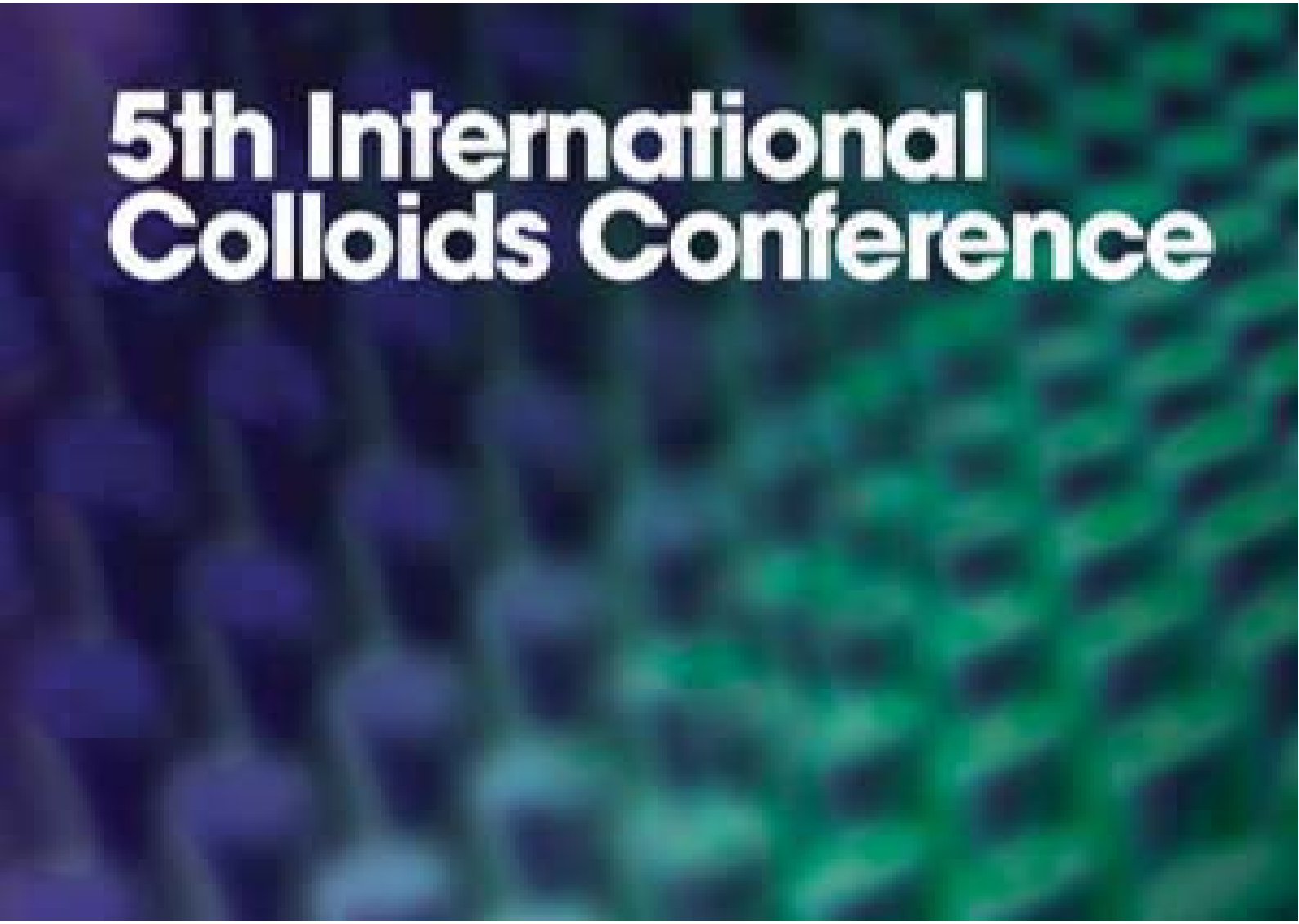
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Enhanced colloidal properties of palygorskite by associated sodium metaaluminate and high-pressure homogenization process

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Introduction

Palygorskite (PAL) is a hydrated Mg-rich silicate clay mineral with nanorod-like crystal morphology and plentiful surface groups [1]. The aqueous dispersion of PAL has excellent thickening, suspending, stabilizing, rheological and thixotropic properties, and has been potentially used as eco-friendly colloids for the substitution of traditional toxic organic gels, and plays key roles in modern chemical industry [2, 3].

