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DEFLOCCULATION OF KAOLIN SUSPENSIONS – THE EFFECT OF VARIOUS ELECTROLYTES

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ABSTRACT:
Viscosity reduction of aqueous kaolin suspensions by conventional additives (deflocculation) is studied, using standard viscosity measurements. Apparent viscosity at 100 s^{-1}, and flow behavior index *n* give complex information about changes of viscosity and flow character of deflocculated suspensions. Several widely used deflocculants – electrolytes and polyelectrolytes – are tested in a wide range of concentrations. The optimum concentrations of these deflocculants, which result in minimum apparent viscosity of suspension, are found. Sedimentation stability of deflocculated suspensions is monitored. Inorganic electrolytes are found to be more effective in viscosity reduction. On the other hand, low-molecular-weight polyelectrolytes produce more stable final suspensions.

KEY WORDS:
kaolin suspensions, deflocculants, viscosity measurements, stability of suspensions

1 INTRODUCTION

Reducing viscosity by addition of a small amount of suitable electrolyte is widely used for aqueous kaolin suspensions in ceramic, paper and dye industries to facilitate transport, agitation, and other mechanical operations. This process is called deflocculation, due to the assumed mechanism of the particle interactions in a liquefied suspension. Mineral kaolinite is a dominant compound of the kaolin clays. Kaolinite particles with their two-face layer structure (the octahedral alumina layer covered by hydroxyl groups and the tetrahedral silica layer with excreted oxygen [1, 2]) are susceptible to creating of hydrogen bonds and thus exhibit strong electrochemical interactions in aqueous media. This is the reason why a small addition of an electrolyte influences the finally achieved viscosity and stability of aqueous kaolin suspensions. Adsorption of chemical agents on different parts of kaolin structure (faces or edges) is strongly affected by pH value of the suspension.

The intensity of electrochemical interactions is manifested via zeta-potential. It gives information on the difference of potentials between the particles covered by electrical double layer and the surrounding medium. If zeta-potential is high, repulsion forces between particles are strong, interacting particles do not aggregate, and the prepared suspension is stable and low viscous. A lot of works deal with the measurement of zeta-potential of mineral suspensions in dependence on the content of additives and the actual value of pH [3–9]. The information obtained from zeta-potential measurement of kaolin suspensions is not easy to interpret because of the complex structural character of kaolinite (silica and alumina faces have different surface potentials [10]). The dominant particle interactions influence the internal structure and consequently also the rheological behavior of kaolin suspensions [3, 11]. The viscosity measurements, therefore, can provide fundamental information on the quality of suspensions. Changes in flow behavior of mineral suspensions caused by additives are usually described in the form of the dependence of yield stress on the content of additives and the actual value of pH [3, 4, 8, 9]. The yield stress is found to be inversely proportional to square of zeta-potential and directly proportional to a power of the volume fraction of solid particles in the suspension [3].

Only few works deal with detailed viscosity measurements of aqueous kaolin suspensions, see [12] for the primary suspensions and [13–20] for the suspensions with additives. Unfortunately, these works are focusing on a limited number of additives and their concentrations. The observed flow curves exhibit mostly shear-thinning character, but in some cases shear thickening [13, 18] or even anti-thixotropy [19] has been observed. Practically all used additives decrease viscosity of aqueous kaolin suspensions. Only the additives with the presence of Ca^{2+} ions play an opposite role, increasing suspension viscosity [18]. Settling of kaolin suspensions is widely studied as a separation process connected with flocculated kaolin suspensions [9, 21–26]. A typical observed parameter is the settling time in dependence on type and concentration of the flocculant agents. Also deposit and supernatant quality are inspected, e.g. via turbidity measurement [26], and a characteristic density profile in settling suspension is expected [21]. Nasser and James [23] studied sedimentation of both flocculated and deflocculated kaolin suspensions. The character of sedimentation process differs strongly for these two situations. In flocculated suspensions particles create aggregates due to dominant Van der Waals interactions and these aggregates settle fast with sharp interface between structured deposit and clear supernatant. Deflocculated suspensions contain the particles, which are influenced mainly by electrostatic repulsions, and therefore they settle slowly. The deposit grows from bottom and the border between the deposit and turbid supernatant is not clear.

The aim of this work is to study the effect of added electrolytes on the changes in viscosity of aqueous kaolin suspensions. The results of viscosity measurements are presented for several widely used deflocculants in wide range of concentrations (from 0.1 to 3 %). Also the stability of resulting deflocculated suspensions is qualitatively classified and the final evaluation of deflocculation process is given.

2 EXPERIMENTAL

2.1 MATERIALS

Kaolin “Sedlec Ia” produced by Sedlecký Kaolin Inc. was used for preparing aqueous kaolin suspensions. This kaolin contains more than 90 % of mineral kaolinite ($Al_2O_3.2SiO_2.2H_2O$) with wide particle size distribution (typically 60 % of particles are smaller than 2 μm, negligible amount of particles is larger than 60 μm). The BET surface area is 18.57 m^2/g. The list of the electrolytes used as deflocculation additives is presented in Table 1. NaOH and Na_2CO_3 are well-defined chemical compounds. The sodium hexametaphosphate (SHMP) is a mixture of polymeric metaphosphates with the prevailing hexamer $(NaPO_3)_6$. The water glass (WG) is 36 % aqueous solution of a sodium silicate with ratio SiO_2:Na_2O about 3 : 1. Three samples of NaCMC with different molar masses, which differ also by degree of substitution, were used as polyelectrolytes.

