Comparative Characteristics of Local and Foreign Bentonites

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Summary: Comparative analysis was performed of local bentonites of SPECJAL EXTRA U and IZOL types, produced by Zakłady Górniczo-Metalowe Zębiec, and of LT type bentonite, produced by Rheox company. Principal physicochemical properties of the bentonites were established, including bulk density, capacities to absorb water, dibutyl phthalate and paraffin oil and their sedimentation rates in water, xylene and gasoline were estimated. Bentonite morphology was examined using scanning electron microscope (SEM). Moreover, particle size distribution, BET surface area and zeta potential were determined.

Introduction

Bentonites find several applications, particularly in foundries (as materials to prepare moulds), in drilling (as a drilling fluid), in paint, varnish and pigment paste industries (as fillers), as tixotropic agents, leak stoppers, in fertilizer production (to prepare suspension fertilizers), in construction, purification of oils, in production of veterinary drugs.[1]

The most important trait of bentonite involves its potential to swell under effect of solvent, e.g. water, which results from packet structure of the stratified bentonite. An approximate formula of the bentonite may be presented as follows:

$mMg_3[Si_4O_{10}](OH)_2*p(Al_2\ Fe^{III})_2[Si_4O_{10}](OH)_2*nH_2O$,

with m : p ratio = 0.8-0.9.

On the average, bentonites contain: 48-56% SiO_2, 11-22% Al_2O_3, 5% or more Fe_2O_3, 4-9% MgO, 0.8-3.5 % CaO, 12-24% H_2O, traces of K_2O, Na_2O etc.[2-4]

Measurements

Bentonite samples were subjected to numerous physicochemical tests. Bulk density, capacities to absorb water, dibutyl phthalate and paraffin oil were determined. Estimation of sedimentation rate permitted to determine directly suitability of bentonite

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samples to play role of fillers in paints and varnishes. Bentonite sedimentation was tested in water, xylene and gasoline. In order to determine morphology of tested samples SEM studies were conducted using the Philips 515 scanning electron microscope. Specific surface area (BET) of bentonites was calculated on the basis of the curves of nitrogen adsorption-desorption on their surface, using ASAP 2010 apparatus. The adsorption curves permitted also to calculate total volume of pores and diameter of pores. The particle size distribution was analysed by the dynamic light scattering (DLS) technique in ZetaPlus apparatus (Brookhaven). The same equipment permitted also to estimate zeta potential by the electrophoretic light scattering (ELS).

Results and discussion

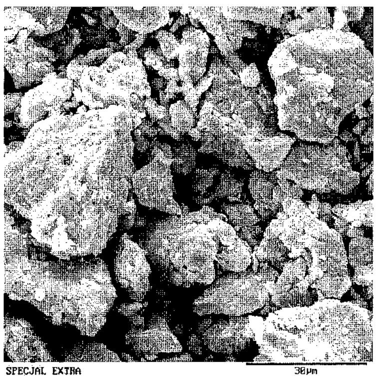
Results of principal physicochemical tests are presented in Table 1.

The bentonites exhibited a variably hydrophilic character. LT bentonite was evidently hydrophilic, as shown by its high capacity to absorb water (of 1900 $cm^3/100g$ order) and by its lack of wettability with xylene and gasoline. The bentonite proved to be very light showing bulk density of 350 g/cm^3 order. The local bentonites, SPECJAL EXTRA U and IZOL manifested a much lower hydrophilic character (capacity to absorb water within the range of 200 - 650 $cm^3/100g$) and were well wettable with xylene and gasoline (sedimentation time in gasoline of 60 s order and in xylene of 30 s order) Both of the bentonites were relatively heavy: bulk densities amounted to over 500 g/cm^3.

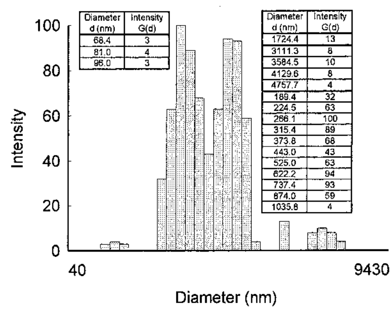
Table 1. Principal physicochemical properties of tested bentonites.

