Powder Technology 322 (2017) 378–385

Contents lists available at ScienceDirect

Powder Technology

journal homepage: www.elsevier.com/locate/powtec

Comparison of colloidal stability of montmorillonite dispersion in aqueous NaCl solution with in alcohol-water mixture

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A R T I C L E I N F O

Article history:
Received 24 June 2017
Received in revised form 14 August 2017
Accepted 14 September 2017
Available online xxxx

Keywords:
Montmorillonite
Surface tension
Wettability
Swelling capacity
Colloidal stability

A B S T R A C T

The colloidal stability of montmorillonite (MMT) dispersions in aqueous NaCl solution and in alcohol-water mixture has been studied in this work. The study was performed through the measurements of particle size, zeta potential, surface tension and swelling capacity. The experimental results have shown that the stability of colloidal MMT dispersion is distinct in the two cases, although the zeta potential has the same change trend. This observation might be attributed to the different behavior of surface tension in aqueous NaCl solution with alcohol-water mixture. The former would increase the surface tension of the media that deteriorate the wettability and swelling capacity of MMT, while the latter would decrease the surface tension. It is demonstrated that the surface tension of the media would affect strongly the colloidal stability of aqueous MMT dispersions, which is of great importance in many industrial processes as well as in soil chemistry and environmental science.

1. Introduction

Stability of colloidal montmorillonite (MMT) dispersion is of great importance in several industrial processes as well as in soil chemistry and environmental science. Taking the oil recovery process as an example, the produced water is constantly contact with clay particles when the crude oil flows through underground reservoirs. A high concentration of MMT particles are serious problems in produced water, and MMT particles may cause the formation of clogging or change the oil–water interfacial properties. The MMT particles in produced water are more difficult to treat than those from water flooding or polymer flooding [1,2]. In addition, MMT has been considered as a relevant buffer and backfill material in deep geological repositories for high-level radioactive wastes of many countries. The colloidal MMT dispersion can be generated at the interface of a host rock and buffer of repositories and constitute an additional mechanism for radionuclide migration, provided they are stable and mobile under the given groundwater conditions. Consequently, the stability of colloidal MMT dispersion in the relevant groundwater conditions may be important in terms of a long-term performance of radioactive waste repositories [3,4].

It is known that a unit of MMT (a primary particle) consists of a quite thin platelet of thickness of 10 Å. The platelet consists of two kinds of sheets: two tetrahedral layers of silicon oxide between which one octahedral layer formed by aluminum, magnesium, or iron oxide is sandwiched. Its general formula is $(Na)_{0.7}(Al_{3.3}Mg_{0.7})Si_8O_{20}(OH)_4 \cdot nH_2O$. MMT has very small particle size, a high specific surface area and a cation exchange capacity values. The particles have permanent negative charges on their faces due to isomorphic substitutions which are Al^{3+} for Si^{4+} substitution in tetrahedral sites and Mg^{2+} for Al^{3+} substitution in octahedral sites. The broken bonds located at the edges of the platelet (alumina sheet) have a capacity to adsorb H^+ or OH^-, depending on pH value [5]. Due to these characteristics, MMT can show complex colloid properties when they are dispersed in aqueous media.

Since the colloidal state of dispersed clay minerals is decisive in many practical applications, the stability of MMT dispersions was investigated for many decades [6–11]. Numerous studies indicated that the stability behavior of colloidal particles is closely related to the surface charges and these surface charges in turn are a function of the pH and ionic strength [6]. Zeta potential has been considered in the stability prediction of colloids since the zeta potential indicates the electrical charge of the diffuse layer of the colloids and the distance into the solution that the effect of the charge extends. Thus unstable colloids can become much closer together than stable colloids. Zeta potential has also been widely used to investigate the stability of colloidal systems such as polymeric nanocapsules and silica colloids [10,11]. However, the influence of the surface tension of the media on the stability of colloidal MMT dispersion has received almost no interest among surface scientists.

In this study, the colloidal stability of MMT dispersion in sodium chloride solution compared with alcohol-water mixture has been studied. The objective is to investigate the stability of colloidal MMT

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https://doi.org/10.1016/j.powtec.2017.09.032
0032-5910/© 2017 Published by Elsevier B.V.