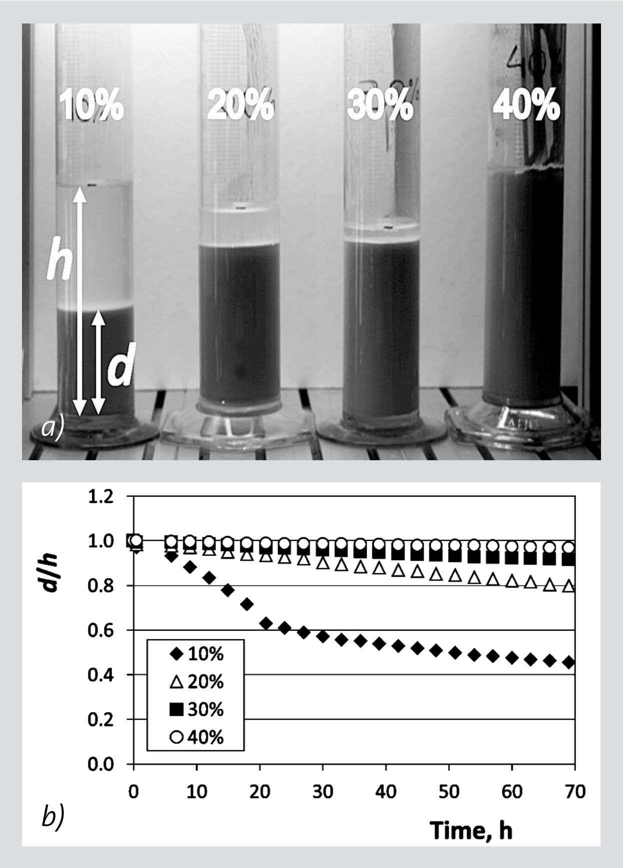

Figure 1: Sedimentation test of 10, 20, 30, and 40 % aqueous kaolin suspensions. a) Final state after 70 hours. b) Sedimentation course (h = total height, d = height of the deposit).

The primary suspensions were prepared by blending kaolin with distilled water. Resulted suspensions were let at rest for 3 days and then gently agitated until reaching homogeneous state. Deflocculated suspensions were prepared in a similar way, by blending kaolin with aqueous electrolyte solutions. The concentration of additives, c_{add}, is expressed in weight percentage rel-

Electrolyte notation	Molar mass [g/mol]	Note on chemical composition	Producer
SHMP	612	$(NaPO_3)_6$	Penta
NaOH	40	-	Penta
WG	224	$SiO_2 : Na_2O \approx 3$	Kittfort
Na_2CO_3	106	-	Penta
SHMP/Na_2CO_3	-	1:1 wt.	Penta
NaCMC-90	90×10^3	DS* ≈ 0.7	Aldrich
NaCMC-250	250×10^3	DS* ≈ 0.9	Aldrich
NaCMC-700	700×10^3	DS* ≈ 0.9	Aldrich

*Table 1: List of the additives used as deflocculants (SHMP – sodium hexametaphosphate, WG – water glass, NaCMC – sodium salt of carboxymethylcellulose, *DS – Degree of substitution = number of carboxymethyl groups per anhydroglucose unit).*

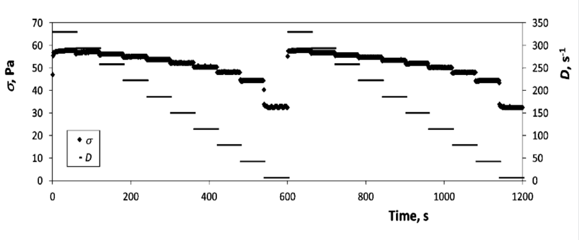

Figure 2: Shear stress response σ to staircase course of apparent shear rate D measured for 35 % aqueous kaolin suspension.

atively to the mass of kaolin. A simple sedimentation test was used to determine the suitable concentrations of the tested aqueous kaolin suspensions. The suspensions containing 10, 20, 30 and 40 %wt. of kaolin were let at rest for 70 hours and their settling was monitored by a high resolution camera. Typical result of the monitoring is shown in Figure 1a (photograph of the final state) and Figure 1b (course of the sedimentation). This settling test proved that the primary (not deflocculated) suspensions containing 30 % or more of kaolin are sufficiently stable against sedimentation. The subsequent viscometry testing was made with the 30, 35, and 40 % primary aqueous kaolin suspensions, modified by additions of deflocculants. Prior the viscosity measurements, the suspensions had been kept at rest and shaken from time to time. After becoming homogeneous, they were used for the viscosity measurements.

