы: крахмал, целлюлоза, белок, гликоген, инулин, натуральный каучук. Преимущество природных полимеров в том, что ресурсы исходного сырья постоянно возобновляемы.

Вторая группа – полимеры, производимые микроорганизмами в ходе своей жизнедеятельности (полигидроксиалканоаты PHA - производные полиоксимасляной кислоты). Наиболее перспективным в настоящее время полимером этой группы является поли-3-оксибутират, или полигидроксибутират (ПГБ). В природе этот полимер синтезируется некоторыми видами микроорганизмов и играет роль внутриклеточного энергетического резерва, подобно гликогену и полифосфатам в других микроорганизмах. Полимер находится в цитоплазме клеток микроорганизмов в виде гранул и обычно составляет более 40 % от их веса в сухом состоянии.

Поскольку PHA – биоразлагаемый и не вредит живым тканям, его часто используют в медицине в качестве рассасывающихся шовных нитей, повязок и тампонов, пластин и стержней в ортопедии.

Третья группа – полимеры, искусственно синтезированные из природных мономеров, например, PLA полилактиды.

Изделия из полилактида (ПЛА) – прозрачного термопласта, который является продуктом поликонденсации молочной кислоты, разлагаются в компосте в течение одного

месяца и немногим дольше в морской воде. Важным достоинством ПЛА является возможность его переработки на традиционном оборудовании. Из ПЛА формуют одноразовую посуду, пленки, волокна, имплантаты для медицины.

Четвертая группа – традиционные синтетические пластики с введенными в них биоразрушающими добавками.

Создаются смеси из синтетических (полученных главным образом из нефти) и природных материалов, в которых непрерывной, матричной фазой является синтетический полимер.

К синтетическим полимерам относятся: полиэтилен, феноло-формальдегидные полимеры, синтетические волокна, синтетические каучуки.

Необходима инициация научно-исследовательских работ биопластика в Казахстане.

Ключевые слова: биопластик, природные полимеры, натуральный каучук.

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