# Rheological Characterization of Bentonite Suspensions and Oil-In-Water Emulsions Loaded With Bentonite

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**Abstract:**
With stress controlled rheometer we investigate the behavior for different concentrations, of paraffin oil-in-water emulsions, bentonite suspensions as well as charged bentonite emulsions. We were particularly interested in how aging affects the rheological properties. Using a structural model, we correlate the macroscopic experimental results to the fluid microstructure characteristic parameters and we calculate the emulsions and suspensions mean characteristic unit size. The comparison of these mean particle diameters with those obtained by microscopy and light-scattering measurements confirms the soundness of such procedure to estimate the structural characteristics, the effective concentrations and the effective mean particle diameter of oil-in-water emulsions and bentonite suspensions.

**Zusammenfassung:**
Das Verhalten von Paraffinöl-Wasser Emulsionen, von Bentonitsuspensionen sowie von geladenen Bentonitemulsionen mit verschiedenen Feststoffkonzentrationen der wurde mittels eines schubspannungskontrollierten Rheometers untersucht. Im Speziellen wurde der Alterungeinfluss auf die rheologischen Eigenschaften analysiert. Die makroskopischen experimentellen Resultate wurden mit Hilfe eines Strukturmodelles in Zusammenhang mit den charakteristischen Parametern der Fluidmikrostruktur gebracht und die mittlere charakteristische Partikelgrösse der Emulsionen und Suspensionen berechnet. Der Vergleich der so bestimmten mittleren Partikeldurchmesser mit den Ergebnissen der Untersuchungen durch Mikroskopie und Lichtstreuung bestätigt die Zuverlässigkeit einer solchen Methode zur Abschätzung der Strukturcharakteristiken, der effektiven Konzentrationen, sowie der effektiven mittleren Partikeldurchmesser in Öl-Wasser-Emulsionen und in Bentonitsuspensionen.´

**Résumé:**
Des émulsions d'huile de vaseline et d'eau à différentes concentrations en huile, des suspensions de bentonite à différentes concentrations et des émulsions chargées en bentonite ont été étudiées. Les propriétés visqueuses de ces différents fluides ont été déterminées au moyen d'un rhéomètre à contrainte imposée. On s'est également intéressé à l'évolution des caractéristiques rhéologiques au cours du vieillissement. L'application d'un modèle de type Milieux Effectifs a permis de corréler de manière satisfaisante les résultats expérimentaux. Il a été possible de calculer le diamètre moyen des particules. La bonne concordance avec les valeurs obtenues expérimentalement par microscopie et traitement d'images montre que cette méthode constitue un moyen aisé d'accéder aux caractéristiques structurales des émulsions d'huile de vaseline et d'eau et des suspensions de bentonite. Les concentrations effectives et les diamètres moyens effectifs ont été calculés.

**Key words:** Oil-in-water emulsions, bentonite suspensions, rheology, aging effects, structural models, packing, particle size analysis.

## 1 INTRODUCTION

In many industrial applications, emulsions are not necessarily composed of oil and water phases only; they often contain a third solid phase in suspension in one of the liquid phases or both simultaneously. All these systems represent a significant part of the production of food industries (vinaigrettes), cosmetics (cream), chemical (paints) or petroleum (drilling fluids). In order to answer the demand of economic media, confronted with the necessity to improve and to optimize the production processes, it is of primary importance to improve the knowledge of the rheological behavior of such fluids, particularly the dependence of the flocculated structure from the physical parameters of the dispersed particles (morphology, particle-size distribution, volume particle fraction, density, surface characteristics) and also the interaction between the





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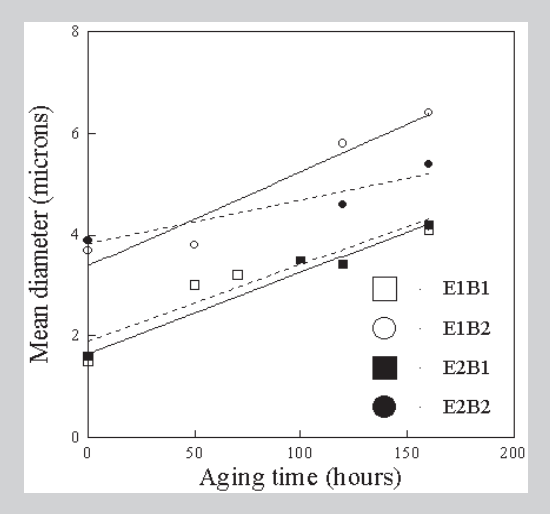


*Figure 12: Mean particle diameter calculated with Eq. 7 versus aging time of oil-in-water emulsions loaded with bentonite.*

eter increases with the bentonite concentration. Furthermore, the increase of the oil volume fraction of the base emulsion seems to have no remarkable effect on the change in aggregates mean diameter. Nevertheless, for a lack of particle size experimental data, the numerical results cannot be generalized to other types of O/W emulsions loaded with solids. Moreover, this study being a preliminary approach, neither the form of the structural units as defined in the Quemada model, nor their composition were investigated. It would be interesting to study intimately the nature of the continuous and dispersed phases of this type of fluids. In spite of the scarce experimental data, which prevents the confirmation of all the numerical results, it is quite obvious that such an approach could be useful in yielding easily the prediction of the morphology evolution of these fluids in terms of change in particle size and particle size distribution under shearing and with aging, especially considering the difficulties in performing such experimental measures.

## 5 CONCLUSION

In this work, the rheological behavior of paraffin oil-in-water emulsions, bentonite suspensions at different dispersed phase fractions and oil-in-water emulsions loaded with ben tonite has been investigated experimentally. The main results suggest that:

- Oil-in-water emulsions exhibit a non-Newtonian behavior following the Ostwald-de Waele power law with an apparent viscosity decreasing with aging at rest.
- Bentonite suspensions were found to have a viscoplastic behavior. The yield stress remains constant during aging but increases with the bentonite concentration. Contrary to the emulsions, the viscosity increases with aging time.
- For a fixed oil fraction, the viscosity of oil-in-water emulsions loaded with bentonite increases with solid fraction (bentonite) and with aging.
- The Quemada model was found to apply successfully for the correlation of rheological behaviors of oil-in-water emulsions, bentonite suspensions and oil-in-water emulsions loaded with bentonite.
- It was possible to determine the average diameter and the effective average diameter of the dispersed phase in the case of oil-in-water emulsions and oil-in-water emulsions loaded with bentonite. The results obtained were in reasonable agreement with those found experimentally by microscopy visualization and image processing.

To approach more closely the experimental reality of the drilling fluids, it would be interesting to study systems containing other solids, in particular inert particles (e.g. silica) or heavy particles (e.g. barite) added to clay mud in order to gain a higher density of drilling fluids.

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