

Sorption characteristics of paper produced from sepiolite

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(Received 10 January 2001)

Paper laboratory-produced from sepiolite, Goleš-Serbia was studied to determine its sorption characteristics for nitric oxides, water vapor, and ammonia. The paper adsorbed high percentages of nitric oxides and ammonia was stoichiometrically chemisorbed on paper saturated with NO₂ and H₂O. Infrared spectroscopy showed that the sorption of nitric oxides and ammonia does not destroy the crystal lattice of sepiolite, which was confirmed by XRD-analysis. Sorption of both nitric oxides and ammonia occurred by zeolitic water inside the structural channels of sepiolite. Pressure swing adsorption (PSA) or temperature swing adsorption (TSA) cycles can be repeated many times, in the case of NO_x and NH₃.

Keywords: ammonia, IR, nitric oxides, sepiolite, sorption, XRD.

The mineral sepiolite has an idealized unit half-cell Mg₈Si₁₂O₃₀(OH)₄(OH₂)₄*n*H₂O, where *n* = 6–8. It has a fibrous morphology related structurally to Mg-Si bands with narrow channels of specified widths on the fiber surface and contains zeolitic, bonded and constitutive water molecules, which are released at different temperatures.¹ Owing to its channels with dimension 0.6–0.9 nm, sepiolite can be classified as a molecular sieve. Miller and Koltermann² found that at 293 K and atmospheric pressure CO₂, SO₂, *n*-C₄H₁₀, CCl₃NO₂, and *n*-C₄H₉OH are adsorbed on sepiolite, whereas CO and N₂ are not adsorbed. Dandy³ investigated the adsorption of CH₃NH₂, C₂H₅NH₂, and NH₃ and concluded that ammonia molecules enter into the channels, not only because of the molecular diameter of about 0.4 nm, but also because of strong interaction with the channel walls.

Barrer and Mackenzie⁴ suggested that the accessibility of sepiolite channels may depend more on the polarity of a substance than on the dimensions of the molecules. Both polar and nonpolar molecules can enter the channels, with a negative free energy change for polar molecules and a positive one for nonpolar molecules. If the adsorbed cations or water molecules are distributed within the sepiolite channels, the diffusion of nonpolar molecules is suppressed. Thus, the adsorption of substances such as N₂, O₂, and CO₂ occurs at or near the channel entrance. From ESR measurements of ammonia

adsorption on sepiolite, Hasashi and Makiyo⁵ concluded that the sepiolite changes its electron-spin state when ammonia is adsorbed. The adsorption compensates the charge produced by the polarization of the planes of Mg, O and OH in the sepiolite crystal lattice. The OH⁻ and O⁻ planes are accessible to adsorbed gases, so the positive charges of an oxygen plane are neutralized. In this case, the electrostatic potential of a negatively charged Mg-plane is increased and a free electron moves into a cavity, so ammonia is adsorbed as NH₃⁺. In this way, adsorbed molecules, although they are not in direct contact with a negatively charged Mg-plane, compensate the charge by the positive charge of an oxygen plane.

Aznar *et al.*⁶ Serna *et al.*⁷ and Gonzales-Roman *et al.*⁸ used infrared spectroscopy (IR) to investigate the structure of sepiolite. According to Gonzales-Roman *et al.*⁸ the main IR vibration region is between 4000 cm⁻¹ to 3000 cm⁻¹, and in this range are OH-extended bands of some important groups. The absorption at 3720 cm⁻¹ corresponds to free SiO-H groups, and occurs only when samples have many external silanol groups; at 3680 cm⁻¹ the sharp band of the Mg₃OH group appears; the absorption of structurally bonded water is at 3580 cm⁻¹; and the bands, attributable to zeolitic water are at 3440 cm⁻¹ and 3640 cm⁻¹. There is another vibration band at 1655 cm⁻¹, which is attributable to bonded water, while the shoulder at 1700 cm⁻¹ is attributable to zeolitic water. The lattice vibrations are between 1200 cm⁻¹ and 400 cm⁻¹; the connecting SiO bands are at 1200 cm⁻¹, 1080 cm⁻¹ and 980 cm⁻¹, the Si-O-Si bands are at 1020 cm⁻¹ and 470 cm⁻¹, the Si-O-Mg bands are at 440 cm⁻¹; and the Mg₃OH bands are at 655 cm⁻¹.