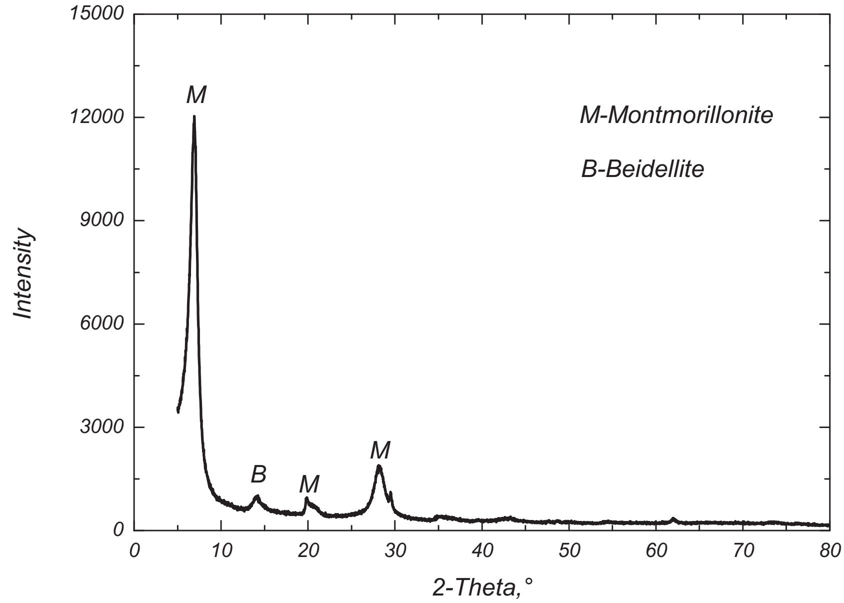

Fig. 1. XRD trace of the MMT sample.

dispersion as a function of the surface tension of the media, in order to obtain more understandings of the colloidal stability of MMT dispersion.

2. Experimental

2.1. Materials

The original MMT used in the present study was obtained from Sanding Technology Co., Ltd., Zhejiang province, China. A common method for obtaining purified colloidal MMT is fractionation by sedimentation after removal of carbonates, oxides, and organic materials and smashed by the ultrasonic grinder.

Sodium chloride (NaCl) and alcohol for adjusting surface tension were from the Sinopharm Chemical Reagent Co., Ltd. (China). All of them were of analytical purity. The water used in this work was produced using a Millipore Milli-Q Direct 8/16 water purification system with 18.2 MΩ.

2.2. Measurements

A Malvern Zetasizer Zeta-Nano was used to determine the zeta potentials of the MMT particles in solutions. This instrument works with the technique of laser Doppler electrophoresis. Then, the suspension was poured into the measuring cell of zeta meter. The temperature was kept at 25 ± 1 °C throughout the measurement. All the measurements were performed with 1 mmol/L KCl background electrolyte concentration. An average value of three measurements was taken to represent a zeta potential of the MMT particle for a given condition.

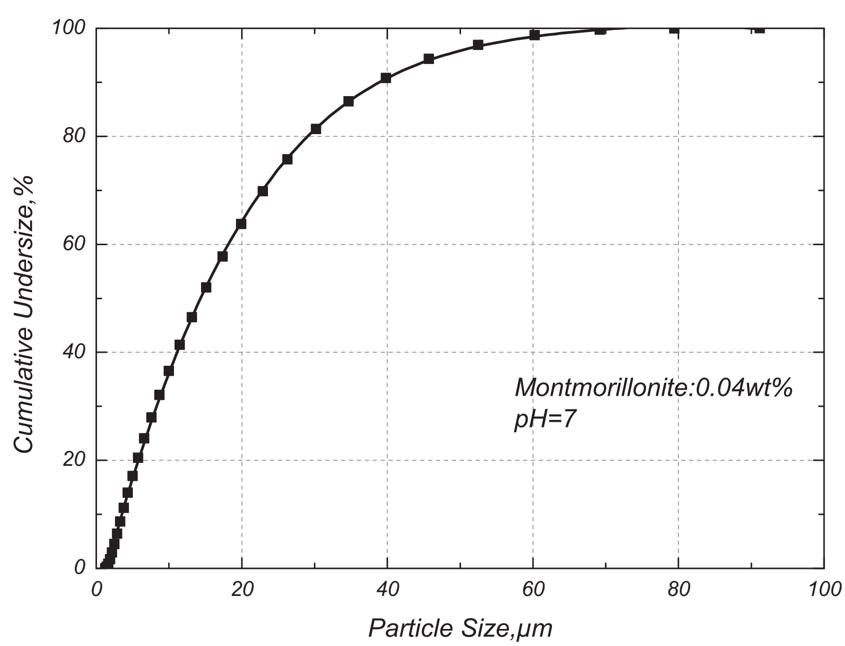

Fig. 2. Particle size distribution of the colloidal MMT dispersion.