2.2 VISCOMETRY

Brookfield viscometers LVDV-II+Pro Extra and HBDV-III Ultra were used for viscosity measurements. The chamber SC4-13R/RP (R_c = 9.53 mm, depth 64.77 mm) was used in combination with the spindle SC4-18 (R = 8.74 mm, L = 31.72 mm, L_{eff} = 35.53 mm) or SC4-31 (R = 5.88 mm, L = 25.15 mm, L_{eff} = 30.68 mm). The vane spindle V72 (R = 10.84 mm, L = 43.38 mm) in a large beaker ($R_c \approx 35$ mm) was used in preliminary test. All viscosity measurements were done at 25 °C. The viscosity results are expressed in the shear stress $\sigma = M/(2\pi R^2 L_{eff})$ and apparent shear rate $D = 2\Omega/(1-\kappa^2)$ or the corresponding apparent viscosity $\eta = \sigma/D$ as the primary data, obtained from the commercial software RheoCalc32, Brookfield Engineering Labs. Here, M is the torque, R_c the container radius, R the spindle radius, L the spindle length, L_{eff} the effective spindle length, Ω the angular rotation speed of spindle, and $\kappa = R/R_c$. It is well known [27, 28, 29] that the flow curve $D = D(\sigma)$ coincides with true viscosity function $\dot{\gamma} = \dot{\gamma}(\sigma)$, where $\dot{\gamma}$ stands for the shear rate, only for Newtonian flow behavior or narrow enough gaps, and provides acceptable estimates only for liquids with the flow index $n > 0.3$ assuming $R/R_c > 0.8$.

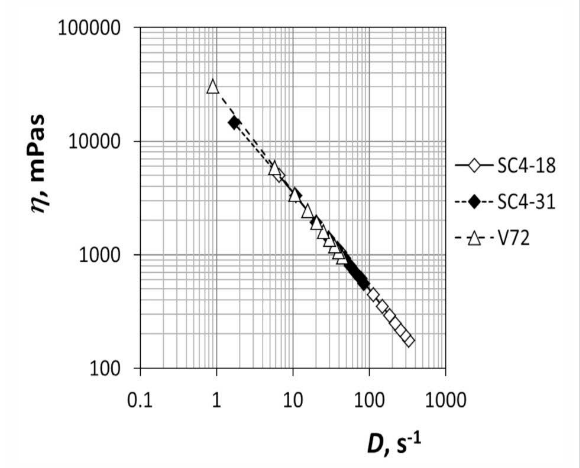

Figure 3: Steady state flow curves measured for 35 % aqueous kaolin suspension with using three different spindles.

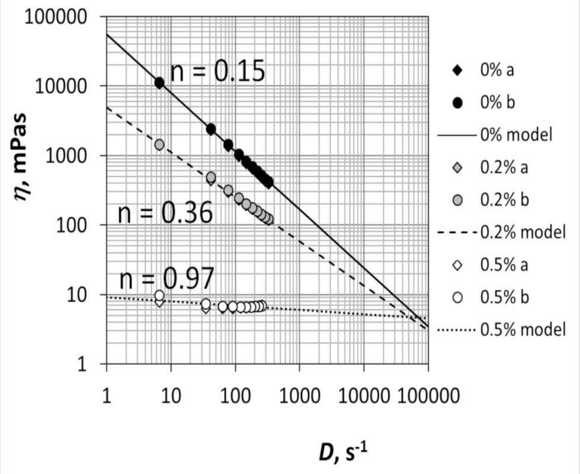

Figure 4: Example of steady state flow curves measured for 40 % aqueous kaolin suspensions without (black) and with SHMP additive (0.2 % grey, 0.5 % white symbols). Two independent samples were measured (series a and b). Data are fitted and extrapolated using power-law model (Equation 1).

First, the time necessary for reaching steady viscometric flow after a step change of rotation speed was determined. This test was done for the 35 7% primary suspension with the spindle SC4-18. An example of the shear stress response on a staircase change of apparent shear rate is given in Figure 2. In the test with 60 s delays on each step, the duration 30 s was sufficient for reaching the steady state. Therefore, the staircase course with the step period of 30 s was used in all the subsequent viscosity measurements. Repeating the staircase experiment twice without changing the sample then verified that an eventual sedimentation did not affect the viscosity measurements.

The apparent wall slip (AWS) [30] could influence viscosity measurements of colloidal suspensions and leads to their misinterpretation. This effect can be expected especially for smooth cylindrical spindles with narrow gaps ($h = R_c - R$), i.e. the corresponding apparent viscosity at a given shear stress would be higher than real one. For wide gaps AWS effect is weaker and for vane spindles completely avoided [31]. There-