Fernandez-Montreal and De Sande-Moreno⁹ used sepiolite in the form of sepiolite ceramics as a sorbent, catalyst, catalysts support, or a reagent for ethylene oxidation. Its corresponding use in the form of sepiolite paper is advantageous for the following reasons:

- paper can be used either for sorption during filtration through a sorbent layer or with a flow parallel to the paper sheets.
- for filtration through the paper, the diffusion paths are short and the flow resistance is high. For flow parallel to the paper sheets, the diffusion paths are longer and the flow resistance is negligible. In both cases, the sorption dynamics are better than when sorbent granules are used;
- for industrial or small-scale applications, paper sheets have some advantages in regard to equipment construction and exploitation;
- if sepiolite is used as a catalyst or a catalyst support, paper sheets can be applied as either membrane catalysts or ordinary catalysts;
- sepiolite paper is also easy and inexpensive to produce in any quantity;
- because paper is produced at a temperature of 105 °C, the sepiolite structure is not affected. Also, paper based on organic or mineral fibers can be produced, thus the sorption or catalytic elements can be used over a broad temperature range;
- finally, sepiolite paper can be used to produce corrugated paper board, Ishida *et al.*,¹⁰ or honeycomb structures, which are advantageous for many applications.

The purpose of this paper is to present the results of an investigation of the sorption characteristics of sepiolite paper made from sepiolite from the magnesite and sepiolite mine, Goleš - southern Serbia. NO_x , NH_3 and H_2O were used as adsorptives and temperature swing adsorption (TSA) cycles were used for sorption and paper regeneration. XRD analysis and IR spectrometry were employed to determine if structural OH groups at the sepiolite surface are excited by sorption of nitric oxides and ammonia, as well as other functional groups bonded to the sepiolite crystal lattice. Also, both techniques can be used to determine whether irreversible loss of crystallinity occurs during regeneration of the sepiolite paper. These data on sorption and desorption of NO_x and NH_3 , on possible structural changes of the sepiolite, and on the conditions for the TSA cycles are useful for the design of filters for gas purification.

EXPERIMENTAL

Preparation of sepiolite paper sheets

Several grades of sepiolite paper were prepared in the laboratory and tested:

The papers were prepared: (1) with bleached conifer cellulose pulp (30 % to 80 % sepiolite); (2) with borosilicate glass fibers (30 % to 60 % sepiolite, 5 % sodium silicate), and (3) on borosilicate glass paper with a thin layer of pure sepiolite. In the preparation of the first two types of paper, sepiolite pink from a trace of Fe oxides was used, whereas the third paper was prepared with white sepiolite (as is used for thin-layer chromatography where the color is important). Papers with 60 % sepiolite were used for most experiments. The pink sepiolite has the following chemical constitution (wt. %): 38.56 SiO_2 , 3.42 CaO , 27.57 MgO , 0.04 Fe_2O_3 , 0.07 NiO , 0.29 Na_2O , and 28.61 loss on ignition. The sepiolite was ground to an average particle size of 5.8 μm (particles from 2.1 μm to 17 μm), mixed with pulped cellulose fibers in deionized water (suspension with 1 % dry matter), and circular paper sheets were made on a laboratory paper-making set. The paper disks were dried at 105 °C. To increase the surface area, some disks were corrugated before drying. Detailed preparation procedures have been presented by Mitrović *et al.*¹¹ Each disk was 250 \times 0.5 mm with a weight of 250 g/m^2 . Results of scanning electron microscopy (SEM) of sepiolite paper, obtained using a JEOL 4-JSM-840a instrument, are presented in Fig. 1.



Fig. 1. SEM of the sepiolite – cellulose paper (60 % : 40 %).



Fig. 2. SEM of crystallized NH_4NO_3 in the sepiolite paper.

Determination of the sorption equilibrium characteristics

Cellulose-based sepiolite paper disks 60 mm in diameter were activated by heating at 160 °C for two hours. In the initial experiments, NO_x , CO_2 , NH_3 , HCl , and H_2O were adsorbed at room temperature (22 \pm 2 °C) by placing paper disks over aqueous solutions of each gas for 24 h. The adsorbed quantities were measured gravimetrically.

