CELLULOSE-BASED COMPOSITE MATERIALS

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Annotation. Cellulose, the primary polymer of plants, is of great importance as an environmentally friendly material obtained from natural resources. Cellulose-based composite materials are generally composed of cellulose substances mixed with other natural or synthetic polymers and additives, possessing high mechanical, thermal, and chemical properties. These materials stand out due to their environmental protection, recyclability, and low cost. Cellulose-based composites are widely used in industries such as construction, automotive, packaging, and electronics. This paper discusses the preparation technologies of cellulose-based composite materials, their composition, properties, and potential applications. In the production of composites, cellulose nanofibrils (CNF), microfibrils (MFC), and other natural particles are combined with various polymers, enhancing the strength and rigidity of the materials. Additionally, the ecological and economic aspects of cellulose-based composites, their environmental impact, and recyclability are analyzed. The paper discusses the new possibilities of cellulose-based materials in the industry and their future development. The ecological purity of these materials and their application in various industrial sectors make them important and competitive materials in the future.

Keywords. Cellulose, composite materials, natural polymers, mechanical fibrillation, nanofibrillation, chemical modification, thermomechanical processing, extrusion, solvent dissolution, nanocomposite materials, biocomposites, packaging materials, biodegradation, natural resources, biopolymers, automotive industry.

Аннотация. Целлюлоза, основной полимер растений, имеет большое значение как экологически чистый материал, получаемый из природных

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ресурсов. Композиционные материалы на основе целлюлозы, как правило, состоят из целлюлозных веществ, смешанных с другими природными или синтетическими полимерами и добавками, обладающими высокими механическими, термическими и химическими свойствами. Эти материалы отличаются защитой окружающей среды, возможностью вторичной переработки и низкой стоимостью. Композиты на основе целлюлозы широко используются в таких отраслях, как строительство, автомобилестроение, упаковка и электроника. В данной статье рассматриваются технологии получения композиционных материалов на основе целлюлозы, их состав, свойства и потенциальные области применения. При производстве композитов нановолокна целлюлозы (CNF), микрофибриллы (MFC) и другие природные частицы сочетаются с различными полимерами, повышая прочность и жесткость материалов. Кроме того, анализируются экологические и экономические аспекты композитов на основе целлюлозы, их воздействие на окружающую среду и возможность вторичной переработки. В статье рассматриваются новые возможности использования материалов на основе целлюлозы в промышленности и перспективы их развития. Экологическая чистота этих материалов и их применение в различных отраслях промышленности делают их важными и конкурентоспособными материалами будущего.

Ключевые слова. Целлюлоза, композиционные материалы, природные полимеры, механическая фибрилляция, нанофибрилляция, химическая модификация, термомеханическая обработка, экструзия, растворение растворителями, нанокомпозитные материалы, биокомпозиты, упаковочные материалы, биодеградация, природные ресурсы, биополимеры, автомобильная промышленность.

Annotatsiya. O'simliklarning birlamchi polimeri bo'lgan tsellyuloza tabiiy resurslardan olingan ekologik toza material sifatida katta ahamiyatga ega. Tsellyuloza asosidagi kompozit materiallar odatda boshqa tabiiy yoki sintetik polimerlar va qo'shimchalar bilan aralashtirilgan tsellyuloza moddalaridan iborat bo'lib, yuqori mexanik, termal va kimyoviy xususiyatlarga ega. Ushbu materiallar atrof-muhitni muhofaza qilish, qayta ishlash va arzonligi tufayli ajralib turadi. Tsellyuloza asosidagi kompozitlar qurilish, avtomobilsozlik, qadoqlash va elektronika kabi sohalarda keng qo'llaniladi. Ushbu hujjatda tsellyuloza asosidagi kompozit materiallarni tayyorlash texnologiyalari, ularning tarkibi, xususiyatlari va potentsial qo'llanilishi muhokama qilinadi. Kompozitlarni ishlab chiqarishda tsellyuloza nanofibrillari (CNF), mikrofibrillar (MFC) va boshqa tabiiy zarralar turli polimerlar bilan birlashtirilib, materiallarning mustahkamligi va qattiqligini

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oshiradi. Bundan tashqari, tsellyuloza asosidagi kompozitlarning ekologik va iqtisodiy jihatlari, ularning atrof-muhitga ta'siri va qayta ishlanishi tahlil qilinadi. Maqolada tsellyuloza asosidagi materiallarning sanoatdagi yangi imkoniyatlari va ularning kelajakdagi rivojlanishi muhokama qilinadi. Ushbu materiallarning ekologik tozaligi va ularning turli sanoat tarmoqlarida qo'llanilishi ularni kelajakda muhim va raqobatbardosh materiallarga aylantiradi.

