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Impact of flocculant dose onto fractal dimension of titanium white, kaolin clay and chalk aggregates

Introduction

The aggregation and breakage play an important role in nature as well as in different branches of industry such as biotechnology, paper production, mineral ore processing or waste water treatment [*Wickramasinghe et al., 2010; [2] Tang et al., 2011; Alam et al., 2011; Samaras et al., 2010; [5] Menkhaus et al., 2010; Razali et al., 2011*]. Often these processes are crucial for the final product properties like color, filtration cake compressibility and final moisture content [*Oi, et al., 2011; Sakong et al., 2011*].

The ability of particles to aggregate under different conditions discloses their fractal nature. Typical of fractal structures is that their density decreases as the size increases. While forming aggregates clusters may adopt different shapes. In the simplest case when particles are equal spheres there is only one possible shape of doublet. Third particle can join the doublet in other different ways. The possibility of number of structures increases with larger aggregates [*Allen, 1997*]. It is known that majority of aggregates of solid particles suspended in liquid have unchangeable structure with changing scale in which they are considered. This inclines to treat this objects as fractals [*Jinwook, Kramer, 2006*].

The goal of this work is to verify the impact of flocculant dosage onto the fractal dimension of aggregates.

Experimental

Measurements were carried out for three different powders, i.e. chalk, titanium white and kaolin clay. For each of them the identical procedure was applied, consisting of equal doses of flocculant *Magnafloc 1011* of the same concentrations. It allowed one for better comparison of the results of flocculation process for above mentioned components.

Experimental medium preparation was initiated by addition of chalk, kaolin clay or titanium white to RO water (Reverse Osmosis). Samples of 2g were previously weighted on the analytical balance and mixed with a very small amount of RO water in the beaker. Such sludge was poured into a cylindrical baffled mixing tank of diameter 0.19 m and of the volume $5.39 \cdot 10^{-3}$ m^3 filled with RO water. While adding the suspension the Rushton turbine of diameter 0.08 m was working. This procedure allowed the suspension to spread easily in the tank giving the concentration equal to 0.371 kg/m^3.

Firstly, the particle size distribution of suspensions were determined using the *Analysette 22* laser particle sizer by *Fritch GmbH*. Simultaneously ten samples of suspension were prepared for the microscopic analysis. The samples were examined using biological microscope *Olympus CH30/CH40*. The microscope was connected to the computer with specialized software designed to take microscopic pictures. Each sample has been photographed ten times that gives totally 900 pictures used for further examination.

Results and Discussion

In order to analyze the microscopic images fractal dimension the box-counting method was used. The basic technique of determination the fractal dimension, is to build a double logarithmic plot. The structure of aggregate particles became very important when their fractal nature has been discovered. During the experiment the analysis of microscopic images was performed using [*HarFA* software 2011], that is designed especially for this purpose. Software based on the box counting method determines the fractal dimension as the slope of the curve from the plot presenting the dependency of size of mesh square vs. number of steps used to cover the object. As in the case of microscopic analysis of particle size distribution each of the 900 images were analyzed individually. Results of fractal analysis are set in Table 1.

Tab. 1. Average fractal dimension

Polymer dose [mg/g]	Average fractal dimension					
	Titanium white	Std. dev.	Kaolin clay	Std. dev.	Chalk	Std. dev.
0.0	1.193	0.131	1.332	0.187	1.136	0.087
0.1	1.315	0.112	1.529	0.147	1.349	0.133
1.0	1.242	0.098	1.361	0.165	1.518	0.206

In case of titanium white suspension without (0.0 mg/g) flocculant the particles were small and freely suspended, that reflects their lowest fractal dimension 1.193 (Fig. 1, Tab. 1). In the suspension containing 0.1 mg/g of flocculant the bridging mechanism occurred. The clusters formed large and closely spaced flocs (Fig. 1). Their fractal dimension was equal to 1.315, and it was the highest value measured for titanium white. In case of the highest polymer dose (1.0 mg/g) the result for fractal dimension measurement was a value intermediate between two

