STUDY OF BENZENE VAPOR ADSORPTION BY LOGON BENTONITE AND ITS ORGANIC MODIFICATIONS

No‘monov M.A.
Fergana State Technical University, Fergana, Uzbekistan

Abdikamalova A.B.
Institute of General and Inorganic Chemistry, Tashkent, Uzbekistan

Mirsalimova S.R.
Fergana State Technical University, Fergana, Uzbekistan

Eshmetov I.D.
Institute of General and Inorganic Chemistry, Tashkent, Uzbekistan

Bentonites are naturally occurring hydrated aluminosilicate minerals widely used due to their high ion-exchange capacity and large specific surface area. As a result, bentonite is commonly applied in adsorption processes across various environmental and industrial domains [1].

The adsorption properties of bentonite are effectively utilized in applications such as environmental remediation, water purification, and the separation of various chemical substances. One effective approach to enhancing the adsorption capacity of bentonite is through its modification. During the modification process, both the structure and surface characteristics of bentonite are altered, which significantly improves its adsorptive performance.

Among the most common methods of bentonite modification is organic functionalization using substances such as surfactants (surface-active agents) or organic amines. Organic modification enhances the hydrophobicity of bentonite, thereby increasing its capacity to adsorb other organic, particularly hydrophobic, substances [2].

This study aims to investigate the adsorption behavior of benzene vapor on natural Logon bentonite and its organically modified forms. The research focuses on analyzing the adsorption capacity of organically modified bentonite samples in relation to the modification process. Studying the adsorption of benzene on both raw and modified bentonites provides novel opportunities for utilizing these materials in environmental cleanup applications.

The adsorption isotherms of benzene vapor on natural Logon bentonite and three organically modified samples reveal significant differences in their adsorption characteristics. These variations are attributed to changes in pore structure and the interactions between benzene molecules and the modified surfaces. These results are illustrated in **Figure 1**.

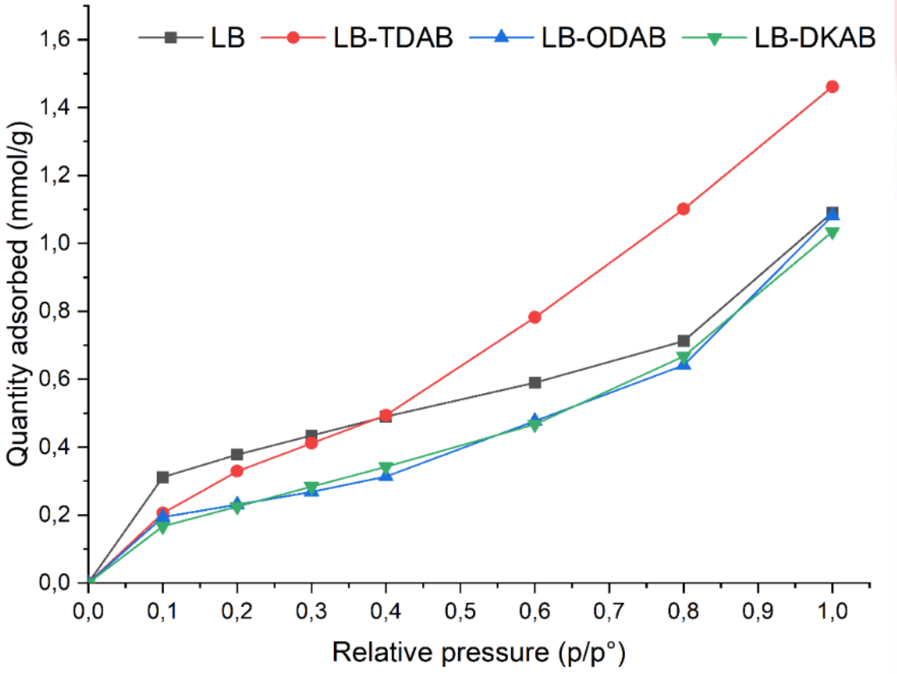

Figure 1. Adsorption isotherms of benzene vapor on the studied samples: A) LB; B) LB-TDAB; C) LB-ODAB; D) LB-DKAB.

The experimental results reveal significant insights into the adsorption behavior of benzene vapor on both natural and organically modified Logon bentonite samples. The pristine bentonite (LB) displayed the highest adsorption capacity at low relative pressures ($P/P_0 \leq 0.2$), with a value reaching 0.31 mol/kg. This high adsorption performance is indicative of the abundant microporous structure present in the unmodified sample, which facilitates the uptake of benzene molecules through capillary condensation and micropore filling mechanisms.

Upon modification with organic surfactants, a notable decrease in benzene adsorption capacity at low pressures was observed in the samples LB-TDAB and LB-ODAB, registering adsorption capacities of 0.21 mol/kg and 0.19 mol/kg, respectively. This reduction can be attributed to the partial blockage or collapse of micropores caused by the incorporation of organic chains into the bentonite's interlayer spaces. The surfactant molecules tend to occupy active adsorption sites or create steric hindrance that limits benzene access to smaller pores.

The LB-DKAB sample, which was modified with a long-chain organic compound, exhibited the lowest adsorption capacity at low pressures (0.17 mol/kg). This suggests that the long hydrocarbon radicals not only obstruct the entrance to micropores but also decrease the effective surface area available for interaction with benzene molecules. The decrease in microporosity due to the dense packing of long organic chains leads to a substantial reduction in adsorption performance under low-pressure conditions.

At higher relative pressures ($P/P_0 \approx 1$), all bentonite samples showed an increase in adsorption capacity, likely due to multilayer adsorption and pore condensation effects becoming more pronounced. Interestingly, the LB-TDAB sample recorded the highest overall adsorption capacity at saturation pressure, reaching 1.46 mol/kg. This can be explained by the enhanced hydrophobic nature of the modified surface, which improves interactions with non-polar benzene molecules. The organic moieties grafted onto the bentonite surface promote van der Waals and hydrophobic interactions, thereby increasing the retention of benzene vapor despite the reduced microporosity.

The adsorption mechanism in modified bentonites is therefore governed by a complex interplay between textural changes (pore structure and surface area) and surface chemistry (hydrophobicity and functional groups). In LB-TDAB, the balance between partial micropore loss and improved hydrophobic surface interaction leads to a net increase in adsorption efficiency at higher pressures. In contrast, in LB-DKAB, the excessive steric hindrance caused by long alkyl chains negates the beneficial effects of hydrophobic modification, resulting in overall lower adsorption.

These findings underscore the importance of carefully selecting organic modifiers to tailor the adsorptive behavior of bentonite for specific applications. The study demonstrates that while surface modification can enhance affinity toward organic pollutants like benzene, it must be optimized to avoid excessive pore blockage.

Thus, organically modified Logon bentonites, especially those with medium-length alkyl chains such as TDAB, show promise as effective adsorbents for hydrophobic volatile organic compounds in environmental remediation contexts. The study also provides a framework for designing advanced clay-based materials with tunable surface properties for targeted adsorption processes.

References

1. No'monov, M. A., & Mirsalimova, S. R. (2024). Methods of enrichment of Logon bentonite. In Proceedings of the International Scientific-Practical Conference on “Ensuring the Consumer Market with Quality Food Products – a Key Factor of Welfare and Development” (pp. 28–29). Fergana Polytechnic Institute.
2. Xamidov I.A., Karimov B.X. Bentonit gilining fizik-kimyoviy xossalari va ularni modifikatsiya qilish yo‘llari. // "O‘zbekiston fanlari akademiyasi axborotnomasi", Kimyo seriyasi, 2022, №2, B. 45–49.