However, natural PAL nanorods are usually existed as bulk crystal bundles or aggregates, which fail to assembly with each other to form strong and stable colloidal network [4]. Thus, to disaggregate the PAL crystal bundles as individual nanorods is the key to enhance the colloidal properties, but the conventional methods fail to achieve this.

High-pressure homogenization is a technology that is usually employed to produce fine emulsion on large scale. The higher shear, impact and cavity effect on the dispersed phase contribute to reduce the droplet diameter [5]. In this work, the high-pressure homogenization technology was successfully used to disaggregate the crystal bundles of PAL, promote the interaction of modifier (sodium metaaluminate, SM) with PAL and enhance the colloidal properties. It was found that homogenizing at 30 MPa may effectively disaggregate the crystal bundles as single dispersed nanorods, and evidently enhance the colloidal viscosity from 1812 to 2678 mPa•s.

Experimental

PAL (100.0 g) was dispersed in 1400 mL of aqueous solutions with various amounts of SM (0, 0.05, 0.1, 0.25 and 0.5 g) of SM. After stirring for 4 h, the suspension was homogenized at 30 MPa on a high-pressure homogenizer (GJB 40-10S, Shanghai Donghua Homogenizer Machinery Corporation, Ltd., Shanghai, China), and then centrifuged at 5000 rpm to separate the solid from the solution. The solid product was dried at 105 ºC for 4 h, and then ground and passed through a 200-mesh screen. The samples were coded as SM-x and SMH-x (x is the dosage of SM) for unhomogenized and homogenized samples, respectively.

Results and discussion

As shown in the SEM images (Fig. 1), the nanorods of SM-0 are tightly hugged together to form many bulk crystal bundles or aggregates (Fig. 1a). After high-pressure homogenization, the crystal bundles and aggregates were fully disaggregated (Fig. 1b), and many individual nanorods with the size of 0.5-1.5 μm appeared. The dispersion of PAL nanorods was further improved by adding SM (Fig. 1c,d), because the increased surface negative charges on PAL intensified the repulsion among rods and restrain the re-aggregation of dispersive nanorods. More importantly, the length of PAL nanorods has no change after the one-step modification process.

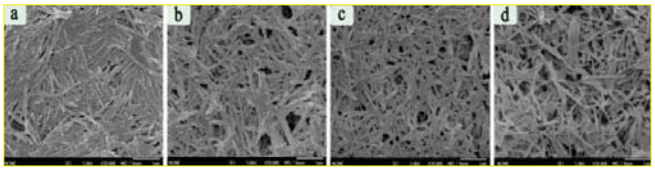

Fig. 1 SEM images of (a) SM-0, (b) SMH-0, (c) SMH-0.1 and (d) SMH-0.5

Fig. 2 shows the XRD pattern of PAL samples. The (110) characteristic peaks of PAL samples appear at 2θ = 8.35° (SM-0), 8.40° (SM-0.1), 8.35° (SMH-0), 8.35° (SMH-0.05), 8.33° (SMH-0.1) and 8.38° (SMH-0.5), which only have minor change after modified with MS and homogenization treatment. This indicates that the structure of $Mg(Al)O_6$ octahedron and $Si(Al)O_4$ tetrahedron of PAL has not been damaged during homogenization, which is obviously superior to the ultrasound method [6].

