**Brief information about the project**

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| Name of the project | AP15473268 «Creation of scientific bases for the formation of new, inexpensive stable sorbents based on natural zeolites of the Kazakhstan deposit for carbon dioxide capture» |
| Relevance | Carbon dioxide emissions play a critical role in global warming and capturing them is useful for climate change mitigation. Commonly used methods for capturing carbon dioxide include absorption, adsorption, membrane separation, and others. Absorption and adsorption are the most widely used methods for capturing carbon dioxide. Adsorption with porous materials is an energy efficient method compared to absorption, the latter being associated with high energy costs for regeneration and corrosion. Currently, the development of highly efficient and inexpensive porous adsorbent materials for carbon dioxide capture is an active and topical area of research.<br>Solid adsorbents used to capture carbon dioxide include carbonaceous materials such as activated carbon, carbon nanotubes, mesoporous silica, zeolites, etc. Zeolites play a critical role in carbon dioxide capture due to their molecular sieve nature, controlled physico-chemical properties, and higher selectivity towards carbon dioxide. Natural zeolite is not inferior to artificial zeolite in terms of physicochemical characteristics; besides it is cheaper. Therefore, in some processes where the use of synthetic zeolites is unfavorable, the use of natural materials is of great importance.<br>In Kazakhstan, two large zeolite deposits are known - these are Tayzhuzgen and Chankanay. Zeolites of these deposits belong to clinoptilolite aluminosilicates (clinoptilolite content 55-60%). Clinoptilolite can adsorb carbon dioxide due to van der Waals forces, and modification of the chemical composition can increase the adsorption capacity of $CO_2$. Therefore, clinoptilolite is an interesting material for $CO_2$ capture because they have promising adsorption capacity along with high abundance and relatively low cost. Several studies of $CO_2$ adsorption at room temperature (20-30 °C) and atmospheric pressure are reported in the clinoptilolite literature. However, studies of $CO_2$ capture by clinoptilolite at high temperatures have not been carried out.<br>Therefore, the goal of the project is to develop a scientific approach to the synthesis of new, inexpensive porous, stable to high temperatures, modified sorbents based on natural zeolites from the Kazakhstan deposit for capturing carbon dioxide from flue gases. |
| Purpose | The aim of the project is to create a scientific basis for the formation of new, inexpensive porous, stable to high temperatures, modified sorbents based on natural zeolites from the Kazakhstan deposit for capturing carbon dioxide from flue gases. |
| Objectives | To study the main properties of natural zeolites of Kazakhstan deposits (Tayzhuzgen and Chankanay).<br>Determine the effect of preliminary preparation of zeolites on their adsorption properties for $CO_2$.<br>To study the effect of mechanical activation on the physical and chemical properties of natural zeolites. |

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| | Modification of natural zeolites with alkali metal cations ($Na^+$, $Mg^{2+}$, etc.).<br>To study structural transformations of natural sorbents as a result of their modification.<br>Establish optimal technological parameters for $CO_2$ sorption and sorbent regeneration.<br>To study the selectivity of sorption of sorbents to $CO_2$.<br>Determine the stability of the sorption properties of sorbents.<br>Determination of patterns of formation of textural, phase and structural features of carbon dioxide sorbents based on natural zeolites of Kazakhstan deposits.<br>Publish research results in journals included in the Scopus or Web of science database, in journals recommended by CQAES. |
| Expected and achieved results | The basic properties (texture, morphological, etc.) of natural zeolites from the Tayzhuzgen and Shankanay deposits were studied using physical and chemical methods. The influence of preliminary preparation of zeolites (drying and heating) on their $CO_2$ adsorption properties was determined. The basic properties (texture, morphological, etc.) of natural zeolites from the Tayzhuzgen and Shankanay deposits were studied using physical and chemical methods. The influence of preliminary preparation of zeolites (drying and heating) on their $CO_2$ adsorption properties was determined. The novelty of the project is the study of the adsorption properties of natural zeolites from the Tayzhuzgen and Chankanay deposits in capturing carbon dioxide. The results obtained showed that under mechanical activation conditions (mass ratio of grinding balls and crushed material (6:1), activation time - 60 min, rotation speed - 800 rpm /min) of natural zeolite from the Tayzhuzgen deposit, its specific surface area increases from 11.12 to 16 $m^2/g$. Mechanical activation of natural Tayzhuzgen zeolite affects not only the specific surface area and particle size, but also their structure and phase composition. The highest adsorption capacity of sorbents for $CO_2$ is observed under the condition of mechanical activation - the mass ratio of grinding balls and crushed material is equal to 6:1. After mechanical activation, the sorption capacity for $CO_2$ of zeolite from the Tayzhuzgen deposit at 25 °C is 30.5%, the sorption capacity of zeolite from the Shankanai deposit at 25 °C after mechanical activation is 19.5%. Natural zeolites are modified with alkali metal cations ($Na^+$, $Mg^{2+}$, etc.). The highest sorption capacity - 34.2% for $CO_2$ - is observed on the sorbent 10 wt.% MgO/Tayzhuzgen at an adsorption temperature of 300 °C. The results of physicochemical studies showed that the decrease in the sorption capacity of zeolite with the addition of lithium oxide is associated with a decrease in the specific surface area, enlargement of sample particles, as well as with the formation of $Li_2SiO_3$ and $Li_2Si_2O_5$ phases that are not active in the adsorption of carbon dioxide.<br>**Expected results:**<br>- two publications in peer-reviewed foreign scientific journals, reviewed in Web of Science (from the first and second quartiles with a percentile of at least 50 according to Scopus CiteScore).<br>The optimal technological parameters for $CO_2$ sorption and regeneration of the most effective sorbents will be determined. The |

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| | sorption selectivity of sorbents to $CO_2$ will be investigated. The stability of the sorption properties of effective sorbents will be determined. Fundamental aspects will be established between the structural, textural and phase characteristics of sorbents with their ability to effectively sorb carbon dioxide from flue gases. |
| Research team members with their identifiers (Scopus Author ID, Researcher ID, ORCID, if available) and links to relevant profiles | 1. Mambetova Manshuk Muratkyzy - project manager, PhD, senior researcher. Ih-2, Web of Science Researcher ID: N-5696-2014. Scopus Author ID: 57211435956. ORCID ID: https://orcid.org/0000-0002-1744-3647.<br>2. Yergazieva Gaukhar Yergazievna - scientific consultant, Ph.D., leading researcher. Ih-5, Web of Science Researcher ID: F-5165-2015. Scopus Author ID: 57221777155. ORCID ID: https://orcid.org/0000-0001-9464-5317 |
| List of publications with links to them | 1. Mambetova M., Yergaziyeva, G., & Zhoketayeva A. (2023). Physicochemical characteristics and carbon dioxide sorption properties of natural zeolites. *Combustion and Plasma Chemistry, 21*(2), 81–87. https://doi.org/10.18321/cpc21(2)81-87 |
| Patents | - |