Kalit so'zlar. Tsellyuloza, kompozit materiallar, tabiiy polimerlar, mexanik fibrilatsiya, nanofibrilatsiya, kimyoviy modifikatsiya, termomekanik ishlov berish, ekstruziya, erituvchini eritish, nanokompozit materiallar, biokompozitlar, qadoqlash materiallari, biodegradatsiya, tabiiy resurslar, biopolimerlar, avtomobilsozlik.

Introduction

Cellulose, as a natural polymer, is the main structural component of plants and stands out due to its ecological purity, recyclability, and biocompatibility. This natural substance is widely used in various industrial sectors, especially in the production of composite materials. Cellulose-based composite materials, derived from natural resources, possess high mechanical, thermal, and chemical properties, and are increasingly used as environmentally and economically effective materials.

Composite materials are a combination of two or more different materials, each contributing its own properties to complement the others, resulting in enhanced overall properties of the new material. Cellulose-based composites are enriched with high-quality materials such as cellulose nanofibrils (CNF) or microfibrils (MFC), and combined with synthetic or other natural polymers. These materials have lightweight, high strength, and good insulation properties, and are developing as new-generation materials widely used in industry, while also being environmentally friendly.

In recent years, there has been an increasing demand for materials that are non-polluting and recyclable. As a result, the production technologies and applications of cellulose-based composite materials have gained more importance. This article focuses on the processes of manufacturing cellulose-based composite materials, their properties, industrial applications, and ecological advantages. It also provides analyses of the future development prospects of cellulose-based materials and the growing demand for them.

In our country, the source of fiber-based natural polymers for cellulose and paper production is very large. The main stage in the process of obtaining cellulose from plant stalks is the cooking of the stalks. During this process, non-cellulose substances are separated from the stalks. The cooking technology for all types of plant stalks is similar, with the main difference being in the cooking parameters

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and the amount of chemicals used. It is worth noting that both foreign and domestic scientists have conducted research on obtaining cellulose from annual plants. Most of them have studied cellulose extraction from cotton stalks, red clover, and millet husks, as well as their physical-mechanical and chemical properties. For our experiment, we selected flax, safflower (thistle), cotton stalks, and wheat straw. In the process of extracting the cellulose portion from these plant stalks, we initially studied the cooking process. For this, we chose the most commonly used and harmless method today. By researching the alkali method of obtaining cellulose from annual plants, we studied the effect of alkali concentration on various quality indicators of the synthesized cellulose [2-3].

Results and Discussion. Local annual plants were cooked with an alkali concentration ranging from 10 g/L to 30 g/L, at temperatures from 25°C to 150°C, for 30-90 minutes. The quality indicator of the obtained cellulose was studied. The analysis of the results showed that both an increase and a decrease in alkali concentration had a negative effect on cellulose yield. Cooking the stalks with a low concentration of alkali makes cellulose production more difficult, resulting in an increase in the amount of semi-celluloses. These results are presented and analyzed in the following (1 figure).

