Project name, IRN	BR18574094 - Development of scientific and technological fundamentals for the creation of epoxy nanocomposites with improved properties.
Completion date	01.10.2022-31.12.2024
Project supervisor	Bekeshev Amirbek Zarlykovich, Associate Professor
Report	The goal of the program is the development of scientific and technological fundamentals for the creation of epoxy nanocomposites with improved physicochemical (heat resistance, thermal stability, reduced combustibility) and mechanical properties. The polymer matrix used is epoxy resin ED-20, plasticized with tris(2-chloroethyl)phosphate/tris(2-chloropropyl)phosphate, containing flame retardants (phosphorus, chlorine). **Main tasks:** Functionalization of nanofillers (aluminum nitride, tungsten disulfide, nanodiamonds) with glycine to improve distribution in the matrix and increase specific surface area. Optimization of the nanofiller content (0.01–0.5%) to achieve maximum strengthening effect. Study of the processes of structure formation, mechanisms of interaction between matrix components and fillers, and enhancement of interphase bonding. Investigation of the mechanical (tensile strength, bending, compression) and thermal properties of the composites. **Expected results:** Development of a new class of nanocomposites with improved characteristics (mechanical, flame retardant, thermal). Creation of functionalization methods and prediction of nanocomposite characteristics. Reduction of polymer filler content while maintaining operational properties. Ensuring industrial applicability of the composites in energy, shipbuilding, construction, and aviation.
Purpose	**Project Goal:** Development of scientific and technological fundamentals for the modification of epoxy nanocomposites with improved physicochemical (heat resistance, thermal stability, and reduced combustibility) and mechanical properties.
Expected results	The program will thoroughly investigate issues related to the impact of nanomodifiers on the processes of structure formation, the structure, and operational characteristics of polymer composites, as well as the mechanisms for improving the properties of composite materials. A significant increase in the strength of epoxy resin-based composite materials will be achieved through the introduction of small additions (from 0.01% to 0.5%) of nanofillers in combination with chemical modification. The mechanisms of bond formation (chemical and/or physical) between the polymer matrix and the fillers (aluminum nitride, tungsten disulfide, nanodiamonds) will be studied, and the presence of chemical interactions between the functional groups of glycine, epoxy oligomer, and nanofillers will be established. The effectiveness of functionalizing nanodisperse fillers will be demonstrated, ensuring the reduction of their aggregation, polydispersity, and uniform distribution in the polymer matrix, as well as an increase in specific surface area. This, along with the involvement of amino groups of glycine in the structure formation during the curing process of the epoxy oligomer, will lead to a significant improvement in the physicochemical and mechanical properties of epoxy composites. The influence of the type of additive and the percentage ratio of reinforcing additives on the tensile strength, bending, compression, Young's modulus, thermal conductivity, and heat and thermal resistance of the composites will be investigated. The effect of nanofillers on the processes of structure formation and the structure of epoxy composites will be established, allowing for targeted regulation of the duration of gel formation and curing processes. As part of this program, new polymer composite materials with improved properties (physicochemical and mechanical) will be developed using

	functionalized (with glycine) nanomaterials (aluminum nitride, tungsten disulfide, nanodiamonds) as reinforcing materials, with epoxy resin ED-20, plasticized with tris(2-chloroethyl)phosphate/tris(2-chloropropyl)phosphate, used as the polymer matrix. The conducted research will expand the understanding of the structure and properties of nanomaterials, as well as the mechanisms of their functionalization.