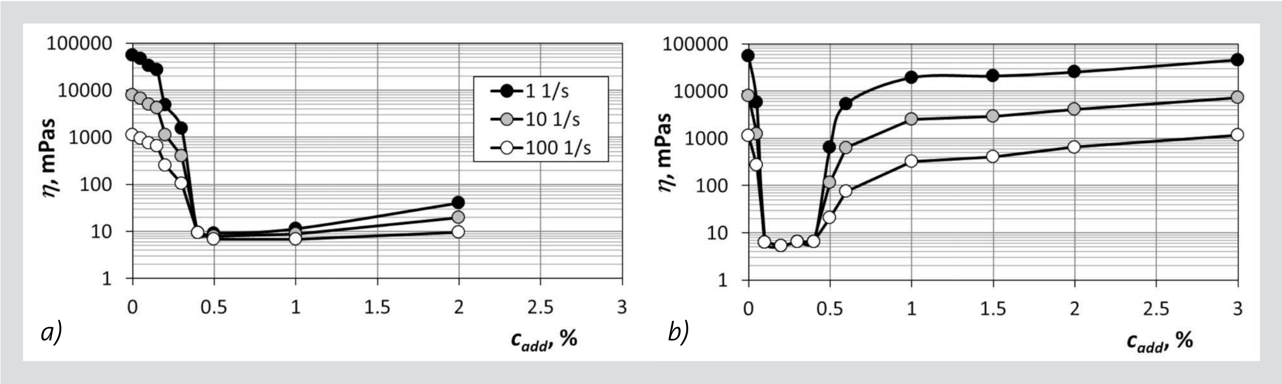

Figure 5: Variation of apparent viscosity η at various D with concentration of additive c_{add} for 40 % aqueous kaolin suspensions with addition of a) SHMP and b) NaOH.

fore, two cylindrical spindles (SC4-18, SC4-31) with different gap thickness and the vane spindle V72 in a beaker were used to inspect whether the AWS effect play a role in our viscosity measurements. The results for the 35 % primary suspension are shown in Figure 3. As the almost identical flow curves was obtained for all the used sensors, the AWS effect is found not to be playing an important role in our viscosity measurements within the given range, accuracy and sensitivity of primary viscometric data. Steady state flow curves for all tested samples were then measured using the spindle SC4-18. This configuration with the ratio $R/R_c = 0.92$ matches satisfactorily the narrow gap approximation. The reproducibility of viscosity measurements is demonstrated for 40 % kaolin suspensions with addition SHMP. The viscosity data for two independent samples (marked as series a and b) given in Figure 4 are almost identical, confirming good reproducibility. The flow curves can be fitted very well over the measured range of *D* by the power-law model

$$\eta(D) = KD^{n-1} \tag{1}$$

where *K* stands for the consistency coefficient, and *n* is the flow index. As seen in Figure 4, an addition of electrolyte strongly affects not only the consistency of samples, but also the character of shear thinning behavior from almost ideal plastic ($n = 0.15$) to practically Newtonian ($n = 0.97$). Note that the analogous data can be drawn for all studied samples, for various kaolin concentrations and different electrolyte additives. A part of results gives flow indexes less than 0.3. The flow curves corresponding to them differ from the true viscosity functions. In these cases, the apparent shear rates calculated from angular rotation speeds of the spindle are determined with quite large errors, overwhelming 10 % (see the study of Estelle at al. [29] for the analysis of using Newtonian approximation for power law liquids). In spite of this inaccuracy the main goal of this study (i.e. finding of the optimum additive concentration for the maximum reduction of suspension viscosity) could be satisfactorily realized.

3 RESULTS AND DISCUSSION

Not only low viscosity but also good homogeneity and stability are needed to classify the suspensions as reasonable from the technological viewpoint. In this section, first the viscosity and stability results are discussed separately, and then the final evaluation for all used deflocculants is given.

3.1 APPARENT VISCOSITY

The fluid mechanics of inelastic non-Newtonian liquids, so called Generalized Newtonian Liquids [32, 33], is based on the notion of viscosity material function. Even if the viscosity function is represented by the simple power-law model, the related two-parameter information can be too complex for a pragmatic use by chemical and production engineers. For this reason, the results of physicochemical studies on deflocculation [14–16, 18, 20] are commonly presented in terms of the apparent viscosity, which is measured at some a priori chosen reference apparent shear rate *D*. The problem, in comparing the viscosity results from various sources, lies in differences of the chosen reference *D* (e.g. $D = 1\ s^{-1}$ in [14], 58 s^{-1} in [15], 65 s^{-1} in [18], 120 s^{-1} in [16], 50 and 199 s^{-1} in [20]). To clarify this point, we present in Figure 5 viscosity data from two series of our measurements (40 % suspensions with addition of SHMP and NaOH) for three different *D*. For both additives there is a sharp decrease of apparent viscosity at some characteristic concentration of additive, c_{add}, independent of the chosen reference *D*. On the other hand, the level of viscosity decrease given by the ratio between the viscosity of deflocculated suspension and that of primary suspension is strongly shear rate dependent. Much higher viscosity reduction is observed at low than at high shear rates (e.g. data from Figure 5a provide viscosity reduction 5000 times at $D = 1\ s^{-1}$ and just 100 times at $D = 100\ s^{-1}$). There is also a limitation in arbitrariness for choosing the reference *D*: when comparing viscosity functions with very different flow behavior indexes and choosing too high extrapolated *D*, it would be possible to operate close to intersections of the flow curves, where the apparent viscosity is the same at all concen-