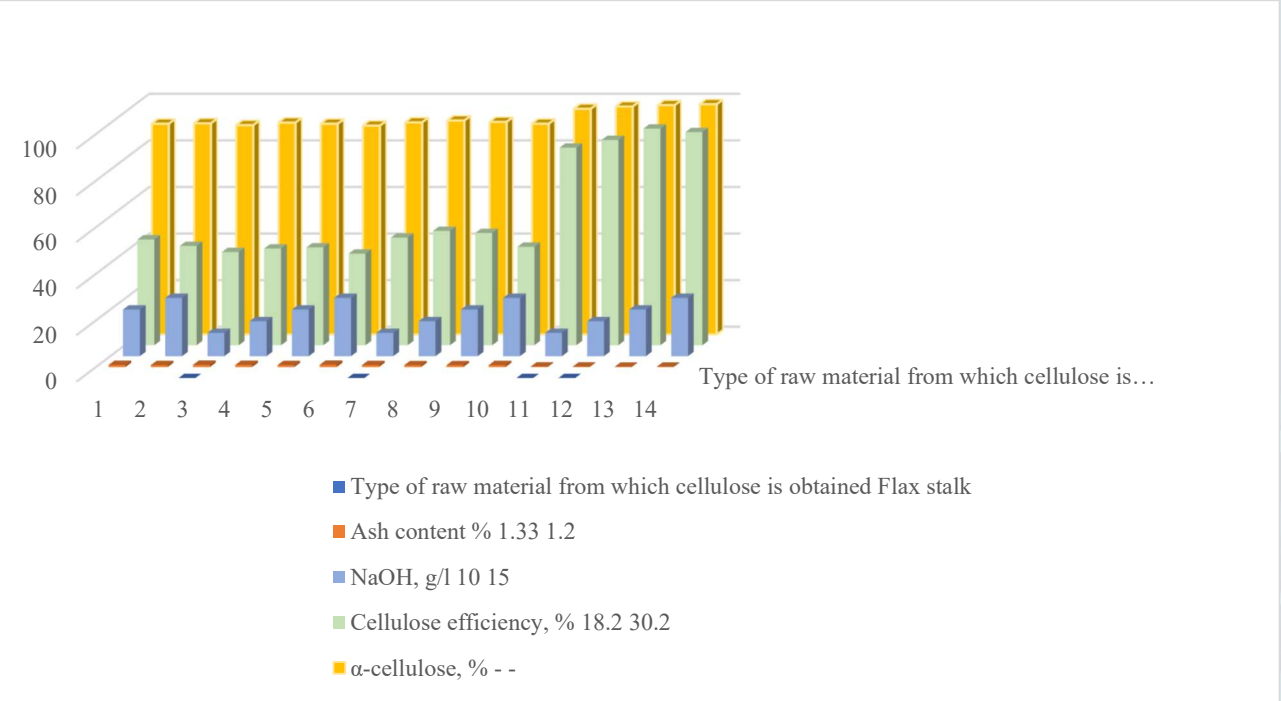


Figure 1. The effect of alkali concentration on cellulose extraction from natural polymers and its quality indicators

On the contrary, an increase in alkali concentration leads to the destruction of the resulting cellulose. The selection of bleaching agent concentrations plays a crucial role in the yield and quality of cellulose. Therefore, we studied the effect of

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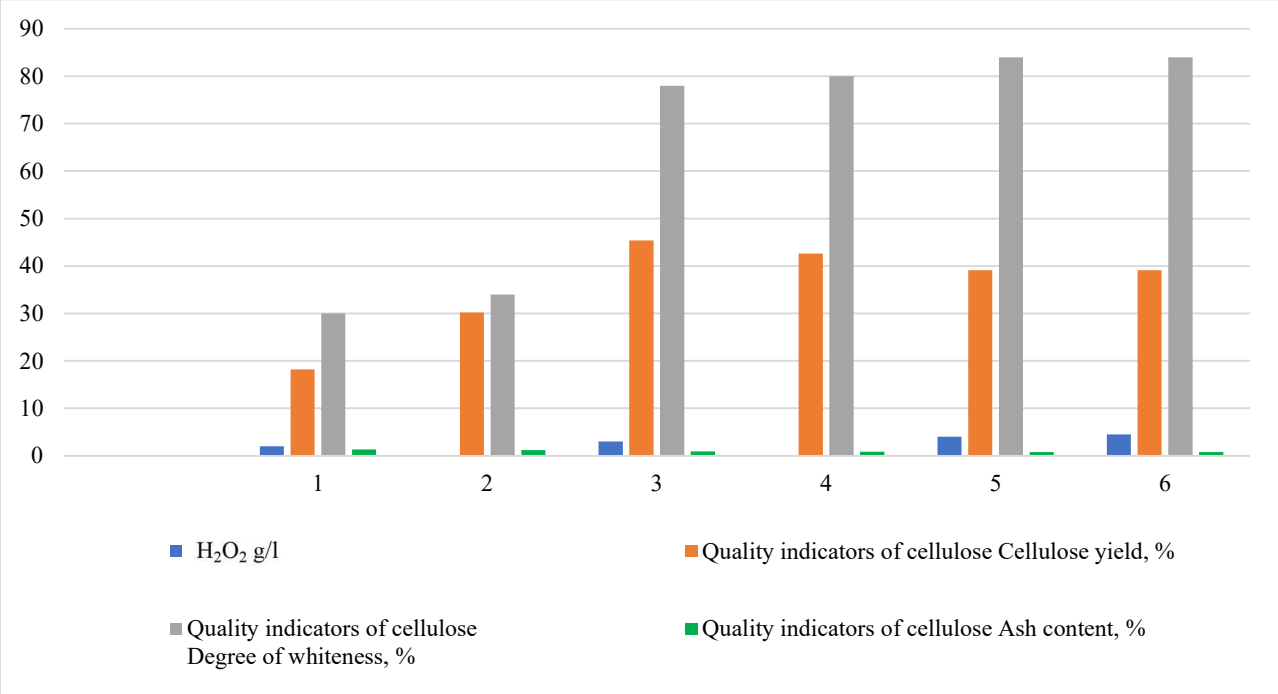
H_2O_2 concentration on the quality indicators of cellulose obtained from flax stalks during the bleaching process.