As the equilibrium quantity of sorbed NO_x was much greater than for the other investigated gases, additional experiments were performed with NO_x and H_2O only. Ammonia was used to neutralize NO_x by subsequent sorption of NH_3 on paper saturated with NO_x . These sorption experiments were performed in the same way as described above. The ammonium nitrate formed at the surface of the paper was either desorbed by heating to $160\text{ }^\circ\text{C}$ or leached with distilled water. Sorption experiments were repeated thirty times on each disk. The disks were activated at $160\text{ }^\circ\text{C}$ for two hours after each adsorption-desorption cycle.

Determination of non-equilibrium-sorption characteristics

The same kind of sepiolite-cellulose paper disks and experimental techniques as described above were applied to measure the influence of temperature on the sorption of NO_x and H_2O (temperatures of $30\text{--}80\text{ }^\circ\text{C}$ and sorption steps of 30 min). Desorption was performed at $160\text{ }^\circ\text{C}$.

The potential of sepiolite paper or paper structures to remove NO_x from industrial waste gases by the use of TSA requires good regeneration efficiency, and high mechanical stability after many adsorption-desorption cycles. At a specified adsorption temperature ($80\text{ }^\circ\text{C}$, the temperature of waste gases from the nitric fertilizer factory in Pančevo, Serbia, was used) and a desorption temperature of $160\text{ }^\circ\text{C}$, the regeneration efficiency is expressed as the ratio of sorbed quantities: S_n/S_i where $i = 1 - n$ is the number of sorption cycles, and the stability is the ratio of corresponding tensile strengths: F_n/F_0 . F_0 and F_n are the initial tensile strength and the tensile strength after n cycles, respectively.

To measure the regeneration efficiency and the mechanical stability of the sepiolite-cellulose paper, cycling adsorption and desorption of NO_x and H_2O in the temperature interval of $80\text{--}160\text{ }^\circ\text{C}$ was repeated thirty times.

To ensure that only the sepiolite is the effective adsorbent for NO_x and not the basic, cellulose fibers, a series of parallel experiments with adsorptions and desorptions of NO_x and H_2O were performed using paper disks based on glass fibers (60 % sepiolite).

IR spectrometry and X-ray diffraction (XRD) analysis

Disks 60 mm in diameter and composed of 60 % sepiolite and 40 % cellulose fibers were placed in sealed glass vessels in atmospheres of water vapor over water or vapor over 90 % aqueous nitric acid or 25 % aqueous ammonia solution for 24 h at room temperature. Then, the disks were exposed for 24 h to open air. Subsequently, IR spectra were recorded with a Specord 75 IR spectrometer (Carl Zeiss, Jena) in the range of 4000 cm^{-1} to 400 cm^{-1} using the KBr pellet technique. To discern the effects of regeneration, one sample with adsorbed NO_x was heated for two hours at $180\text{ }^\circ\text{C}$ and another sample at $160\text{ }^\circ\text{C}$ before recording the IR spectra.

To determine how NO_x sorption changes the crystallinity of sepiolite, untreated sepiolite paper, paper after activation at $160\text{ }^\circ\text{C}$, and paper regenerated at $160\text{ }^\circ\text{C}$ after several NO_x sorption-desorption cycles were examined by XRD.

The XRD data were obtained using a Philips PV Automated Powder Diffractometer system with a TTK Temperature Attachment Unit (Anton Paar K.G.) on a Philips PW Vertical Goniometer (820, $\text{CuK}\alpha$ radiation, 35 kV, 50 mA, scanning rate of $1.5\text{ }^\circ\text{/min}$).

RESULTS AND DISCUSSION

The experiments showed that paper based on either cellulose or borosilicate glass fibers is easy to produce with 60 % ground sepiolite, and that such paper has a satisfactory structure and sepiolite fiber distribution, thickness (0.5 mm), and tensile strength (4.5 N/15 mm). Such paper may be produced on standard continuous paper machines.

The initial set of equilibrium sorption experiments (Table I) indicated that sepiolite paper at room temperature is not an outstanding sorbent for any of the used vapours

(sorbence of 6 % on average) other than NO_x , where the average sorbed quantity was 32.7 %.

TABLE I. Sorption equilibrium characteristics for humid gases

Sorbate	% Sorbed	Desorption (temperature) °C
NO_x	32.7	160
H_2O	6.0	100
CO_2	5.8	70
NH_3	5.8	70
HCl	6.7	64

Sorption equilibriums of $\text{NO}_x + \text{H}_2\text{O}$ after 8 cycles for the same sorbent were higher (3.8–6 %), with a desorption temperature of 160 °C.

