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"WOMEN IN INNOVATION AND SCIENCE" XALQARO ILMIY-AMALIY KONFERENSIYA VA FORUMI ILMIY ISHLARI TO'PLAMI

Toshkent davlat transport universitetida 2026-yil 27-mart kuni "Women in Innovation and Science" xalqaro forumi ilmiy ishlari to'plami chop etildi.

Mazkur nufuzli tadbirlar O'zbekiston Respublikasi Oliy ta'lim, fan va innovatsiyalar vazirligi hamda Transport vazirligi hamkorligida tashkil etilib, mamlakatimizda ilm-fan, innovatsiyalar va zamonaviy texnologiyalarni rivojlantirish, shuningdek xalqaro ilmiy hamkorlikni yanada kengaytirishga qaratilgan muhim platforma hisoblanadi.

Konferensiya ochilish marosimida davlat organlari, xalqaro tashkilotlar va yetakchi oliy ta'lim muassasalari vakillari ishtirok etdi. Jumladan, Toshkent davlat transport universiteti rektori G'ulomov Abdulaziz Abdullayevich, O'zbekiston Respublikasi Transport vazirligi vakili Ulmasova Lobarkhon Adilovna, Osiyo taraqqiyot banki eksperti Claire Charamnac, Istanbul Aydin universiteti vasiylik kengashi raisi Mustafa Aydin, Belarus davlat transport universiteti rektori Kazakov Nikolay Nikolayevich hamda Qirg'iziston Respublikasi Transport vazirligi vakili Dinara Moldokalieva ishtirok etdilar.

Konferensiya ilmiy dasturi doirasida plenar va panel sessiyalar, shuningdek ilmiy ma'ruzalar taqdimoti o'tkazilib, ularda sun'iy intellekt va raqamli texnologiyalarni iqtisodiyot va ta'limga joriy etish, transport va aviatsiya sohasida innovatsion yechimlar, sanoat va IT sohasida texnologiya transferi, shuningdek ta'limda raqamli platformalar va intellektual tizimlar kabi dolzarb masalalar yoritildi.

2026-yil 27-mart kuni o'tkazilgan "Women in Innovation and Science" xalqaro forumi ayollar yetakchiligi, innovatsiyalar va STEM sohalariga bag'ishlangan bo'lib, mamlakatimizda ayollarning ilm-fan va texnologiya sohalaridagi ishtirokini kengaytirish, ularning yetakchilik salohiyatini rivojlantirish hamda xalqaro hamkorlikni mustahkamlashga qaratilgan strategik maydon sifatida tashkil etildi.

Forum doirasida ayollar yetakchiligini rivojlantirish va rag'batlantirish, xalqaro tajriba almashinuvi va ilmiy tarmoqlarni kengaytirish, yosh tadqiqotchi ayollar va PhD talabalarni qo'llab-quvvatlash hamda innovatsion ekotizimlarda gender tenglikni ta'minlash kabi ustuvor vazifalar amalga oshirildi. Shuningdek, forumda ayollar yetakchiligi va STEM, gender tenglik va ilm-fan institutsional rivoji, ayollar tadbirkorligi va innovatsion startaplar, innovatsiya ekotizimlari va xalqaro hamkorlik, yosh ayol tadqiqotchilarni rivojlantirish, mentorlik va akademik tarmoqlar yo'nalishlarida tematik sessiyalar tashkil etildi.

Forumda davlat organlari, xalqaro tashkilotlar, yetakchi oliy ta'lim muassasalari va ilmiy markazlar vakillari, jumladan "OLIMA" uyushmasi raisi Murtazayeva Raxbar Hamidovna, "Sharq ayoli" xalqaro ayollar jamoat fondi raisi Tursunbayeva Saodat Gafurovna, Osiyo taraqqiyot banki eksperti Claire Charamnac, O'zbekiston Respublikasi Transport vazirligi vakili Ulmasova Lobarkhon Adilovna, Toshkent davlat transport universiteti rektori G'ulomov Abdulaziz Abdullayevich, Qirg'iziston Respublikasi Transport vazirligi vakili Dinara Moldokalieva hamda Indoneziyadan universitet dekani Yoga Prihatin ishtirok etdilar.