PARAMETER	SPECJAL EXTRA U	IZOL	LT
Bulk density, g/dm^3	565	506	350
Capacity to absorb water, $cm^3/100g$	650	225	1900
Capacity to absorb dibutyl phthalate, $cm^3/100g$	150	175	150
Capacity to absorb paraffin oil, $cm^3/100g$	75	100	175
Sedimentation in water, s	Stable suspension	Few hours	Stable suspension
Sedimentation in petrol, s	57	58	No wettability
Sedimentation in xylene, s	32	31	No wettability

Studies on morphology using scanning electron microscopy demonstrated differences in surface structure between the bentonites. Bentonites IZOL and LT manifested a packet structure while SPECJAL EXTRA U bentonite showed an irregular structure. The bentonites demonstrated a variable particle size distribution: SPECJAL EXTRA U bentonite (Fig. 1) contained particles within the range of 68.4 nm to 4757.7 nm (maximum intensity of 100 corresponded to particles of 266.1 nm in diameter). The IZOL bentonite proved to be most uniform (Fig. 2); it contained particles within the narrow range of 399.4 nm to 405.9 nm (maximum intensity of 100 corresponded to particles of 404.3 nm in diameter). The LT bentonite, on the other hand, demonstrated two ranges of particle size: the first of 534.0 nm to 811.3 nm and the other of 8,111.6 nm to 10,000 nm (Fig. 3).



a)



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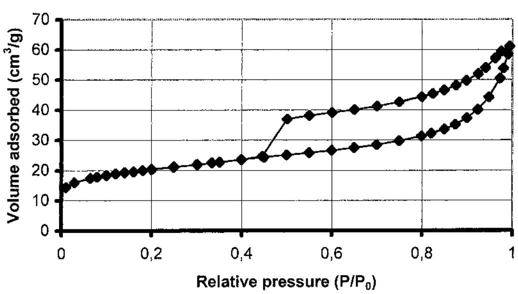


c)

Figure 1. SEM micrograph (a), multimodal particle size distribution (b) and adsorption/desorption curve of N_2 (c) of SPECJAL EXTRA U bentonite.

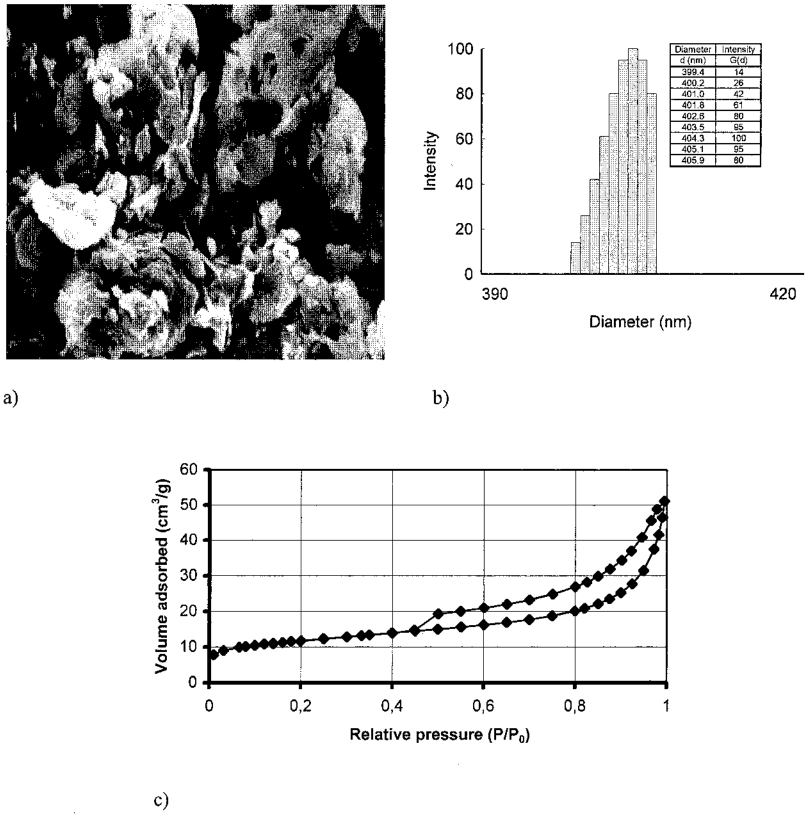
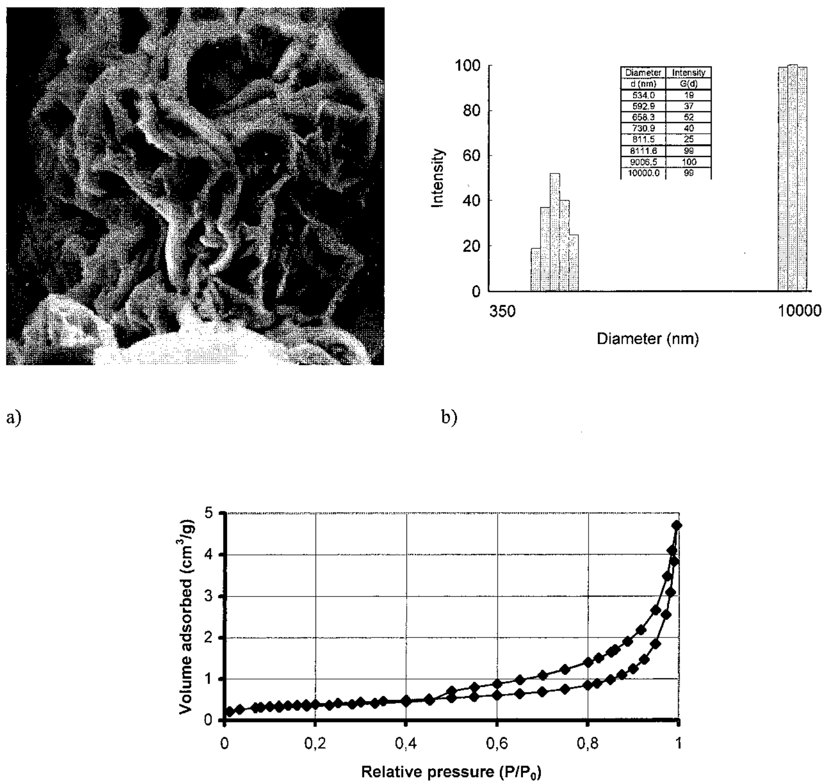