Samples with adsorbed NO_x were neutralized with vapor phase NH_3 . The produced NH_4NO_3 remains in the structure of the paper and crystallizes inside it if the samples are left in sealed vessels (Fig. 2).

The quantities of NH_4NO_3 desorbed by heating at 160 °C in 8 cycles, are 35–7, or by leaching at 22–2 °C in 8 cycles are 27–5 %. Four possibilities of utilizing sepiolite paper with sorbed ammonium nitrate were considered:

1. Direct consumption of ground paper as a low grade fertilizer.
2. Leaching the NH_4NO_3 and drying and activating the paper (dry NH_4NO_3 is a high-grade fertilizer).
3. Repulping the paper, leaching ammonium nitrate, and producing new paper from the pulp.
4. Catalytic destructive desorption of NH_4NO_3 by heating the paper at 160 °C.

Chemical analysis confirmed that only NH_4NO_3 was leached by distilled water. Thermal desorption probably proceeds by catalytic destruction with sepiolite as the cat-

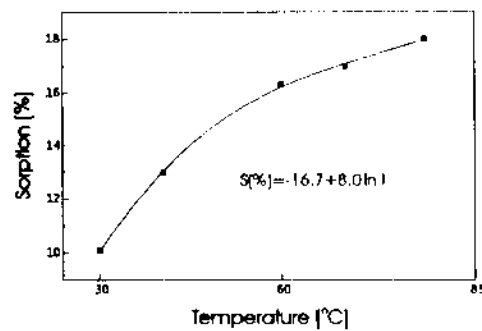


Fig. 3. Sorption-desorption of NO_x on sepiolite paper as a function of the sorption temperature (desorption at 160 °C).

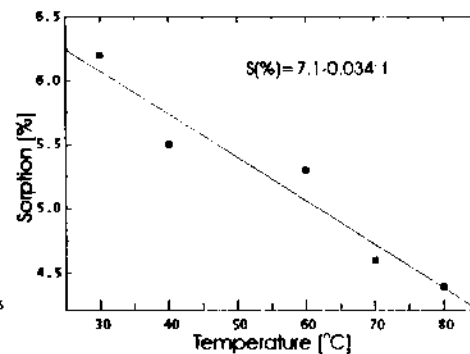


Fig. 4. Sorption-desorption of water vapor on sepiolite paper as a function of the sorption temperature (desorption at 160 °C).

alyst: $2 \text{NH}_4\text{NO}_3 \rightarrow 2\text{N}_2 + 4\text{H}_2\text{O} + \text{O}_2$ where O_2 reacts with the cellulose in the paper. This may explain the higher values obtained by thermal desorption.

The non-equilibrium measurements of the sorption capacity vs. temperature of the paper based on cellulose fibers (sorption steps of 30 min) are presented in Table II for NO_x and water vapor.

TABLE II. Sorption quantities as a function of the sorption temperature (desorption at 160 °C)

Sorbate	Temperature/°C	Sorp. - Desorp.	Average/%	Number of measurements	
NO_x	30	Sorp.	10.1 0.9	3	
		Desorp.	10.1 0.6	3	
	40	Sorp.	13 2	3	
		Desorp.	14 1	3	
	50	Sorp.	16 2	3	
		Desorp.	16.3 0.9	3	
	60	Sorp.	16.3 0.5	3	
		Desorp.	16.3 0.5	3	
	70	Sorp.	17.0 2.0	3	
		Desorp.	17.0 0.3	3	
	80	Sorp.	18 1	4	
		Desorp.	18 1	4	
	H_2O	30	Sorp.	6.2 0.2	3
			Desorp.	6.2 0.2	3
40		Sorp.	5.5 0.4	3	
		Desorp.	5.5 0.4	3	
50		Sorp.	6.2 0.2	3	
		Desorp.	6.2 0.1	3	
60		Sorp.	5.3 0.2	3	
		Desorp.	5.3 0.2	3	
70		Sorp.	4.6 0.0	3	
		Desorp.	4.6 0.1	3	
80		Sorp.	4.4 0.1	4	
		Desorp.	4.5 0.1	4	

The sorption capacity of the sepiolite paper for NO_x increases with temperature (Fig. 3).

