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THE EFFECT OF GLUCOSE ON SORPTION PROPERTIES OF H-MONTMORILLONITE

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Abstract. The paper presents the results of X-ray, IR spectroscopic and sorption investigations of H-montmorillonite complexes with glucose. It has been found that glucose is sorbed on the surface of montmorillonite without inducing changes of interlayer spacings. The amount of sorbed organic substance depends on its concentration in solution. Glucose sorption modifies only slightly the sorption properties of montmorillonite. Interesting to note is an insignificant increase in sorption capacity with respect to water vapour at relative pressures $p/p_0 > 0.4$.

INTRODUCTION

Surface properties of montmorillonite are generally modified using organic cations. There are only few papers dealing with the effect of polar organic compounds on sorption properties of this mineral. Therefore, the present authors carried out appropriate investigations to determine the influence of glucose adsorbed on the surface of H-montmorillonite on the nature of surface of resulting complexes.

EXPERIMENTAL

Montmorillonite separated from bentonite from the Chmielnik deposit was used for tests. It was converted into the hydrogen form by washing with 0.1 n HCl solution. Excess acid was removed by washing the sample with distilled water. From this montmorillonite water suspension was prepared, containing 10 g of the mineral in 1 l of distilled water. Glucose

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solutions containing respectively 10, 50, 70 and 100 wt. % of this compound in relation to montmorillonite were added to a few portions of the suspension. After stirring for several hours, the suspension was centrifuged and dried at 60°C. Samples prepared in this way were subjected to X-ray and infrared spectroscopic analysis and their sorption properties were determined. X-ray investigations were carried out with a *TUR M-61* diffractometer, using flat powder samples. Infrared spectra were recorded with an *UR-10* spectrophotometer, using KBr discs technique. Sorption investigations involved determination of isotherms for water, benzene and argon vapour sorption and desorption on the obtained montmorillonite-glucose complexes. Water and benzene sorption isotherms were determined using microburettes for liquids (Lasoń, Żyła 1963) whereas argon sorption and desorption were recorded with sorption manostats (Ciembronicz, Lasoń 1972).

RESULTS

X-ray powder investigations have shown that the 001 reflection of montmorillonite ($d_{001} = 14.6 \text{ \AA}$) does not change its position under the influence of glucose. It appears, therefore, that under the experimental conditions, glucose molecules are not sorbed in the interlayer spaces of montmorillonite or sorption occurs without changes in the interlayer distances. According to the studies of Greenland (1956), H-montmorillonite can form

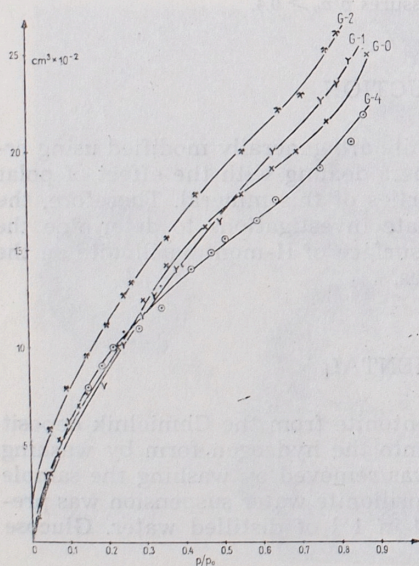


Fig. 1. Isotherms of water sorption on H-montmorillonite modified with glucose (G-0 — untreated sample; G-1, G-2, G-4 — samples containing glucose)

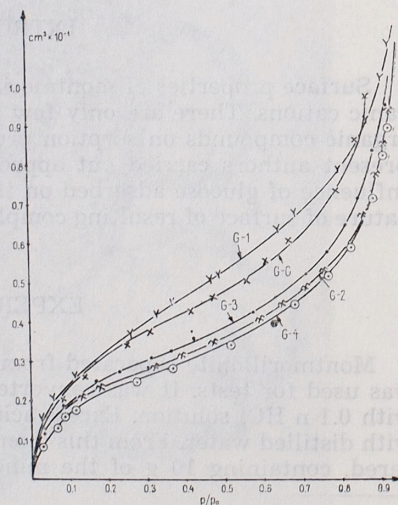


Fig. 2. Isotherms of benzene sorption on H-montmorillonite modified with glucose (G-0 — untreated sample; G-1 to G-4 — samples containing glucose)

a complex with glucose which contains a monomolecular layer of this compound in its interlayer spaces, having a value of $d_{001} = 14.6 \text{ \AA}$. Infrared spectroscopic analysis has revealed that the amount of glucose sorbed on montmorillonite depends on its concentration in the solution. This suggests that organic molecules can penetrate into the interlayer spaces without inducing changes in the d_{001} spacings. Infrared spectra show absorption bands (the most intense in the region between 2800 and 3000 cm^{-1}) caused by vibrations of functional groups within the glucose molecules. They do not allow, however, to define the nature of bonds between glucose and montmorillonite.