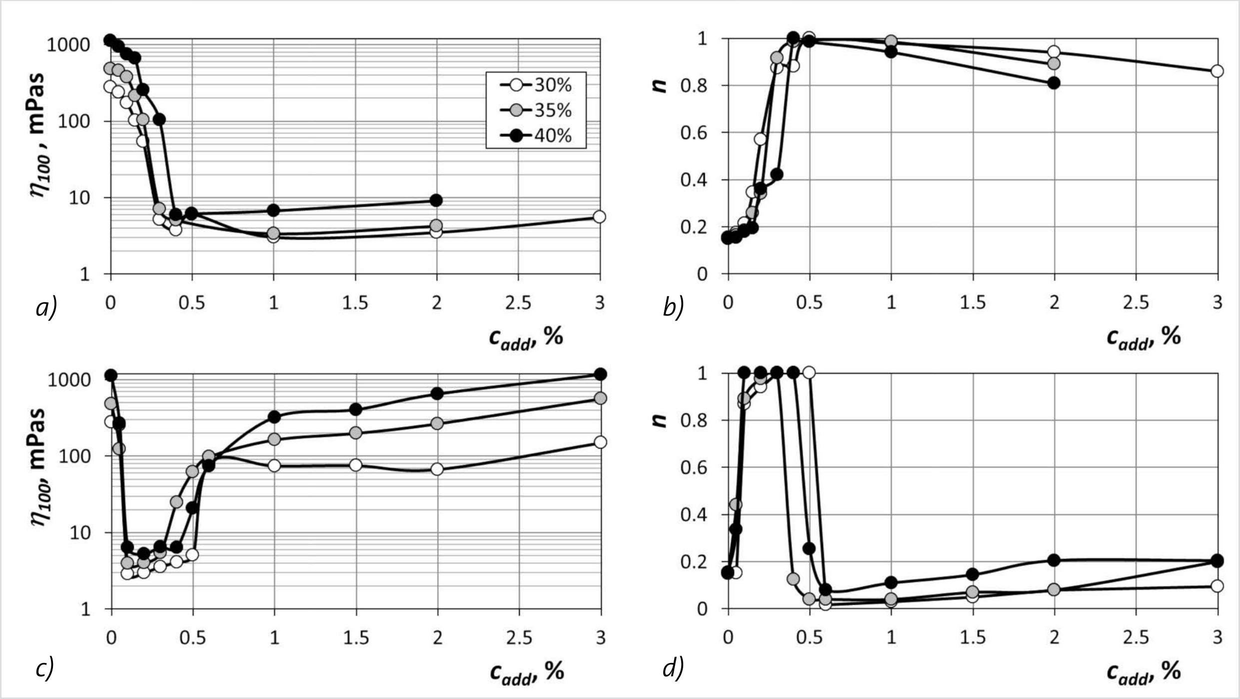

Figure 6: Variation of the apparent viscosity η_{100} and flow index n with concentration of additive c_{add} for 30, 35 and 40 % aqueous kaolin suspensions with addition of a), b) SHMP and c), d) NaOH.

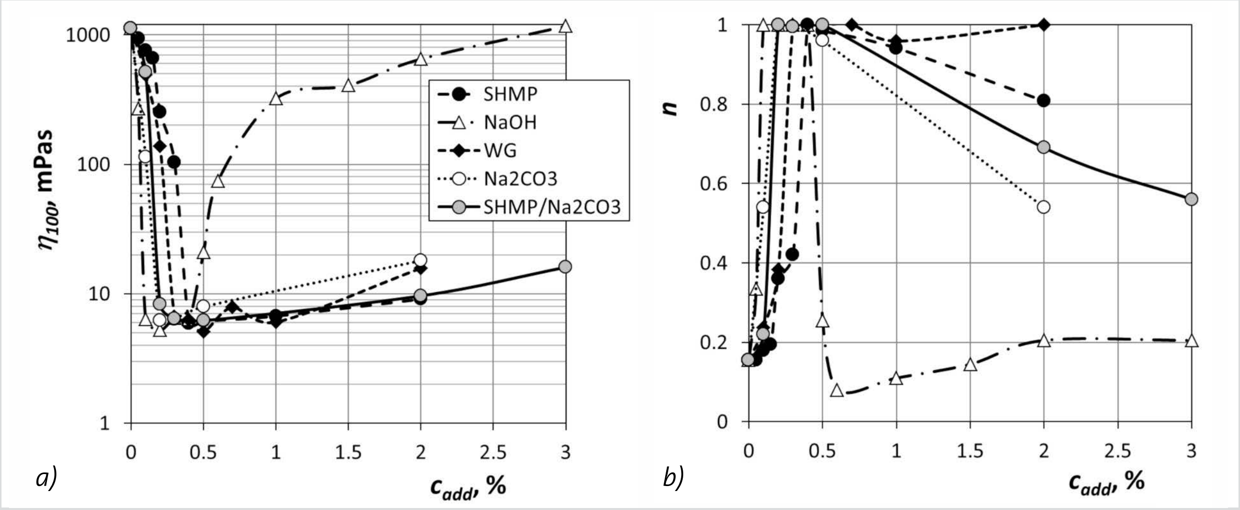

Figure 7: Variation of a) apparent viscosity η_{100} and b) flow index n with concentration of additives c_{add} for 40 % aqueous kaolin suspensions with addition of inorganic electrolytes.

trations c_{add} (see Figure 4). In this study, the viscosity data are specified by the apparent viscosity η at $D = 100\ s^{-1}$, which is marked as η_{100}. For keeping the complete experimental information, the information on flow behavior index *n* accompany the η_{100} data. As it is obvious from Equation 1, this information enables to calculate, if needed, the value of consistency coefficient and to obtain the value of apparent viscosity at any other reference *D*.