These results and the logarithmic dependence of the sorbed NO_x on temperature suggest a chemisorption mechanism for NO_x sorption.

The linear decrease of the sorption capacity for water on sepiolite (Fig. 4) confirms the results of other research on the physical adsorption of water on sepiolite.

Cycling TSA experiments between 80 °C and 160 °C under non-equilibrium conditions are presented in Table III.

TABLE III. Cyclic sorption-desorption quantities, for the mixture water vapor-NO_x (repeated cycles with the same sepiolite paper)

Sorbate	Number of measurements	T/ °C	max. %	min. %	Aver. %	
NO _x	30	Sorp.	80	25.0	10.2	13 2
		Desorp.	160	24.4	9.7	13 2
H ₂ O	30	Sorp.	80	6.1	3.5	5.2 0.5
		Desorp.	160	6.1	3.6	5.2 0.5

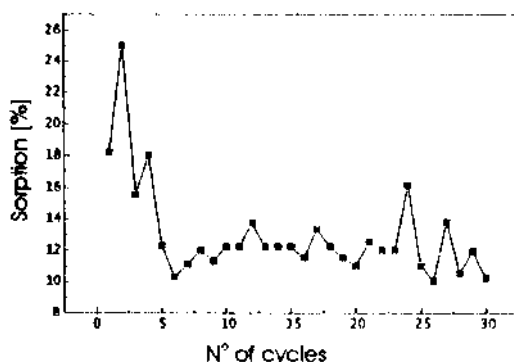


Fig. 5. Desorbed quantities of NO_x as function of the number of sorption-desorption cycles.

The results show that the adsorbed and desorbed quantities of NO_x decrease after several cycles to a near constant value of approximately 12 % (Fig. 5).

The regeneration efficiency for NO_x is: $S_{30}/S_1 = 0.55$ and $S_{30}/S_6 = 1$ which indicates that sepiolite paper may be useful as a high-capacity sorbent for a few cycles, or as a somewhat lower-capacity sorbent for a greater number of cycles. The chemisorption mechanism (Fig. 3) and the decrease in sorption capacity after several cycles is explained by partial irreversible binding of NO_x to sepiolite while the remaining NO_x is reversibly adsorbed. This was also confirmed by IR-analysis.

The sorption capacity of sepiolite paper for water slowly decreases: $S_{30}/S_1 = 0.84$.

As water adsorption on sepiolite is completely reversible between 80 °C and 160 °C, this decrease is attributed to the deterioration of the cellulose during desorption at 160 °C.

Measurements of the tensile strength of sepiolite paper strips show that the paper is partially damaged during 30 TSA cycles with NO_x because: $F_{30}/F_0 = 0.47$.

Also, the paper samples are discolored after 30 cycles, showing partial carbonization of the cellulose fibers. However, the integrity of the paper is sufficient for handling.

The measurements presented in Table IV show that approximately the same amount of NO_x is adsorbed on sepiolite paper based on borosilicate glass fibers as on

paper based on cellulose fibers: $S_{av(1-3)} = 17.2\%$ (160 °C/80 °C). However, smaller quantities of water vapor are adsorbed and desorbed than on cellulose-based paper under the same conditions: $S_{av(1-3)} = 3.6 \pm 0.2\%$ (160 °C/80 °C). These measurements show that only the sepiolite in a paper adsorbs NO_x , whereas a portion of H_2O is adsorbed on the cellulose in papers with cellulose fibers.

TABLE IV. Sorbed and desorbed quantities at a sepiolite-glass paper

Sorbate	Number of measurements	$T/^\circ\text{C}$	% Sorption
NO_x	3	Sorp.	17.2
	3	Desorp.	17.2
H_2O	3	Sorp.	3.6 ± 0.1
	3	Desorp.	3.6 ± 0.2

After three NO_x TSA cycles, the glass fiber-based sepiolite paper appears unchanged. It is to be expected that even after a very large number of TSA cycles the mechanical strength of the paper will not have changed.

The IR spectra of a cellulose-based sepiolite paper with adsorbed water and NO_x after regeneration at 180 °C and after regeneration at 160 °C, and after it is allowed to reach equilibrium with adsorbed water in a laboratory environment are presented in Fig. 6. Fig. 6a presents the spectrum of the sepiolite paper submitted to water vapor.