Table 1

The effect of H_2O_2 concentration on the quality indicators during the bleaching process of cellulose obtained from flax stalks

№	H_2O_2 g/l	Quality indicators of cellulose				
		Cellulose yield, %	Polymerization degree (PD)	α - cellulose, %	Degree of whiteness, %	Ash content, %
1	2.0	18.2	-	-	30	1.33
2	2,5	30.2	-	-	34	1.20
3	3.0	45.4	820	90.4	78	0.89
4	3,5	42.6	740	90.6	80	0.82
5	4.0	39.1	700	91.4	84	0.78
6	4.5	39.1	690	91.3	84	0.76

The analysis of the results of the research conducted by us shows that as the concentration of the bleaching reagent increases, the whiteness degree of the cellulose and the amount of its α-cellulose increase positively, while the ash content in its composition significantly decreases (table 1). Conversely, the degree of polymerization of the cellulose decreases, meaning it moves in the negative direction.



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Figure 2. The effect of the bleaching process on the quality characteristics of cellulose.

In addition, in this section, paper products were obtained from the composition of annual plants, and the physical-mechanical properties of the obtained paper, such as breaking length, breaking strength, and the number of breaks in both directions, were studied, and their analysis is presented (table 2).

Table 2

Physical-mechanical properties of paper obtained from the composition of annual plant cellulose

№	Composition of the mixtures	Composition ratio of the mixtures, %	Mass per 1 m², g	Breaking length, m	Tensile strength, N	Number of folds in both directions
1	Wheat straw cellulose	100	110	2050	26,5	8
2	Wheat straw cellulose and flax stalk cellulosic fibers	80:20	110	2193	27,0	15
3	Wheat straw cellulose and flax stalk cellulosic fibers	60:40	110	2895	35,5	39
4	Wheat straw cellulose and flax stalk cellulose	40:60	110	2850	36,8	48
5	Wheat straw cellulose and flax stalk cellulose	20:80	110	2880	38,8	50
6	Flax stalk cellulose	100	110	2690	33,4	55

In determining the quality indicators of paper products, the elongation length, tensile strength, and the number of folds in both directions are considered important [17-19].