Inorganic additives

The viscosity changes with addition of SHMP and NaOH were firstly tested for suspensions with three concentrations of kaolin, i.e. 30, 35, and 40 %wt. As depicted in Figure 6, both these deflocculants exhibit a sharp viscosity decrease (Figure 6a and c) connected with the change in flow behavior from shear thinning to Newtonian one (Figure 6b and d). For all the kaolin concentrations these changes occur at the same concentrations of additives, c_{add}. The resulting viscosities η_{100} exhibit similar values for all the kaolin concentrations and the both tested deflocculants. For SHMP addition (Figure 6a) the apparent viscosity does not change significantly after reaching the minimum. For NaOH (Figure 6c) there

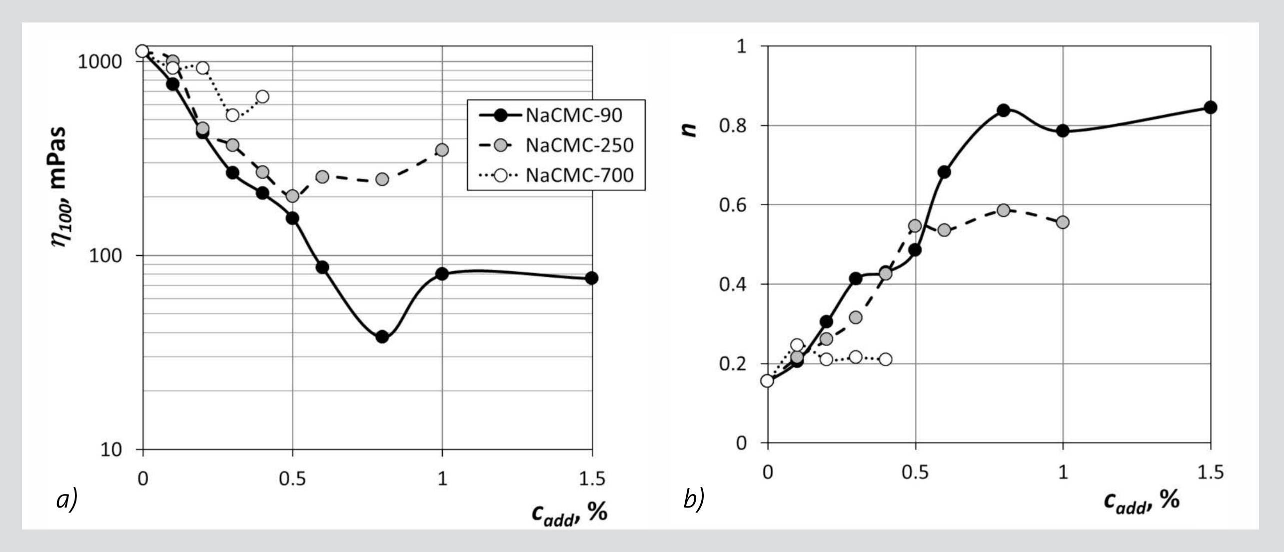

Figure 8: Variation of a) apparent viscosity η_{100} and b) flow index n with concentration of NaCMC additives c_{add} for 40 % aqueous kaolin suspensions.

is only narrow range of c_{add} with reduced apparent viscosity, followed by significant viscosity increase and recovery of shear thinning behavior (Figure 6d) when NaOH is overdosed. At $c_{add} \approx 3$ % the apparent viscosity rises back to the values of primary suspensions. Due to agreement of these viscosity trends for all the kaolin concentrations, the subsequent viscosity measurements for the other electrolytes were done only with the 40 % primary suspension. The results for all the studied inorganic additives are given in Figure 7a (apparent viscosity) and Figure 7b (flow behavior index). All the electrolytes reduce the apparent viscosity of suspensions to the same level of several mPas. This reduction of viscosity is connected with reaching of Newtonian behavior. The optimum c_{add} (necessary for reaching the minimum apparent viscosity) are however different: 0.1 % for NaOH, 0.2 % for Na_2CO_3, and mixture SHMP/Na_2CO_3, 0.3 % for WG, and 0.4 % for SHMP.

Organic additives

The viscosity changes of 40 % aqueous kaolin suspension with NaCMC were studied for three different molar masses of the polymer. The results are again represented by the apparent viscosities η_{100} (Figure 8a) and the flow indexes *n* (Figure 8b). The low molecular weight NaCMC-90 works quite well as deflocculant: the minimum apparent viscosity is achieved at $c_{add} \approx 0.8$ %. The decreasing apparent viscosity is again accompanied by increasing of flow index but, in this case, the flow behavior remains slightly shear thinning ($n \approx 0.8$). The medium-molecular-weight NaCMC-250 shows similar trends, but the decrease of viscosity and the increase of flow index are much smaller. The viscosity changes due to addition the high-molecular-weight NaCMC-700 are not significant at concentrations below 0.4 %. At higher concentrations, the viscosity increase (not measured) indicates that this high-molecular-weight polymer acts rather as thickener than a deflocculant.