Shuningdek, forumda Yevropa va Osiyo davlatlaridan yetakchi olimlar, ekspertlar va yosh tadqiqotchilar keng qatnashdi.

Forum dasturiga ochilish marosimi, panel muhokamalar, ilmiy chiqishlar hamda professional rivojlanish bo‘yicha workshoplar kiritilgan bo‘lib, ular doirasida gender tenglik, ayollar karyerasini rivojlantirish, ilmiy tadqiqotlar va innovatsion boshqaruv bo‘yicha amaliy seminarlar tashkil etildi.

Mazkur tadbirlar Osiyo taraqqiyot banki (ADB), “OLIMA” — O‘zbekiston xotin-qizlar olimlari uyushmasi, “Sharq ayoli” xalqaro ayollar jamoat fondi, Germaniya xalqaro hamkorlik jamiyati (GIZ), shuningdek Rossiya, Turkiya, Indoneziya va Qirg‘iziston oliy ta’lim muassasalari hamda Belarus Milliy fanlar akademiyasi ilmiy institutlari hamkorligida o‘tkazildi.

Mazkur xalqaro ilmiy-amaliy konferensiya va forumning ahamiyati shundaki, ular xalqaro ilmiy hamkorlikni mustahkamlash, innovatsion ishlanmalarni amaliyotga joriy etish, raqamli va barqaror rivojlanishni ta’minlash, shuningdek ayollarning ilm-fan va innovatsiya sohalaridagi rolini kuchaytirishga xizmat qiladi. Shu bilan birga, mazkur tadbirlar yosh olimlar va tadqiqotchilarni qo‘llab-quvvatlash, ilmiy tajriba almashish hamda global ilmiy makonga integratsiyalashuvni jadallashtirishda muhim ahamiyat kasb etadi.

Mazkur xalqaro ilmiy-amaliy konferensiya va forumning maqsadi zamonaviy ilmiy tadqiqot yo‘nalishlarini muhokama qilish, innovatsion yondashuvlar va ilg‘or texnologiyalar bo‘yicha ilmiy natijalar almashuvini ta’minlash, shuningdek xalqaro ilmiy hamkorlikni rivojlantirishdan iboratdir.

Tadbirda O‘zbekiston Respublikasi hamda xorijiy mamlakatlarning oliy ta’lim muassasalari va ilmiy-tadqiqot institutlari olimlari, shuningdek amaliyotda muhim natijalarga ega bo‘lgan mutaxassislar o‘z ilmiy ishlari bilan ishtirok etdilar.

Ushbu ilmiy to‘plamda muhandislik, transport, raqamlashtirish, sun’iy intellekt, innovatsion boshqaruv, gender tenglik va barqaror rivojlanish sohalarida faoliyat yuritayotgan yetakchi olimlar, professor-o‘qituvchilar va tadqiqotchilarning ilmiy ishlari jamlangan. To‘plamda dolzarb ilmiy muammolar, zamonaviy yechimlar, nazariy va amaliy tadqiqot natijalari yoritilib, ushbu yo‘nalishlarning bugungi holati va istiqboldagi rivojlanish tendensiyalari aks ettirilgan.

Mazkur nashr mamlakatimizda ilm-fan va innovatsion rivojlanishni ta’minlash, xalqaro ilmiy aloqalarni mustahkamlash hamda yosh olimlar va tadqiqotchilarni qo‘llab-quvvatlash yo‘lidagi muhim qadamlardan biri sifatida e’tirof etiladi.

Shuningdek, mazkur ilmiy to‘plamda keltirilgan natijalar kelgusida ilmiy tadqiqotlar samaradorligini oshirish, amaliyotga yo‘naltirilgan innovatsion yechimlarni keng joriy etish hamda sohalararo integratsiyani chuqurlashtirish uchun muhim ilmiy asos bo‘lib xizmat qiladi. To‘plam materiallari nafaqat ilmiy jamoatchilik, balki ishlab chiqarish sohasi mutaxassislari, doktorantlar va talabalar uchun ham foydali manba hisoblanadi.