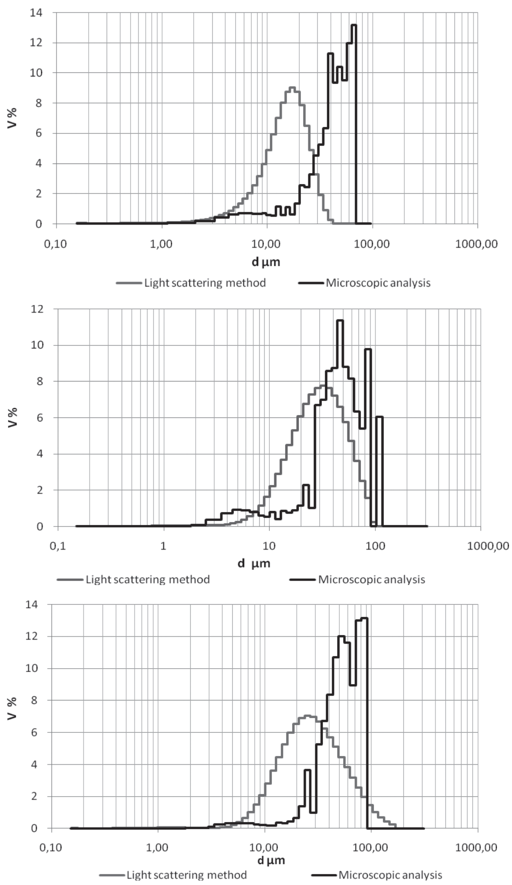

Fig. 1. Comparison of particle size distribution of titanium white: 0 mg/g (top fig.), 0.1 mg/g (central fig.), 1.0 mg/g (bottom fig.)

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previous results, i.e. 1.242. Due to excess of flocculant the bridging was less effective. As a result flocs are smaller, departed from each other that affected the measurement of fractal dimension.

Similar results were obtained from measurements of kaolin clay. The lowest average fractal dimension was determined for a suspension without flocculant (Tab. 1). As it can be seen from Fig. 2, it was caused by fine particles uniformly spread in the suspension. For a dose of 0.1 mg/g flocs were of unusual shapes. They were thick, cramped, dense and their fractal dimension reached the highest value of approximately 1.53. For the suspension of clay the measurement results were a little bit smaller than for the suspension without flocculant. The reason was, perhaps, less dense and far apart spaced flocs.

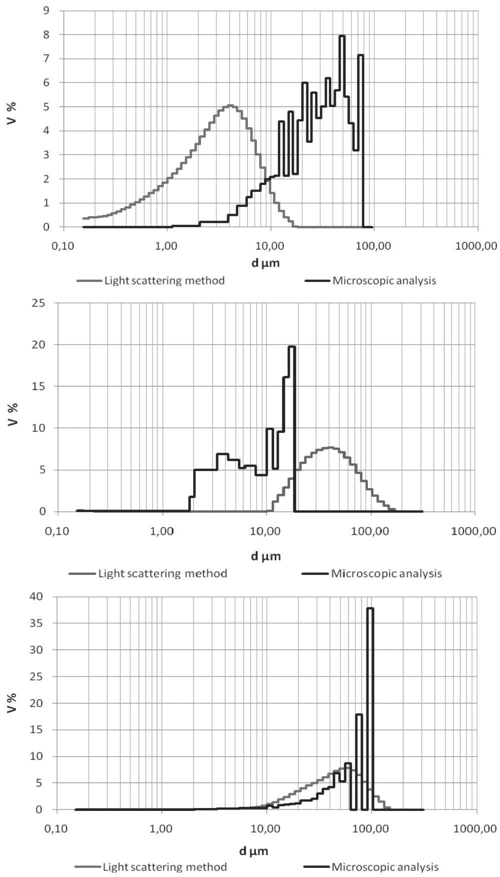

Fig. 2. Comparison of particle size distribution of kaolin clay: 0 mg/g (top fig.), 0.1 mg/g (central fig.), 1.0 mg/g (bottom fig.)

The results of fractal dimension for the suspension of chalk were a slightly different from the two previous suspensions. The average fractal dimension for the suspension without flocculant is the smallest among all the obtained results (Tab. 1). Particles in the suspension with the addition of 0.1 mg/g of flocculant form small and dense flocs (Fig. 3). In contrast to previous observations they are smaller than for the suspension with the addition 1.0 mg/g of flocculant.

Conclusions

The most accurate and reliable results were obtained for titanium white. In this case, the results of microscopic analysis and light scattering method overlap to some extent. The most varied results were obtained for kaolin clay. In the measurements for suspensions with flocculant it is very difficult to notice any analogies between the two methods. Undoubtedly, diameters measured on the basis of microscopic images are much higher than those measured by laser. The results of fractal dimension measurements not only reflect the effect of flocculant dosage on the size of flocs but also provide information on particle shape and structure.