Common trends

The viscosity data from Figures 7a and 8a are plotted in Figure 9 versus the concentrations of additives recalculated to moles of Na^+ per gram of kaolin. This plot shows that the strongest deflocculating effect corresponds to approximately same concentrations of Na^+ ions, thus possible dissociation centers, for all the tested deflocculants (minima around 0.03 mmol/g). Deflocculation of aqueous kaolin suspensions is the process strongly dependent on pH. The measured pH of suspensions are given in Figure 10. Values of pH vary with addition of electrolytes from neutral (SHMP), over weak alkali (primary kaolin suspensions, NaCMC additives) and medium alkali (WG, Na_2CO_3), to strong alkali (NaOH). With respect to the isoelectric point of kaolin suspensions located at pH ≈ 3 [5, 6, 8], all tested suspensions should exhibit high negative zeta-potential values.

3.2 STABILITY OF SUSPENSIONS

This study was not primarily focused on settling processes, only qualitative observations of sedimentation were made. It consisted in (i) visual observations of the movement of the boundary between the settling phase and the clear supernatant, and (ii) probing the hard deposit after a long-time staying. These observations resulted in a qualitative classification shown in Table 2. It is distinguishing between five grades of the sedimentation stability, from long-time stable suspensions (grade 5) to quickly setting suspensions (grade 1). Generally speaking, the deflocculants should reduce viscosity and, at the same time, stabilize the suspension against sedimentation because of preventing flocculation. However, the real sedimentation process is complicated by many aspects of the dispersed phase, e.g. by polydispersity of the colloidal systems under consideration. As a result, the sedimentation stability gets worse with addition of deflocculants, but there are large differences among various deflocculants.

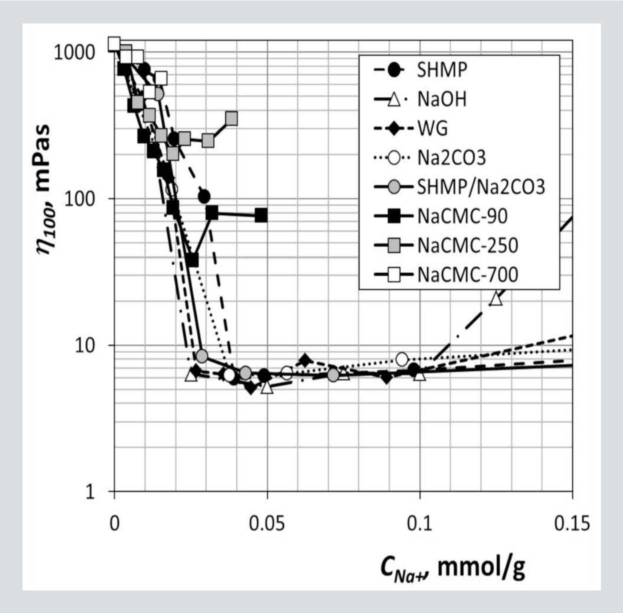

Figure 9: Variation of apparent viscosity η_{100} with concentration of Na^+ ions for 40 % aqueous kaolin suspensions and all tested deflocculants.

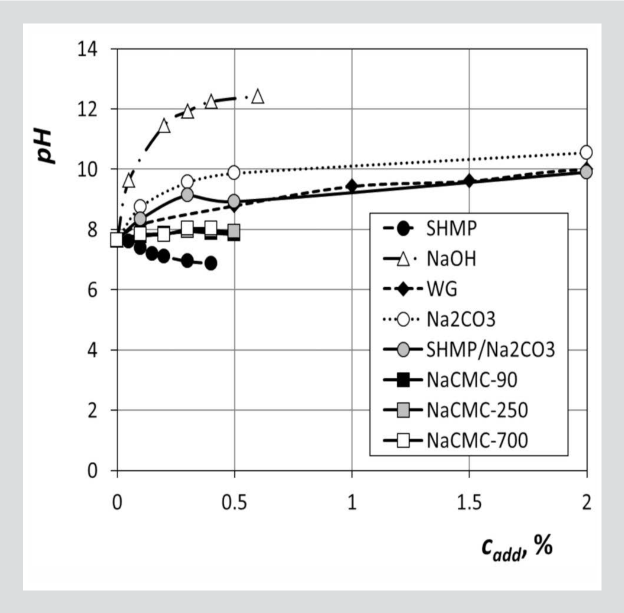

Figure 10: Variation of pH with concentration of additive c_{add} for 40 % aqueous kaolin suspensions and all tested deflocculants.

The worst stability is exhibited by WG suspensions within the optimum range of c_{add}, for which the rigid deposit quickly grows at the bottom. Stability of NaOH suspensions within the optimum range of c_{add} is medium, but outside of this range is very good – same as stability of primary suspension. All inorganic additives produce rather unstable suspensions. On the other side, the sedimentation stability of suspensions deflocculated by NaCMC polyelectrolytes is good. These suspensions remain more stable probably because they preserve certain shear thinning behavior and therefore their apparent viscosity is higher at low shear rates which are typical for the process of sedimentation.