ISSN 3030-3907

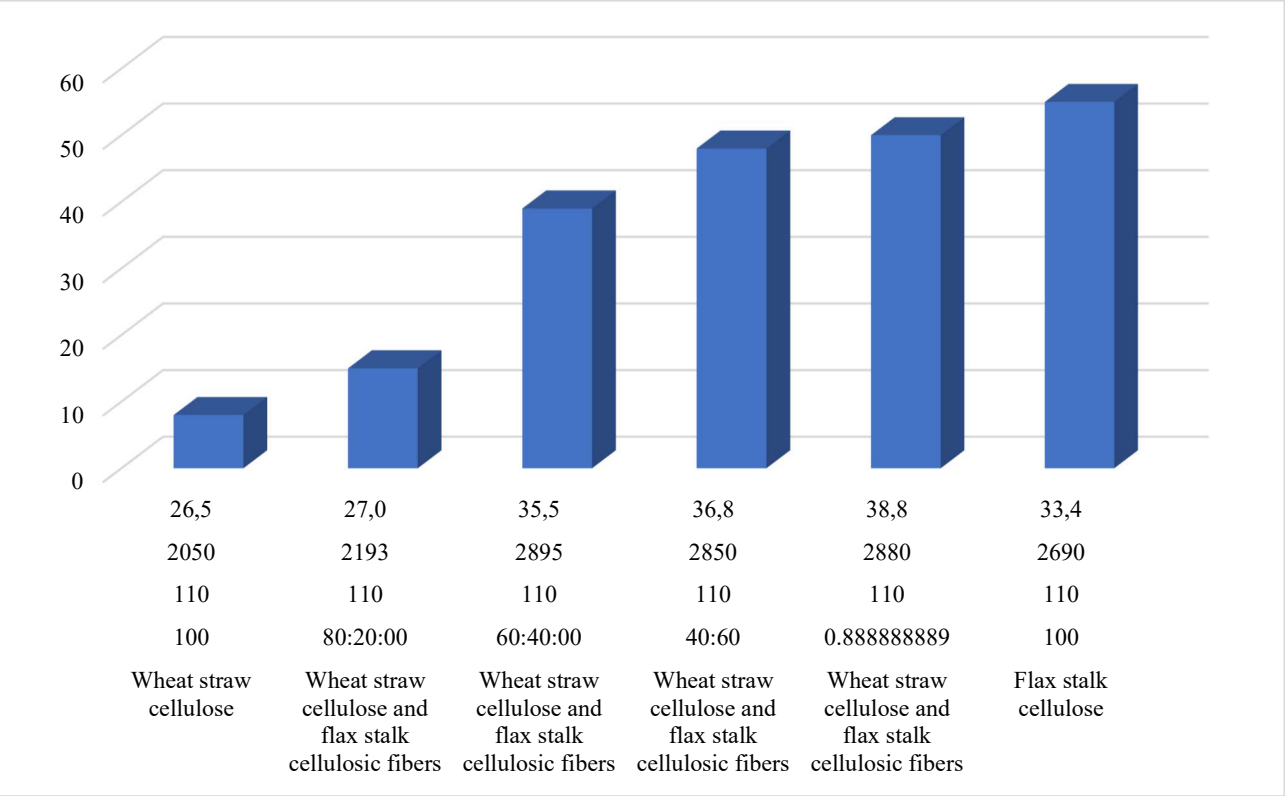


Figure 3. Physical-mechanical properties of cellulose-based composite paper

Analysis of Results (table 2) shows that the paper sample obtained from flax-straw cellulose (60:40) demonstrates higher performance indicators compared to other compositions. Taking into account properties such as strength, fiber length, and reaction capacity, flax cellulose was chosen for further research in comparison to other plant-based celluloses.

Conclusion: Cellulose-based composite materials stand out due to their ecological purity, recyclability, and superior mechanical properties. These materials are produced using natural polymers, which allows them to be recycled and undergo biodegradation processes without harming the environment, making these characteristics some of their main advantages. The various methods of producing cellulose-based composites, such as mechanical fibrillation, chemical modification, and the preparation of nanocomposites and biocomposites, enable the improvement of the mechanical, thermal, and chemical properties of the materials. By using these methods, high-quality and durable materials are produced, which increases their service life and efficiency. Cellulose-based composites, with their lightweight, high strength, and environmental cleanliness, can be widely applied in construction, automotive, packaging, electronics, and other industries. As next-generation materials, they are expected to play a significant role in various industrial sectors. The use of innovations in the manufacturing processes and technologies of such materials will lead to them becoming more efficient and competitive. In the future, the industrial application

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of cellulose-based composite materials may increase, making them economically viable and environmentally friendly. Therefore, further development and optimization of the production technologies for these types of materials will help meet the demand for environmentally and economically sustainable materials.

