

# Zeta potential: a new tool for assessing the properties of clays?

Chassagne Claire and Maria E. Ibanez

Section of Environmental Fluid Mechanics, Civil Engineering and Geosciences, Delft University of Technology, PO Box 5048, 2600 GA, Delft, the Netherlands  
E-mail: [C.Chassagne@tudelft.nl](mailto:C.Chassagne@tudelft.nl)

Important properties of cohesive clays, like flocculation ability, Cation Exchange Capacity (CEC), sedimentation and compaction behaviour are linked to the interfacial properties of the constitutive clay particles. One of the most important properties is surface charge, responsible for clay-clay and clay-(poly)ions interactions. A measure of this surface charge is the zeta potential.

The zeta potential is a parameter that can be obtained from electrokinetic experiments, i.e. measuring the response of a sample to the application of an electric field. One of the most popular electrokinetic techniques for assessing the zeta potential of particles suspended in a liquid is electrophoresis, where the zeta potential is extracted from the velocity at which the particles travel under influence of the electric field.

The link between surface charge and zeta potential has long been established (Sposito, 1984), as is the relation between surface charge and flocculation (Overbeek, 1952). These relations between surface charge – zeta potential – flocculation are however extremely complex, as they are challenging from a theoretical point of view and because some parameters required in the theory, like ionic interactions close to the particle's surface, are very difficult to assess experimentally. Progresses have been made in the recent years, both experimentally and theoretically. Many different clayey systems have been investigated in detail experimentally, and the relations between zeta potential, suspending medium properties and flocculation or settling behaviour have been established (Yukselen and Kaya, 2002; Mpofu *et al.*, 2003; Chassagne, 2009; Lee *et al.*, 2012; Ibanez *et al.*, 2014).

A major shortcoming of the theoretical models linking electrophoresis and zeta potential is that these models are only applicable to spherical particles.

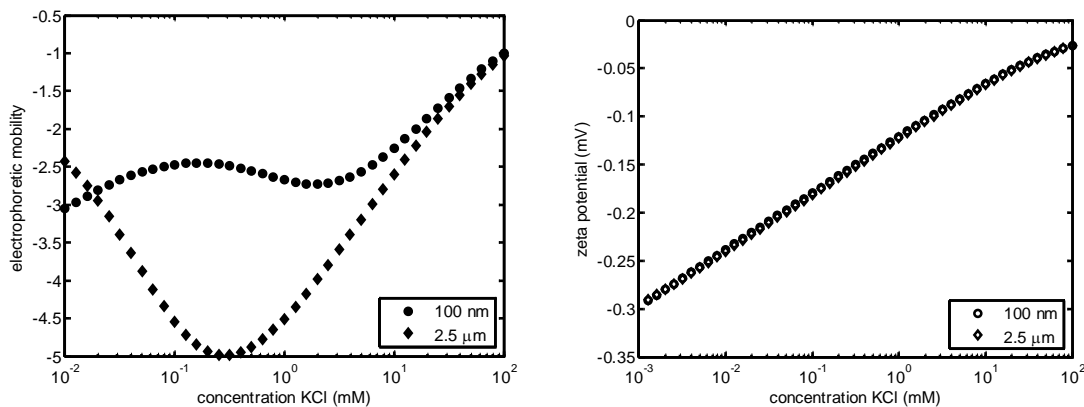


Fig. 1. Left: theoretical velocity (electrophoretic mobility) of two spherical particles, of different sizes but same surface charge density, as a function of added KCl salt concentration. Right: their corresponding zeta potential.

Recent studies have demonstrated the importance of non-sphericity in both the qualitative behaviour and quantitative values of the zeta potential upon changes in salinity in particular (Chassagne and Bedeaux, 2008; Chassagne *et al.*, 2009; Chassagne, 2013; Tsujimoto *et al.*, 2013). From an engineering point of view, the zeta potential ought to be a quantity that is easily accessible and provide sufficient information with a limited amount of data processing and in a reasonable amount of time.

In this study, we will demonstrate that electrophoretic studies can indeed be used to provide useful information about the clay surface properties, when performing a specific set of experiments, and being aware of general rules. These rules are derived from the systematic investigations undertaken in our group on various clayey suspensions, in combination with our theoretical models.

## References

- Chassagne C. and D. Bedeaux. 2008. The dielectric response of a colloidal spheroid. *J. Coll. Int. Sci.* 326(1):240-253.
- Chassagne C., F. Mietta and J.C. Winterwerp. 2009. Electrokinetic study of kaolinite suspensions. *J. Colloid Int. Sci.* 336(1):352-9.
- Chassagne C. 2013. Dielectric response of a charged prolate spheroid in an electrolyte solution. *Int. J. of Thermodynamics* 34(7):1239-1254.
- Ibanez M.E., C. Chassagne and A. Wijdeveld. 2014. Role of mono- and divalent ions on the stability of kaolinite suspensions and fine tailings. (submitted *Clay and Clays Minerals*)
- Lee B.J., M.A. Shloutman, E. Toorman and M. Fettweis. 2012. Competition between kaolinite flocculation and stabilization in divalent cation solutions dosed with anionic polyacrylamides. *Water Res.* 46(17):5696-5706.
- Mpofu P., J. Addai-Mensah and J. Ralston. 2003. Influence of hydrolyzable metal ions on the interfacial chemistry, particle interactions, and dewatering behaviour of kaolinite dispersions. *J. Colloid Int. Sci.* 261(2):349-359.
- Overbeek J.T.G. 1952. Kinetics of flocculation. p.278-300. In: *Colloid Science*. Kruyt H.R. (Ed.). Elsevier Publishing Company.
- Sposito G. 1984. *The surface chemistry of soils*. Oxford University Press, New York
- Tsujimoto Y., C. Chassagne and Y. Adachi. 2013. Comparison between the electrokinetic properties of kaolinite and montmorillonite suspensions. *J. Colloid Int. Sci.* 407:109-115.
- Yukselen Y. and A. Kaya. 2002. Zeta potential of kaolinite in the presence of alkali, alkaline earth and hydrolysable metal ions. *Water, Air, and Soil Pollution* 145:155-168.