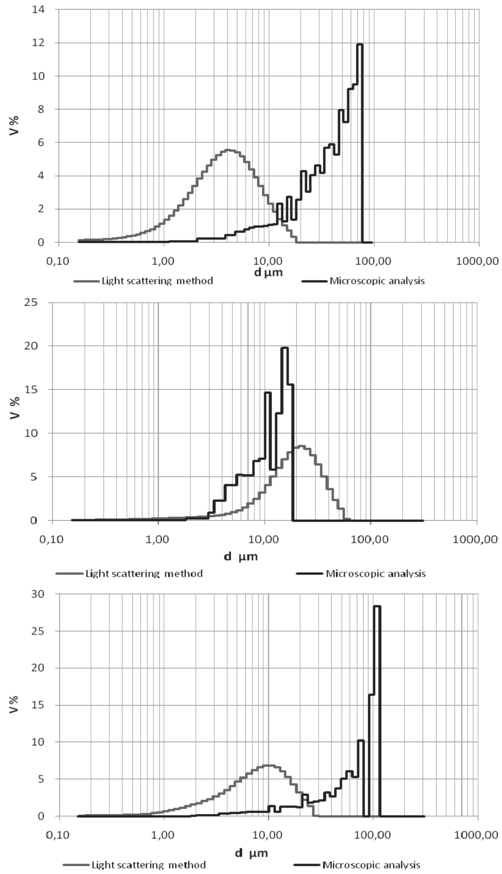

Fig. 3. Comparison of particle size distribution of chalk: 0 mg/g (top fig.), 0.1 mg/g (central fig.), 1.0 mg/g (bottom fig.)

REFERENCES

Alam N., Ozdemir O., Hampton M.A., Nguyen A.V., 2011: Dewatering of coal plant tailings: Flocculation followed by filtration. *Fuel* **90**, nr 1, 26-35. DOI: 10.1016/j.fuel.2010.08.006

Allen T., 1997: *Particle Size Measurement V.1 Powder sampling and particle size measurement,* 5ed., Chapman&Hall, London

Harfa software (22.11.2011): http://www.fch.vutbr.cz/lectures/imagesci/includes/harfa_download.inc.php

Kim Jinwook, Kramer T.A., 2006. Improved orthokinetic coagulation model for fractal colloids: Aggregation and breakup. *Chem. Eng Sci.* **61**, nr 1, 45-53. DOI: 10.1016/j.ces.2005.01.044

Menkhaus T.J., Anderson J., Lane S., Waddell E, 2010. Polyelectrolyte flocculation of grain stillage for improved clarification and water recovery within bioethanol production facilities. *Bioresour. Technol.* **101**, nr 7, 2280-2286. DOI: 10.1016/j.biortech.2009.11.017

Qi Y., Thapa K.B., Hoadley A.F.A., 2011. Application of filtration aids for improving sludge dewatering properties – A review. *Chem. Eng. J.* **171**, nr 2, 373-384. DOI: 10.1016/j.cej.2011.04.060

Razali M.A.A., Ahmad Z., Ahmad M.S.B., Ariffin A.,2011. Treatment of pulp and paper mill wastewater with various molecular weight of polyDADMAC induced flocculation. *Chem. Eng. J.* **166**, nr 2, 529-535. DOI: 10.1016/j.cej.2010.11.011

Sakong C., Kim Y.D., Choi J., Yoon C., Kim J.P., 2011. The synthesis of thermally-stable red dyes for LCD color filters and analysis of their aggregation and spectral properties. *Dyes Pigm.* **88,** nr 2,166-173. DOI: 10.1016/j.dyepig.2010.06.003

Samaras K., Zouboulis A., Karapantsios T., Kostoglou M., 2010. A CFD-based simulation study of a large scale flocculation tank for potable water treatment. *Chem. Eng. J.* **162**, nr 1, 208-216. DOI: 10.1016/j.cej.2010.05.032

Tang Y., Zhang H., Liu X., Cai D., Feng H., Miao C., Wang X., Wu Z., Yu Z., 2011. Flocculation of harmful algal blooms by modified attapulgite and its safety evaluation. *Water Res.* **45**, nr 9, 2855-2862. DOI: 10.1016/j.watres.2011.03.003

Wickramasinghe S.R., Leong Y., Mondal S., Liow J.,2010. Influence of cationic flocculant properties on the flocculation of yeast suspensions. *Adv. Powder Technol.* **21**, nr 4, 374-379. DOI: 10.1016/j.apt.2010.02.006