3.3 EVALUATION OF DEFLOCCULANTS

The optimum concentration of electrolyte necessary for reaching the maximum reduction of suspension viscosity is smallest in the case of NaOH. Little bit higher optimum concentration is obtained for Na_2CO_3, and the mixture SHMP/Na_2CO_3, followed by WG, then by SHMP, and finally by medium- and low-molecular-weight NaCMC. However, as shown above, one must be careful about using the larger than optimum c_{add}, especially in the case of NaOH. As the using of WG leads to highly unstable suspensions, Na_2CO_3 and SHMP (eventually their mixture) seem to be the best choices. The application of Na_2CO_3 as deflocculant can be recommended as the most environment-friendly. In principle all the used inorganic electrolytes are able to decrease viscosity of aqueous kaolin suspension to the similar level (less than 10 mPas) and to change shear thinning behavior to the Newtonian one. In the case of NaCMC, the lower molar mass results in lower viscosities of deflocculated suspension. Anyway, even the low-molecular-weight NaCMC-90 does not reduce viscosity with such efficiency as the inorganic deflocculants and the character of flow behavior still remains shear thinning. In contrary to inorganic electrolytes, which produce rather unstable suspensions, the using of NaCMC polyelectrolytes leads to quite stable suspensions. It is a question of a given technological process, whether it would be better to use Na_2CO_3 (as the best inorganic deflocculant) or low-molecular-weight NaCMC (providing more viscous suspensions but with better stability against sedimentation).

A difference should be noted between the present results and those, obtained by Rossington et al. [14] in their experimental study with similar electrolytes. The efficiency of viscosity decreasing, when Na_2CO_3 and WG is used, is found different. Reduction of apparent viscosity at 1 s^{-1} of 40 % batch suspension (defined mixture of kaoline, quartz, alumina, etc.) was about three orders of magnitude in the case of WG but only one order when Na_2CO_3 was used. This small efficiency of Na_2CO_3 is surprising because this is a deflocculant recommended by

additive \ c_{add}, %	0	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1	1.5	2	3
SHMP	5	3	3	3	3	3			2	2	2	
NaOH	5	3	3	3	4	5	5		5	5	5	5
WG	5	3	3	1	1	1			1	1	1	
Na_2CO_3	5	3	3	2		2					2	
SHMP/Na_2CO_3	5	3	2	2		2					2	
NaCMC-90	5	4	3	3	3	3	4	4	4	4		
NaCMC-250	5	4	4	5	5	5	5	5	3			
NaCMC-700	5	5	4	4	5							

Table 2: The subjective classification of sedimentation stability of 40 % aqueous kaolin suspensions with additives: The highest grade 5 corresponds to stable suspensions and the lowest grade 1 to unstable, quickly settling suspensions. The gray fields mark the range of optimum concentrations which led to the lowest viscosities of suspensions.

our kaolin producer and works very well in our case. Probably the behavior of batch suspension can differ from pure kaolin suspension used in our work. Also different compositions and qualities of used kaolin minerals can play role (e.g. the specific surface area 26.9 and 18.6 m^2/g is stated for Florida (USA) and Sedlec (Czech Republic) deposits, respectively). Also Vlasak at al. [20] have found slightly higher efficiency of WG than Na_2CO_3 (with apparent viscosities at 199 s^{-1} two times smaller). As they used kaolin from the same deposit and producer (kaolin Sedlec Ia), a small discrepancy in the viscosity results suggests that also different batches of the same mineral can behave differently.

4 CONCLUSIONS

The efficiency of deflocculation by addition of various electrolytes to aqueous kaolin suspensions was tested via standard viscosity measurements. Variance of two parameters, apparent viscosity η_{100} and flow behavior index *n*, with an additive concentration c_{add} was used to give complex information about changes of viscosity and flow character of deflocculated suspensions. The independence of deflocculation effect on kaolin concentration was verified. For all three tested kaolin concentrations (30, 35, and 40 %) the range of additive concentrations, which led to lowest viscosities, was the same at the case of two tested additives (SHMP and NaOH). Decreasing of suspension viscosity using optimum deflocculant concentration is always connected with change of flow character from shear thinning toward to Newtonian. Addition of any inorganic electrolyte led to suspensions having seriously Newtonian character and the same level of viscosity less than 10 mPas, only different amount of additive was need. Using organic polyelectrolyte led to more consistent suspensions and both apparent viscosity and flow behavior index depended on molar mass of used NaCMC. An excess of deflocculant led to recovery of shear thinning behavior and increase of apparent viscosity in the case of inorganic electrolytes. This is extremely significant when NaOH is used. Qualitative observations of the stability of prepared suspensions were also made. The suspensions containing inorganic electrolytes was found not very stable, in the contrary organic polyelectrolytes produced more stable suspensions. In summary, inorganic electrolytes produce really low viscous, but not very stable suspensions, whereas organic polyelectrolytes produce more viscous, but rather stable suspensions. It depends on concrete technological process what should be preferred.

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