REFERENCES

1. Новицкий А.Г.Химическая стойкость базальтовых волокон для армирования бетонов.// Хімічна промисловість України. 2003. № 3, с. 16-19.
2. Новицкий А. Г., Ефремов М. В. Волокно из горнов пород для армирования бетонов (Доклады VII Всероссийской научно-практической конференции (г. Белокуриха). М.: ЦЭИ «Химмаш», 2007. — С. 116—120.
3. Bajpai, P. Brief description of the pulp and paper making process.in. Bajpai, P. (Ed.). *Biotechnology for pulp and paper processing*. London: Springer. (2012). pp. 7 – 14.
4. Heinemann, S. (2006). Chemical Pulp.in. Holik, H. (Ed). *Handbook of Paper and* Board. Germany: Wiley-VCH. pp. 21-23.
5. González-García, S., Moreira, M.T., Maldonado, L. and Feijoo, G. (2010). Environmental impact assessment of non-wood based pulp production by soda-anthraquinone pulping process. *Journal of Cleaner Production*, 18(2), 137 - 145.
6. Sridach, W. (2010b). The environmentally benign pulping process of non-wood fibers. *Suranaree Journal of Science and Technology*, 17 (2), 105 - 123.
7. Shakhes, J., Marandi, M.A.B., Zeinaly, F., Saraian, A. and Saghafi, T. (2011a). Tobacco residuals as promising lignocellulosic materials for pulp and paper industry. *Bioresources*, 6(4), 4481 - 4493.
8. Jiménez, L, Pérez, I., García, J.C., Rodríquez, A. and Ferrer, J.L. Influence of ethanol pulping of wheat straw on the resulting paper sheets. *Process Biochemistry*, (2002a). 37(6), 665 - 672.
9. Экологически чистая технология получения целлюлозы из однолетных растений. Lele istvan, Hernadi Alex, Fejes Ferenc. Celul si hart. 2001.50. №2, с. 20.
10. http://www.findpatent.ru/patent/130/1305230.html
11. Ms. Hireni Mankodi Sr. Lecturer; New reinforced material for textile composite - basalt fiber; www.fibre2fashion.com, p93-95. dt 12/10/2010
12. D Saravanan; Spinning the Rocks - Basalt Fibres; Journal of the Institution of Engineers (India): Textile Engineering Division, Feb 2006, Vol. 86, p 39-45.
13. Deak, T.and Czigany, T. “Chemical composition and mechanical properties of basalt and glass fibers: 2009 comparison”, Text Res J; 79: p 645–651.
14. Cerný, M., Glogar, P., Golias, V., Hruska, J., Jakes, P. and Sucharda, Z. “Comparison of mechanical properties and structural changes of continuous basalt