Mazkur nashrda yoritilgan ilmiy g‘oyalar va ilg‘or yondashuvlar asosida yangi ilmiy izlanishlar olib borilishi, xalqaro ilmiy aloqalarning yanada rivojlanishi hamda innovatsion rivojlanish strategiyalarining takomillashishiga xizmat qilishi kutilmoqda.

Research on the synthesis of zeolite NaX using Angren kaolin

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Abstract: In this study, the potential use of Angren kaolin as a source of silicon and aluminum oxides for the synthesis of NaX zeolite was investigated. The synthesis of NaX zeolite involved several stages: obtaining metakaolin from kaolin, preparing the synthesis mixture with the required molar ratio of the initial components, adding silicate to regulate the Si/Al ratio in accordance with X-type zeolites, and subsequent hydrothermal treatment at 120 °C. X-ray diffraction (XRD) analysis confirmed the successful transformation of the synthesized mixture into NaX zeolite. Spectroscopic analyses further verified the formation of the crystalline structure of NaX zeolite synthesized using kaolin as a source of silicon and aluminum.

Keywords: kaolin, porous materials, zeolite NaX, spectroscopy, hydrothermal method, crystal

1. Introduction

Zeolites are typically synthesized from kaolin (a source of Si and Al), mixtures of sodium silicate and aluminate [1], as well as from natural mineral sources [2]. To activate kaolin and enhance its reactivity, it is subjected to thermal treatment in the range of 500–800 °C, leading to the formation of metakaolin. The resulting amorphous metakaolin is then treated with alkaline metal hydroxide solutions of appropriate concentration, usually at temperatures up to 100 °C. The micropore size of the synthesized zeolites depends on the composition of the reaction mixture. When uncalcined kaolin is used in the synthesis process, it tends to transform into feldspar or hydrosodalite under the influence of NaOH solution. Structural variations in synthetic zeolites of types A, P, X, and Y are primarily determined by their aluminum (aluminum oxide) content. These differences affect both the crystalline framework of the zeolite and its selectivity in ion-exchange processes. Furthermore, higher aluminum and sodium contents increase the ion-exchange capacity and dissolution rate of the zeolites.

The synthesis of NaX zeolite from kaolin [3], as well as compounds that include mixtures of other metal oxides [4-5], and silicate and aluminate mixtures containing SiO_2 and Al_2O_3, is aimed at obtaining these compounds through synthesis. The synthesis of NaX zeolite from natural kaolin provides an effective approach to the rational use of natural resources. The synthesis of NaX zeolite from kaolin refers to the reaction between minerals and sodium aluminosilicates, resulting in the formation of Na-X type zeolite. In this process, natural aluminosilicates from kaolin undergo chemical changes to yield zeolite with high surface area and adsorption properties. NaX zeolite, in particular, is used in various industries for gas and liquid filtration, ion exchange, and as a catalyst carrier [6].

NaX zeolite has a cubic crystal system, which provides a structure with a high degree of symmetry and more complex structural arrangements. The NaX zeolite consists of the linkage of silicate (SiO_4) and aluminate (AlO_4) tetrahedra, which forms a "3D" network. In NaX zeolite, sodium (Na^+) ions are positioned within the crystal structure, primarily to balance the charge of the aluminum and silicate tetrahedra. The Na^+ ions contribute to the high porosity and act as carriers, providing NaX zeolite with its high adsorption and ion-exchange properties [7].Its chemical formula is $Na_2O{\bullet}Al_2O_3{\bullet}nSiO_2{\bullet}xH_2O$, where zeolites with an (n) value of 2–3 are categorized as zeolite X, while those with higher (n) values fall under zeolite Y [8–9].