Figure 2. SEM micrograph (a), multimodal particle size distribution (b) and adsorption/desorption curve of N_2 (c) of IZOL bentonite.

Table 2. Zeta potential and adsorption characterization of bentonites.

Parameter	SPECJAL EXTRA U	IZOL	LT
Specific surface area (BET), m^2/g	71.2	40.5	1.4
Zeta potential, mV	(-41.35)	(-32.86)	(-7.30)
Total pore volume, cm^3/g	0.078146	0.059364	0.003951
Mean diameter of pores, Å	43.92	58.65	112.00



c)

Figure 3. SEM micrograph (a), multimodal particle size distribution (b) and adsorption/desorption curve of N_2 (c) of LT bentonite.

As shown by the data of Table 2, the LT bentonite manifested the lowest absolute value of zeta potential. Specific surface area (BET) amounted to 71.2 m^2/g for SPECJAL EXTRA U bentonite, 40.5 m^2/g for IZOL bentonite, while LT bentonite manifested a clearly more restricted specific surface area (1.4 m^2/g only). LT bentonite demonstrated a very low total pore area (only 0.003951 cm^3/g), which reflected its strongly hydrophilic character, reflecting dense packing of silanol groups on its surface. The two remaining bentonites of the less hydrophilic character demonstrated a much more extensive specific surface area and greater total pore volume (within the range of 0.06 – 0.08 cm^3/g).

Minerals of bentonite type belong to laminar and band silicates. They are formed of tetrahedric and octahedric layers bound by weak inter-packet bonds. In aqueous medium, bentonite agglomerates break down upon dispersion, forming gels in the form of a needle meshwork. Individual bentonite packets are separated from each other due to adsorption of up to several monolayers of associated water. The inter-packet water make the structure loose which leads to swelling and agglomeration of crystals forming the needle meshowork structure of the gel. In this way the extensive capacity to absorb water of bentonite can be explained, which is noted even in cases when bentonite exhibits very low specific surface area.

Conclusion

The studied bentonites demonstrated different extent of hydrophilicity. The LT bentonite (Rheox company) showed a strongly hydrophilic character and formed stable dispersions in water. Thus, it may constitute a very good filler of aqueous paints. On the other hand, the Polish bentonites SPECJAL EXTRA U and IZOL show the filler potential in non-aqueous systems due to their low hydrophilicity.

Acknowledgement

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