ISSN 3030-3907

and glass fibres at elevated temperatures". Ceram Silik, 2007, 51(2): p 82-88.
15. Shan, Y. and Liao, K."Environmental fatigue of unidirectional glass-carbon fiber reinforced hybrid composite". Composites Part B, 2001, 32(4): p 355–363.
16. Э.А.Эгамбердиев, Г.Ю.Акмалова, М.К. Абдумавлянова, И.И.Сулаймонов // Фильтр материаллар тайёрлашда маҳаллий хом ашёлардан фойдаланиш «Целлюлоза ва унинг ҳосилаларини кимёси ва технологиясини долзарб муаммолари» Республика илмий-техникавий конференция 2018 й, 288-289 б.
17. Примқулов М., Раҳмонбердиев Ғ., Эгамбердиев Э. Целлюлоза ва қоғоз технологиясидан масалалар. "Фан ва технология" Т.:2010. 140 бет.
18. Э.А.Эгамбердиев, Ғ.Р.Раҳмонбердиев, Г.Ю.Акмалова, Ш.А.Рашидов. Маҳаллий хом ашёлардан олинган ўрам қоғоз намуналарининг сифат кўрсаткичларини ўрганиш ва таққослаш // Композицион материаллар 2019 й. №1, б. 98-100.
21. Э.А.Эгамбердиев, Ғ.Р.Раҳмонбердиев, Г.Ю.Акмалова, С.Ш. Арслонов Зиғир целлюлозаси ва базальт толасидан олинган қоғознинг сифат кўрсатгичлари (букилишга қаршилиги ҳамда узулиш узунлиги)ни ўрганиш //«Целлюлоза ва унинг ҳосилаларини кимёси ва технологиясини долзарб муаммолари» Республика илмий-техникавий конференция 2018 й. б. 232-233
22. Э.А.Эгамбердиев, У.Д.Муҳитдинов, А.А.Ғофуров, Ғ.Р.Раҳмонбердиев Бир йиллик ўсимликлар целлюлозаси ва базальт тола асосида олинган композицион қоғоз намуналарининг сорбцияланишини ўрганиш // Фарғона политехника институти илмий-техника журнали 2018 й. №3, б. 111-114.
23. Э.А.Эгамбердиев, И.И.Сулаймонов, Ғ.Р.Раҳмонбердиев Органик ва ноорганик толалар асосида олинган композитлар таркибига бирикмаларнинг киритилиши таъсирини ўрганиш // «Техник ва ижтимоий-иқтисодий фанлар соҳаларининг муҳим масалалари» Республика Олий ўқув юртлараро илмий ишлар тўплами. Тошкент, 2018 й, б. 178-179
24. E.A. Egamberdiev, M.K. Abdumavlyanova, G.R. RakhmonberdievNew composition materialfor wine filtration // Technical science and innovation2020 й. №1, p. 55-61.
25. Э.А.Эгамбердиев, Ғ.Р.Раҳмонбердиев, А.Ҳ.Мардонов, С.Р.Удикбаева Базальт тола асосида иссиқбардош материал олиш // «Техник ва ижтимоий-иқтисодий фанлар соҳаларининг муҳим масалалари» Республика Олий ўқув юртлараро илмий ишлар тўплами. Тошкент, 2018 й, б. 184-185
26. Э.А.Эгамбердиев, И.И.Сулаймонов, М.К.Абдумавлянова, Ғ.Р.Раҳмонбердиев Композицион қоғоз хусусиятларига pH ни, бор ва гидроксохлорид сифати таъсирини ўрганиш // «Техник ва ижтимоий-

ISSN 3030-3907

иқтисодий фанлар соҳаларининг муҳим масалалари» Республика Олий ўқув юртлараро илмий ишлар тўплами. Тошкент, 2018 й, б. 182-183

27. Э.А.Эгамбердиев, Ғ.Р.Раҳмонбердиев, А.Ҳ.Мардонов, А.Б.Жўраев, Ш.Х.Собиржонов Маҳаллий хом ашёлардан олинган композицион қоғозларнинг мустаҳкамлигига флокулянтларнинг таъсирини ўрганиш // Композицион материаллар 2018 й. №1, б. 71-73.

28. Э.А.Эгамбердиев, Ғ.Р.Раҳмонбердиев, Г.Ю.Акмалова, С.Ш.Арслонов Маҳаллий хом ашёлардан олинган қоғознинг сифат кўрсатгичларини ўрганиш // «Целлюлоза ва унинг ҳосилаларини кимёси ва технологиясини долзарб муаммолари» Республика илмий-техникавий конференция 2018 й, б. 234-235

29. E.A.Egamberdiev, I.I.Sulaymonov, G.R.Rakhmanberdiev Aplication of waste in the composition of materials based on mineral fibers // «Техник ва ижтимоий-иқтисодий фанлар соҳаларининг муҳим масалалари» Республика Олий ўқув юртлараро илмий ишлар тўплами. Тошкент, 2018 й, б. 180-181

30. E.A.Egamberdiev, G.R.Rakhmanberdiev, A.X.Mardonov Study of the sorption rate of composition paper samples obtained on the bases of cellulose-bearing plants cellulose and basalt fiber // Austrian journal of Technical and Natural Sciences. 2018 y. №1-2, p.56-62.

31. E.Egamberdiev, Sh.Shoabdullaev, D.Saidov Paper production based on secondary row materials // XVI XVI International Scientific and Practical Conference «Effective tools of modern science» Prague, 2020 y, p. 21-24.

ISSN 3030-3907