Kaolin, with a Si/Al ratio near 1, is an optimal precursor for synthesizing low-silicon zeolites. While significant research has focused on producing zeolite NaA from kaolin [10–11], investigations into kaolin-derived zeolite NaX remain highly pertinent. To crystallize zeolite NaX, the Si/Al ratio in the reaction mixture must exceed 1, typically achieved by introducing additional silica from external sources [12–13]. Notably, impurities such as quartz and mica in kaolin have minimal impact on its transformation into metakaolin or the subsequent synthesis of zeolite NaX [14].

The synthesis process begins with the purification of kaolin to remove impurities that could hinder the reaction. Organic acids have been identified as effective agents for eliminating iron compounds. Previous studies have also examined the synthesis of NaX zeolites using kaolin in fluoride-rich environments [15]. The production of silicon-based zeolites from kaolin typically involves two main steps: (1) the thermal activation of kaolin to convert it into metakaolin through dehydroxylation, and (2) the hydrothermal reaction of metakaolin with an alkaline solution in an aqueous medium. Research has highlighted the critical role of the metakaolinization temperature in influencing the yield of NaX zeolite, demonstrating its significant impact. Moreover, approaches to incorporate additional SiO_2 sources during NaX synthesis have been investigated [16].

This study explored the potential of using kaolin as an alternative source of silica and alumina for the hydrothermal synthesis of zeolite NaX. To achieve the appropriate Si/Al

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ratio required for zeolite NaX crystallization, external silicate sources were added to the mixture. The synthesized NaX zeolite was characterized through XRD and FTIR analyses, with detailed assessments of its crystalline morphology, framework structure, and pore volume.

2. Materials and methods

In this study, AKF-78 grade Angren kaolin, comprising 31.2% Al_2O_3, 48.4% SiO_2, 1.34% Fe_2O_3, and 1.18% MgO, served as the aluminosilicate source. Sodium hydroxide (99% NaOH) and sodium silicate (99% Na_2SiO_3) were utilized during the synthesis process. Oxalic acid was applied for chemical treatment to eliminate Fe^{2+} ions, while distilled water was used for washing and removing residual chemicals during purification.

Synthesis of zeolite NaX

The kaolin sample was ground using a specialized mill to achieve a particle size of 100 nm. The conversion of kaolin to metakaolin was performedby heating the sample to 650°C. The milled sample was treated with a 0.5 M oxalic acid ($C_2H_2O_4$) solution at 100°C, cooled to room temperature, and subsequently filtered. The filtered material was then dried. To prepare a mixture with a molar ratio of Si/Al =2 and Na/Si=1:1, metakaolin, NaOH, and liquid glass were taken in appropriate amounts. The resulting mixture was processed at 100°C with continuous stirring using a magnetic stirrer. The prepared sample was transferred to an autoclave and subjected to hydrothermal treatment at 120°C for 24 hours. The sample is washed with distilled water, filtered, and dried overnight (Figure 1).

Characterization of synthesized zeolite NaX

The chemical composition of the kaolin used for synthesis was determined by X-ray fluorescence (XRF). The obtained NaX zeolite and kaolin crystal phases were analyzed using X-ray diffraction (XRD) and infrared spectrometry methods (SHIMADZU XRD-6100 and ALPHA II FT-IR).

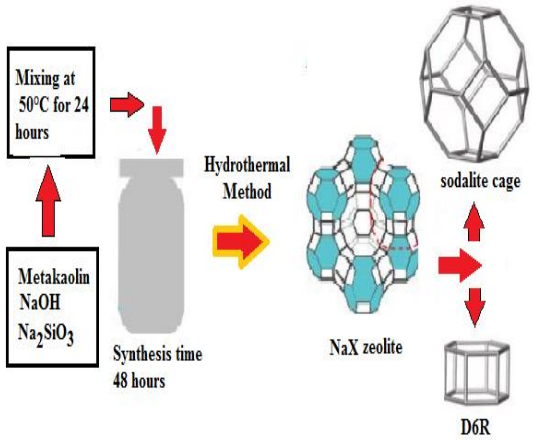

Fig. 1. Method of synthesis of NaX zeolite by hydrothermal method

The composition of kaolin treated with an organic acid solution contains SiO_2 and Al_2O_3 oxides, with small amounts of metal oxides remaining (Table 1). The low concentrations of metal oxides in the purified kaolin do not interfere with the synthesis of NaX zeolite. The chemical composition of the obtained NaX zeolite mainly consists of silicon and oxygen, with sodium acting as a stabilizing cation (Figure 2). During the synthesis process, kaolin dissolves in a NaOH solution and is washed with distilled water in the final stage. It is then calcined at a temperature of 800 °C.