Isotherms obtained for water sorption on samples containing glucose (Fig. 1) differ insignificantly from the non-treated H-montmorillonite isotherm. Worth noting, however, is a slight increase in sorption capacity of some samples with respect to water vapour, especially at relative pressures $p/p_0 > 0.4$.

Isotherms determined for benzene vapour sorption (Fig. 2) evidence that the sorption capacity of samples diminishes slightly with the increasing amount of glucose adsorbed on montmorillonite. This fact is suggestive of slight hydrophobization of montmorillonite or reduced accessibility of pores in the resulting complexes.

The values for specific surface areas determined from argon isotherms decrease markedly upon adsorption of glucose. The specific surface area for the untreated sample is 44.1 m^2/g whereas for the other samples it varies from 11.1 to 14.3 m^2/g . This implies that the porosity of H-montmorillonite decreases, which is most likely due to the formation of montmorillonite aggregates under the influence of glucose.

DISCUSSION

Glucose sorption on the surface of H-montmorillonite causes only slight modification of its properties. This modification manifests itself in insignificant variations in specific surface areas (Table 1). Characteristic is the increase in sorption capacity with respect to water vapour at higher relative pressures. Similar results were obtained by Chassin (1973), who sorbed ethylene glycol on montmorillonite. This author, however, reported a considerably greater increase in sorption capacity of montmorillonite with respect to water vapour.

The effect of glucose adsorbed on the surface of montmorillonite on the sorption properties of this mineral is much less pronounced than in the case of introducing organic cations (Table 1). This difference becomes particularly marked when long-chain cations are used for modification and seems to result from the different chemical nature of the organic compounds used. Organic cations adsorbed on montmorillonite are hydrophobic and give this property to the surface of the mineral. Glucose, on the other hand, being a polar compound, does not induce changes of the surface of montmorillonite leading to its hydrophobization.

Table 1

Surface area (m^2/g) of montmorillonite treated with glucose and heksadecylpyridinium (HDP) chloride

Sample No	Glucose to montmorillonite ratio (in suspension)	Adsorbate			
		water	methyl alcohol	benzene	argon
G-0	0	390.8	381.5	56.3	44.1
G-1	1:9	356.4	322.6	60.4	13.1
G-2	1:2	n.d.	310.4	41.7	n.d.
G-3	1:1.4	341.8	263.7	45.0	14.3
G-4	1:1	311.0	301.2	40.4	11.3
% HDP on exchange sites *					
	7	413.5	296.2	15.3	8.5
	19	245.1	178.4	28.2	17.3
	28	153.1	117.0	38.4	8.1
	59	121.8	113.0	48.0	6.0
	100	125.6	169.1	364.3	7.5

* After Żyła, Kłapyta (1976).

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WPLYW GLUKOZY NA WŁASNOŚCI SORPCYJNE H-MONTMORILLONITU

Streszczenie

W pracy przedstawiono wyniki badań rentgenowskich, spektroskopowych w podczerwieni i sorpcyjnych kompleksów H-montmorillonitu z glukozą. Stwierdzono, że glukoza sorbuje się na powierzchni tego minerału bez zmiany odległości międzypakietowych. Ilość zasorbowanej substancji organicznej zależy od jej stężenia w roztworze. Modyfikacja własności

ci sorpcyjnych montmorillonitu w wyniku zasorbowania glukozy jest nieznaczna. Interesujący jest niewielki wzrost chłonności sorpcyjnej względem pary wodnej w zakresie ciśnień względnych p/p_0 powyżej 0,4.

OBJAŚNIENIA FIGUR

Fig. 1. Izotermy sorpcji wody na H-montmorillonicie modyfikowanym glukozą (G-0 — próbka wyjściowa, G-1, G-2, G-4 — próbki zawierające glukozę)

Fig. 2. Izotermy sorpcji benzenu na H-montmorillonicie modyfikowanym glukozą (G-0 — próbka wyjściowa, G-1 do G-4 — próbki zawierające glukozę)

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ВЛИЯНИЕ ГЛЮКОЗЫ НА СОРБЦИОННЫЕ СВОЙСТВА Н-МОНТМОРИЛЛОНИТА

Резюме

В работе представлены итоги рентгеновских, ИК спектроскопических и сорбционных исследований комплексов Н-монтмориллонита с глюкозой. Было обнаружено, что глюкоза сорбируется на поверхности этого минерала без изменения межпакетных расстояний. Количество сорбированного органического вещества зависит от концентрации раствора. Модификация сорбционных свойств монтмориллонита из-за поглощения глюкозы незначительна. Интересно, что наблюдается небольшое повышение поглотительной способности сорбции водяного пара в диапазоне относительных давлений p/p_0 выше 0,4.

ОБЪЯСНЕНИЯ К ФИГУРАМ

Фиг. 1. Изотермы сорбции воды на Н-монтмориллоните модифицированном глюкозой (G-0 — исходный образец, G-1, G-2, G-4 — образцы, содержащие глюкозу)

Фиг. 2. Изотермы сорбции бензена на Н-монтмориллоните модифицированном глюкозой (G-0 — исходный образец, с G-1 по G-4 — образцы, содержащие глюкозу)