The Si–O–Mg band is at 440 cm^{-1} , the Si–O–Si group is at 470 cm^{-1} , and the vibrations of Mg_3OH are at 655 cm^{-1} . The vibrations at 750 cm^{-1} and 880 cm^{-1} are from CO_3^{2-} since sepiolite contains some MgCO_3 (confirmed by recording the IR spectrum of MgCO_3). The vibrations of the Si–O bonding bands appear at 980 cm^{-1} and 1080 cm^{-1} , and the Si–O–Si vibrations are present at 1020 cm^{-1} .

Shoulders from the Si–O group appear at 1200 cm^{-1} , a shoulder from CO_3^{2-} at 1450 cm^{-1} and vibrations from bonded water occur at 1620 cm^{-1} , vibrations from zeolitic water at 1660 cm^{-1} , and vibrations from CO_3^{2-} at 2880 cm^{-1} . There is a broad extended band at 3400 cm^{-1} (zeolitic water) with a smaller band at 3550 cm^{-1} , (bonded water), which suggests that the surface of the sepiolite fibers is covered by a compact layer of zeolitic and adsorbed water. For this reason, vibrations of Si–OH and Mg_3OH at 3600 cm^{-1} to 3700 cm^{-1} are not visible.

The IR spectrum of sepiolite paper on which NO_2 is sorbed is presented in Fig. 6b. Compared to Fig. 6a, it is clear that the lattice vibrations between 400 cm^{-1} and 500 cm^{-1} are very weak; Mg_3OH group vibrations at 655 cm^{-1} are not visible, and carbonate bands are absent. The lattice band from the Si–O group at 1060 cm^{-1} is evident, and the bands from zeolitic water at 1630 cm^{-1} and from zeolitic and bonded water at 3550 cm^{-1} are strong. Also, new bands appeared, one at 600 cm^{-1} , and at 830 cm^{-1} , and a very strong band at 1380 cm^{-1} .

The IR spectrum of sepiolite paper after both regeneration at 180 °C and NO_2 sorption is presented in Fig. 6c. Compared to Fig. 6b, the bands attributable to zeolitic water are much weaker (1630 cm^{-1} and 3350 cm^{-1}), as is the band at 1380 cm^{-1} . The shoulder attributable to CO_3^{2-} appears at 1340 cm^{-1} , the lattice vibrations at 1060 cm^{-1}