Table 1

Purified Angren kaolin composition

Material	Al_2O_3	Na_2O	SiO_2	Fe_3O_4	K_2O	Other
%	37.4	5.5	55.6	0.1	0.2	1.3

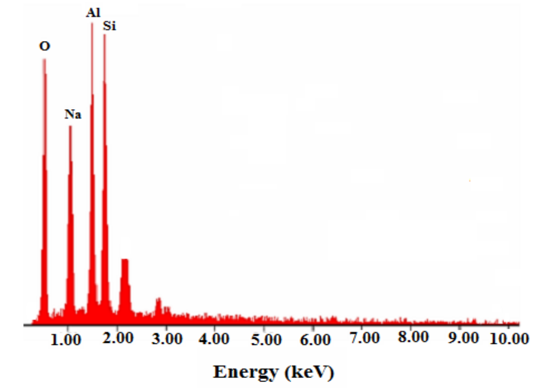

Fig. 2. Elemental composition of NaX zeolite

In the synthesis of zeolites, the synthesis conditions, the purity of the reagents, temperature, and the crystallinity of the obtained product play a crucial role. Crystallization time is significant in thehydrothermal synthesis method, and it is necessary to optimize the crystallization time and temperature duringthe process. The molar ratioof the synthesis products affects the surface area and structure of NaX zeolite.

Temperature is a crucial parameter in the nucleation and crystallization of zeolites synthesized via the hydrothermal method. In zeolite synthesis, high temperatures increase thermal energy and reduce crystallization time. Primarily, zeolite formation occurs more effectively at elevated temperatures. In this study, the crystallization temperature for synthesizing NaX zeolite from processed Agren kaolin was set at 120°C. Several analyses were conducted on the morphological structure and crystallization of the synthesized zeolite.

NaX zeolite synthesized from Angren kaolin via the hydrothermal method, along with Linde NaA zeolite and kaolin samples, were analyzed using X-ray diffraction (XRD) with a SHIMADZU XRD-6100 diffractometer. The XRD data from these samples revealed several distinct diffraction peaks (Fig. 3).

The crystal structure of NaX zeolite is distinctive, and its diffraction peaks are clearly visible in the XRD analysis. The XRD pattern of NaX zeolite exhibits the following characteristics: NaX zeolite has a Faujasite (X) crystal structure, which generates distinct diffraction peaks at 6.08°, 9.94°, 23.27°, 26.61°, and 31.98° in the XRD diagram. These peaks reflect the crystal structure of the aluminosilicate network of NaX zeolite. XRD analysis is crucial in determining the degree of crystallinity of the synthesized NaX zeolite, as the intensity of the peaks identified in the diagram indicates the crystallization degree. Higher peaks correspond to more crystallized NaX zeolite, while lower peaks indicate amorphous or semi-crystalline material. Secondary phases, such as NaY or amorphous silica, may also emerge during the synthesis process. These phases can form distinct peaks in the XRD diagram. Such phases indicate the efficiency of the synthesis process and the complete utilization of the raw materials. In the XRD spectrum of the processed kaolin, two low-intensity peaks at 12.05° and 24.74° can be observed. This situation is explained by the incomplete dissolution of kaolin in the NaOH solution[19].

