THE RHEOLOGY OF SWELLING CLAY DISPERSIONS

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INTRODUCTION

Nearly all muds, in drilling applications, contain smectite clay minerals, such as montmorillonite or hectorite, which have the remarkable property of swelling in the presence of water. Such systems are known to exhibit long-term gelation and thixotropic behavior, of great importance in applications, depending on clay volume fraction, particle properties (origin of the clay, surface charge, etc.) and solvent conditions (pH, ionic strength, etc.) [1-6]. Mainly two mechanisms for gel formation of smectite clays have been proposed up to now: electrostatic attraction between the positively charged edges and negatively charged faces of the platelets, resulting in a card-house structure, [7] and long-range electrostatic repulsion between interacting double layers of clay particles [8]. According to recent works, the latter mechanism has appeared to be the most probable one.

The rheological results presented in the paper have been obtained with a synthetic hectorite-type clay, namely Laponite, often considered as a model reference smectite clay. The data will be compared to those of the literature.

1 EXPERIMENT

Laponite is a smectite clay of high purity composed of particles similar to circular discs of diameter 300 Å and thickness 10 Å.

For all Laponite dispersions, the electrolyte (NaCl) concentration is set to 10^{-3} mole dm^{-3}, corresponding to a Debye length of about 100 Å. All samples have been tested at 25°C using a Low-Shear 30 viscometer, at low volume fractions, and a Carri-Med CSL 50 constant stress rheometer at higher volume fractions.The clay concentration range studied lies from 0.5% w/w to 6% w/w.

All suspensions have been set at rest for about 45 d longest time needed for all samples to attain their equi state.

2 RESULTS

The experimental results clearly show the existen Laponite concentration threshold separating two types of mechanical response. This critical concentrat been proved to be 1.5% w/w, in agreement with result literature [6]; this critical concentration correspon mean interparticle distance of about 200 Å.

2.1 Viscous fluid behavior

Up to a concentration of about 1.5% w/w, all L suspensions exhibit a Newtonian behavior at low shea The zero-shear viscosity increases strongly with c tration from about 1% w/w, as shown on Figure 1.

2.2 Gel-like behavior

Beyond 1.5% w/w, creep tests clearly show the ex of a yield stress, that is a stress marking the transition solid-like behavior to a liquid-like behavior, as illustr Figure 2.

The yield stress thus determined, attributed to the p of a structure, has been proved to depend on concentr a power law with exponent 3.3 over the whole concer range.

In order to characterize the viscoelastic behavior structure below the yield stress, oscillatory shear test linear regime have been carried out. The results clearl that the level of elastic modulus G' is nearly indepen

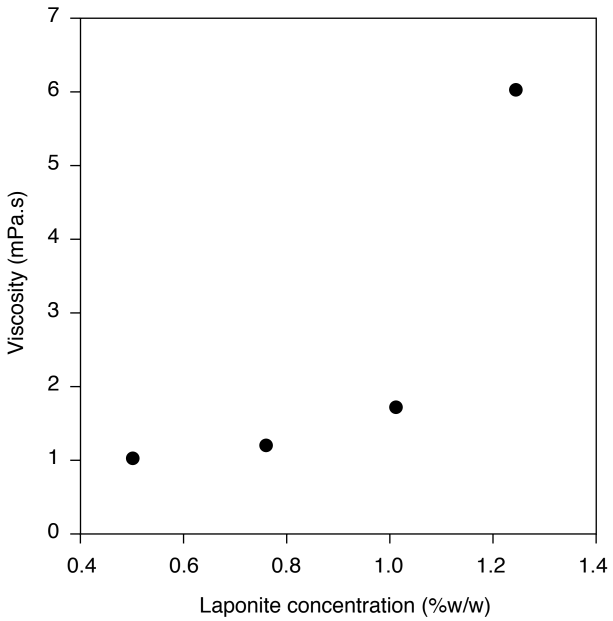

Figure 1

Zero-shear viscosity as a function of Laponite concentration.

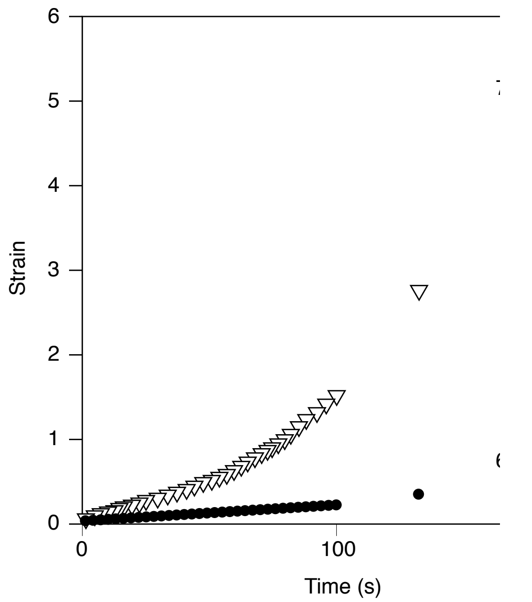

Figure 2

Illustration of the mechanical transition and yie
determination: creep behavior of a 2% w/w
suspension at 6 Pa and 7 Pa imposed shear stress.

The cohesive energy, that is the work required to disrupt the elastic structure, is then a power law of the concentration with exponent 3.

These results are in very good agreement with Sohm and Tadros' data [4] obtained with commercial sodium montmorillonite (Gelwhite H) suspensions.

CONCLUSION

The study of the rheological properties of Laponite dispersions at low ionic strength is essential to understand the mechanism of gelation and to characterize the dynamics and related structure of the gel inside swelling clay suspensions. Still, scattering investigations of the microscopic structures on different length scales are definitely required to precise and complete the rheological characterization. Future work should study in detail the influence of anisometry and dimensions of the clay particles on gel formation and structure.

ACKNOWLEDGMENT

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