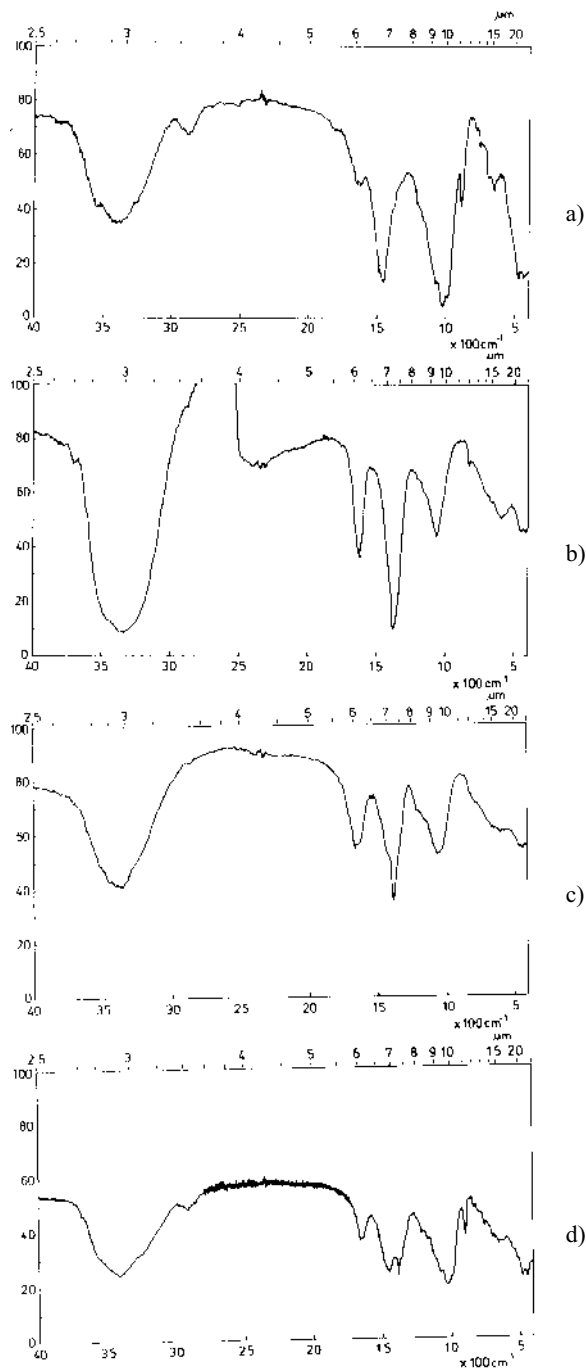


Fig. 6. a) IR spectrum of sepiolite paper submitted to water vapor; b) IR spectrum of sepiolite paper with NO₂ sorbed; c) IR spectrum of sepiolite paper regenerated at 180 °C; d) IR spectrum of sepiolite paper regenerated at 160 °C; and kept in air for about 100 days.

are the same, and a band at 1220 cm^{-1} is visible. Vibrations at 600 cm^{-1} and 830 cm^{-1} are much weaker.

Sepiolite paper regenerated from NO_2 sorption at $160\text{ }^\circ\text{C}$ and then kept in laboratory air for 100 days showed the IR spectrum presented in Fig. 6d. Bands attributable to zeolitic and bonded water are visible, as are carbonate bands at 2880 cm^{-1} , 1447 cm^{-1} , 880 cm^{-1} and 760 cm^{-1} , lattice vibrations between 400 cm^{-1} and 500 cm^{-1} are clear, as are vibrations at 655 cm^{-1} and the band at 1380 cm^{-1} remained, although much weaker than the corresponding band in Fig. 6b.

The IR results indicate that a portion of the nitric oxides bonds to the sepiolite lattice by removing OH groups of the constitutive water and occupying its place (vibrations at 655 cm^{-1} attributable to Mg_3OH are probably covered by a new peak). This produces new bands at 1380 cm^{-1} and 600 cm^{-1} , which probably result from NO_x bonded to the oxygen of the Mg-O-Si group (450 cm^{-1}). This bond is not strong, since NO_x was desorbed as a result of heating and the resulting IR intensity decreased. The strongest bonds with NO_x are within the sepiolite structure, where some OH groups of constitutive water are exchanged by the NO_x , since the band at 1380 cm^{-1} remains after heating the paper or by placing it in air for a long period of time. This fact can explain the decrease in the quantity of NO_x sorbed on the paper, which has a constant value of about 12 % after several sorption-desorption cycles. A portion of the sorbed NO_x is strongly bonded to the sepiolite crystal lattice (a little weaker at the edges of sepiolite cells, where, also, constitutive OH groups are bonded to Mg ions), and, therefore, only a portion of the nitric oxide bonded to the zeolitic water inside the sepiolite channels are sorbed and desorbed.

Fig. 6d also shows that sorbed nitric oxides do not destroy the CO_3^{2-} group, since the band appears after the water and NO_x are desorbed.

The IR-spectrum of paper placed in an ammonia atmosphere and released in air is shown in Fig. 7. There are no great differences between this spectrum and the spectrum presented in Fig. 6a, although the vibrations of bonded water are weaker (at 1620 cm^{-1} and 3550 cm^{-1}). These results, and the fact that only 5 % of NH_3 is sorbed, indicate that ammonia is adsorbed by zeolitic water.

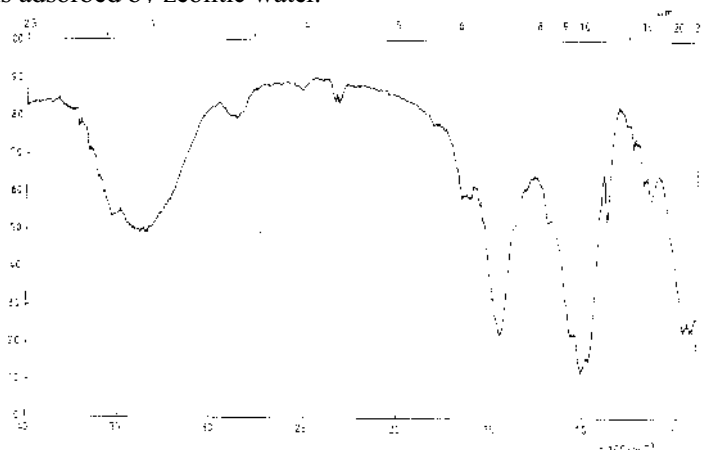


Fig. 7. IR spectrum of paper with sorbed ammonia.