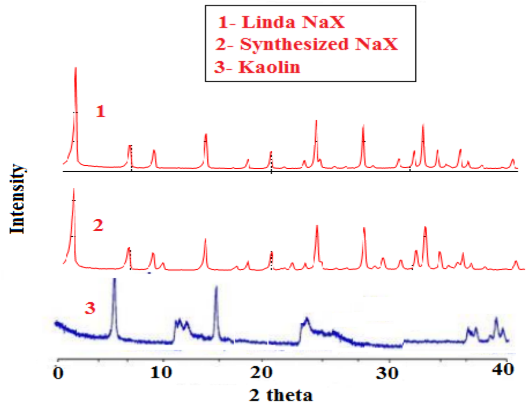

Fig. 3. XRD image of kaolin, Linda NaX, synthesized NaX zeolite crystals

The infrared (IR) transmissivity of kaolin and NaX zeolite synthesized from silicates was analyzed in the study. Analyzing the IR absorption and transmissivity of NaX zeolite helps in understanding its chemical structure, phase properties, and changes. NaX zeolite, with its crystalline and amorphous structures, high porosity, and molecular adsorption characteristics, can be studied using infrared (IR) spectroscopy. The IR spectrum of NaX zeolite reveals the structure of the zeolite and the bonding in its composition, reflecting the connections between silica (SiO_2) and aluminum oxide (Al_2O_3) units in its crystalline structure (Figure 4).

In the IR spectrum of kaolin, peaks related to tetrahedral Si-O and Al-O units were observed at 1108 cm^{-1}, and Si-O bond-related peaks were observed at 1028 cm^{-1}. In the IR spectrum of NaX zeolite, there is no Al-O-H vibration at 914 cm^{-1}. The peak at 756.43 cm^{-1} indicates the symmetric Si-O-Si vibration. NaX zeolite contains silica (SiO_4) tetrahedra, and the Si-O bonds show strong absorption in the IR spectrum around 1000-1200 cm^{-1}. The peaks around 400-600 cm^{-1} originate from the crystalline structure of aluminum oxide. Anothercharacteristicvibrationwas detected at 564.56 cm^{-1}, indicating the presence ofsecondary six-membered rings (D6R), which aretypicalfor the X-type zeolite structure.

NaX zeolite also contains unbonded hydroxyl (OH) groups, which exhibit broad absorption peaks around 3600-3700 cm^{-1}. These hydroxyl groups appear after the zeolite washing or adsorption of water. In the sample, the vibration at 3452.22 cm^{-1} corresponds to hydroxyl (OH) groups, while the peak at 1640.55 cm^{-1} indicates the presence of water molecules. The IR spectrum analysis of NaX zeolite aids in understanding its structure and chemical properties, providing valuable information about Si-O and Al-O bonding as well as OH groups. The zeolite's ion-exchange properties and its conductivity characteristics during gas/liquid adsorption processes are also defined by these interactions.

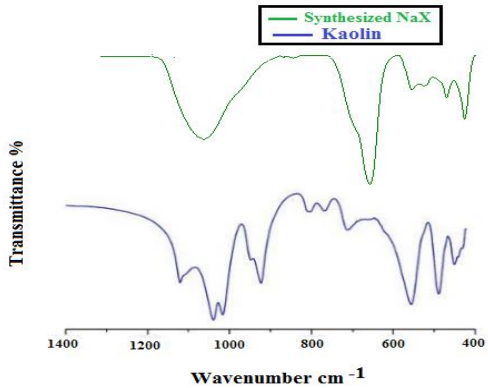

Fig. 4. FTIR spectra of synthesized NaX zeolite and kaolin

These spectroscopic findings confirm that the NaX zeolite, synthesized using kaolin as a silicon and aluminum source, successfully formed a crystalline structure.

3. Conclusion

In this study, the potential use of Angren kaolin as a source of silicon and aluminum oxides for the synthesis of NaX zeolite was investigated. The synthesis of NaX zeolite involved the following stages: obtaining metakaolin from kaolin, preparing the synthesis mixture with the required molar ratio of the initial components, adding silicate to regulate the Si/Al ratio in accordance with X-type zeolites, and subsequent hydrothermal treatment at 120 °C. X-ray diffraction (XRD) analysis confirmed the successful transformation of the synthesized mixture into NaX zeolite. Spectroscopic analyses verified the successful formation of the crystalline structure of NaX zeolite synthesized using kaolin as a source of silicon and aluminum.

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