Research group	Supervisor – Main researcher: Bekeshev Amirbek Zarlykovich, Associate Professor, Hirsch index h=7 (Researcher ID AAO-5844-2020, ORCID ID 0000-0002-7038-4631, Author ID in Scopus6602335201). Mostovoy Anton Stanislavovich, PhD in Technical Sciences, Associate Professor, Hirsch index h=11, (Researcher ID M-7053-2016, ORCID ID 0000-0003-2828-9988, Author ID in Scopus 55998338500). Tastanova Lyazzat Knashevna, PhD in Chemical Sciences, Associate Professor, Hirsch index h=4, (Researcher ID N-8858-2018, ORCID ID 0000-0002-9236-5909, Author ID in Scopus 57202578243). Aymaganbetova Zukhra Kuranievna – PhD, Hirsch index h=6, (Author ID Scopus – 56305678700) Kadykova Yulia Aleksandrovna, Doctor of Technical Sciences, Associate Professor, Hirsch index h=6, (Author ID in Scopus 6505871211) Zhanturina Nurgul Nigmetovna, PhD, Associate Professor, Hirsch index h=6, Researcher ID O-9724-2017, ORCID ID 0000-0001-9540-6334, Author ID in Scopus 55588115900. Orinbasar Raigul Orinbasarkyzy, PhD in Chemical Sciences, Associate Professor, Hirsch index h=1, ORCID ID 0000-0002-6198-3018, Author ID in Scopus 57218950994. Akhmetova Marzhan Kushkinbaevna, Hirsch index h=1, Researcher ID AAR-1671-2020, ORCID ID 0000-0001-6485-8063, Author ID in Scopus57217105534.
Publications in scientific publications	1. Bekeshev Amirbek, Ekaterina Vasinkina , Svetlana Kalganova , Yulia Kadykova , Anton Mostovoy , Andrey Shcherbakov , Marina Lopukhova and Zukhra Aimaganbetova Microwave Modification of an Epoxy Basalt-Filled Oligomer to Improve the Functional Properties of a Composite Based on It. *Polymers*. – 2023. – 15(9). - 2024. DOI 10.3390/polym15092024, Q1; IF = 6,6. 2. Bekeshev A., Mostovoy, A., Shcherbakov A., Zhumabekova A., Serikbayeva G., Vikulova M., Svitkina V. Effect of Phosphorus and Chlorine Containing Plasticizers on the Physicochemical and Mechanical Properties of Epoxy Composites. Journal of Composites Science. – 2023. – 7(5). - 178. DOI 10.3390/jcs7050178, Q2; IF = 3,3. 3. Bekeshev Amirbek, Ekaterina Vasinkina, Svetlana Kalganova, Sergey Trigorly, Yulia Kadykova, Anton Mostovoy, Andrey Shcherbakov, Marina Lopukhova and Nurgul Zhanturina Modeling of the Modification Process of an Epoxy Basalt-Filled Oligomer in Traveling Wave Microwave Chambers. Journal of Composites Science. – 2023. – 7, 392. https://doi.org/10.3390/jcs7090392, Q2 4. Bekeshev A.,Mostovoy A., Shcherbakov, A., Tastanova L., Akhmetova M., Apendina A., Orynbassar R., Lopukhova M.The Influence of Pristine and Aminoacetic Acid-Treated Aluminum Nitride on the Structure, Curing Processes, and Properties of Epoxy Nanocomposites. Journal of Composites Science, 2023, 7, 482. https://doi.org/ 10.3390/jcs7120482 5. Bekeshev , Andrey Shcherbakov , Lyazzat Tastanova , Marzhan Akhmetova , Ainagul Apendina and Marina Lopukhova. Investigating the Structure and Properties of Epoxy Nanocomposites Containing Nanodiamonds Modified with Aminoacetic Acid. Anton Mostovoy , Amirbek Polymers 2024, 16, 449. https://doi.org/10.3390/polym16040449.

	6. Anton Mostovoy , Amirbek Bekeshev, Sergey Brudnik , Andrey Yakovlev , Andrey Shcherbakov , Nurgul Zhanturina , Arai Zhumabekova , Elena Yakovleva, Vitaly Tseluikin and Marina Lopukhova. Studying the Structure and Properties of Epoxy Composites Modified by Original and Functionalized with Hexamethylenediamine by Electrochemically Synthesized Graphene Oxide. Nanomaterials 2024, 14, 602. https://doi.org/10.3390/nano14070602. 7. Investigating of epoxy nanocomposites structure and properties that contain both pristine and aminosilane-treated silicon carbide (SiC) particles. Anton Mostovoy, Amirbek Bekeshev , Andrey Shcherbakov, Ainagul Apendina, Raigul Orynbassar , Victoria Svitkina, Marina Lopukhova. Journal of Composite Materials 2024, Vol. 0(0) 1–12, 2024. DOI: 10.1177/00219983241253818.