The X-ray diffractograms of paper before NO_x sorption and of the same paper after NO_x sorption and desorption by heating at 160°C are shown in Fig. 8a and b, respectively. The letters S and Mg denote sepiolite and magnesite, respectively. Also present are two nonidentified peaks (Fig. 8a). One of these peaks does not occur in Fig. 8b and can possibly be ascribed to the cellulose in the paper.

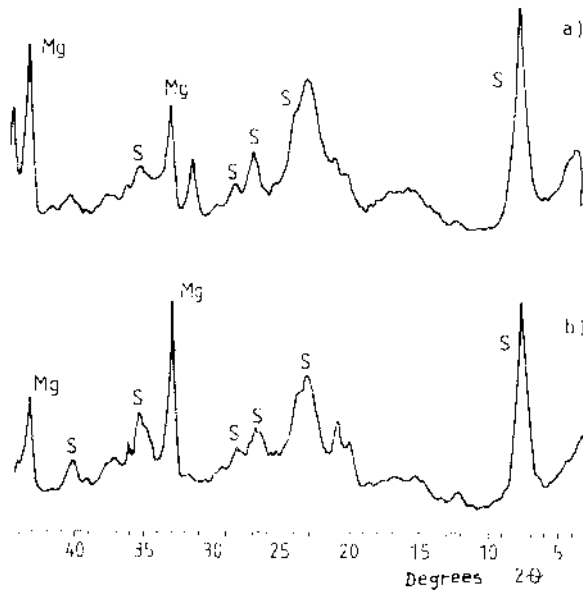


Fig. 8. a) X-Ray diffractogram of paper before NO_x sorption; b) X-Ray diffractogram of paper after NO_x sorption and after regeneration at 160°C .

CONCLUSIONS

- Sepiolite is an excellent material for the production of sorbent, or catalytic papers with either cellulose or glass fibers due to its fibrous structure, affinity for basic fibers, and the properties of sepiolite as a sorbent, a carrier of catalysts, or a catalyst.
- Sorbents in the form of paper have many advantages over powders and granules, such as the accessibility of the surface, pressure losses, and regeneration ability, as well as in production processes and in the construction of adsorption units.
- Sepiolite paper shows good characteristics for the sorption of NO_x and chemisorption of NH_3 when NO_x is already sorbed.
- TSA cycles between 80°C and 160°C and with 30 regenerations show that the capacity of a paper for NO_x decreases after several cycles, but remains constant after that (about 12 % adsorbed and desorbed). Paper based on cellulose fibers is not seriously damaged, and it can be expected that paper based on borosilicate glass fibers will not be damaged at all.
- NH_4NO_3 was removed from the paper by leaching or destroyed by heating.
- Infrared spectrometry shows that the structure of sepiolite is not destroyed by the sorption of NO_x and regeneration of the paper, but a portion of the NO_x is irreversibly bonded to the sepiolite.

ИЗВОД

СОРПЦИОНЕ КАРАКТЕРИСТИКЕ ХАРТИЈЕ ПРОИЗВЕДЕНЕ ОД СЕПИОЛИТА

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Лабараторијски произведена хартија од сепиолита из рудника Голеш (Србија) је испитивана да се одреде ради одређивања њених сорпционих карактеристика за азотове оксиде, водену пару и амонијак. Хартија је адсорбовала високе проценте азотових оксида, а амонијак је стехиометријски хемисорбован на хартији засићеној са NO₂ и H₂O. Инфрацрвена спектроскопија је показала да сорпција азотових оксида и амонијака не разара кристалну решетку сепиолита, што је потврђено XRD-анализом. Сорпција азотових оксида и амонијака се одиграва у зеолитској води унутар структурних канала сепиолита. Адсорпција са варијацијама притиска (PSA) или температуре (TSA) може се применити на десорпцију азотових оксида велики број пута. Амонијум-нитрит настао сукцесивном адсорпциом NO₂ и NH₃ се може из хартије уклонити лужењем, при чему се хартија репулпира, или термичком разградњом. Такође ова хартија може да се користи као вештачко ђубриво.

(Примљено 10. јануара 2001)

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