The Zeta potential of SM-0 (without adding SM and homogenization) is -19.5 mV, which increases to -19.6 mV after homogenization at 30 MPa and decreases to -19.2 mV after modified with alone SM (0.1%). For the homogenized sample, the Zeta potentials become more negative with increasing the addition dosage of SM, which increases to -19.9 mV (for SMH-0.05), -20.5 mV (for SMH-0.1), -23.7 mV (for SMH-0.25) and -25.4 mV (for SMH-0.5).

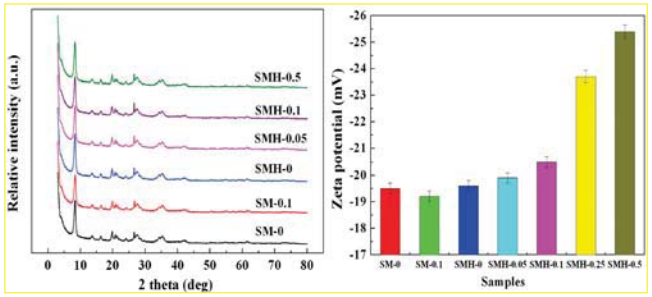

Fig. 2 XRD pattern (left) and Zeta potential (right) of PAL samples

The viscosity of the aqueous dispersion of PAL decreases with prolonging shear time (Fig. 3), indicating a typical non-Newtonian fluid characteristics and ideal thixotropy. The viscosity of SM-0 is only 1812 mPa•s, which increase to 2678 mPa•s after introducing 0.1% SM and homogenization at 30 MPa due to the synergistic effect. However, the rotation viscosity sharply decreases when the dosage of SM exceeds 0.1%, and is only 576 mPa.s for SMH-0.5 sample.

The aqueous dispersion of SM-0 settles rapidly and the sedimentation volume is only 90 mL after settling for 108 h (89 mL) due to the existence of bulk aggregates; whereas the volume reaches 97 mL after 108 h for SMH-0.5 sample due to the enhancement of dispersion of nanorods. Moreover, the sedimentation volume increases with increasing the dosage of SM, which is due to the increase of Zeta potentials (Fig. 2).

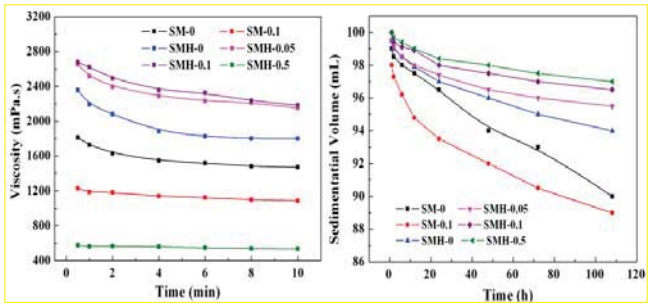

Fig. 3 Colloidal viscosity (left) and sedimentation volume (right) of aqueous dispersion of PAL.

Conclusions

High-pressure homogenization treatment can disaggregate the crystal bundles of PAL into individual nanorods, and the SM may improve the surface charges and restrain the re-aggregation of nanorods. The synergistic effects of SM and high pressure homogenization lead to the robust enhancement of viscosity and colloidal stability. This process is suitable for large-scale industrial production, and the product shows great prospect in fine chemicals and petrochemical industrial fields.

References

[1] W.F. Bradley, Am. Mineral. 1940, 25: 405.
[2] E.A. Hauser, Chem Rev. 1945, 37: 287.
[3] A. López-Galindo, C. Viserasb, P. Cerezo, Appl. Clay Sci. 2007, 36: 51.
[4] A. Neaman and A. Singer, Soil Sci. Soc. Am. J. 2000, 64: 427.
[5] J. Floury, A. Desrumaux, et al., J. Food Eng. 2003, 58: 227.
[6] B. White, S. Banerjee, S. O'Brien, et al., J. Phys. Chem. C 2007, 111: 13684.