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Electroacoustics Phenomena In Concentrated Dispersions

This is the fifth issue of our DT Newsletter. We would like to inform you about new electroacoustic theory which has been developed and experimentally verified by A.Dukhin, H.Ohshima, V.Shilov and P.Goetz. This theory and experiment are published in Langmuir: "Electroacoustic Phenomena in Concentrated Dispersions. New theory and CVI experiment". You can download this paper from Langmuir Web site using the following pathword http://pubs.acs.org/reprint-request?la990317g/w8LH Please, use it only once. We have 50 reprints only.

In addition we reproduce below the Conclusions of this paper.

Conclusions

We have derived a new electroacoustic theory without using O'Brien's relationship between electroacoustic signal and dynamic electrophoretic mobility. Instead we use coupled phase model and cell model concept. We manage to extent this theory to polydisperse systems without using superposition assumption for hydrodynamic part of the problem. This new theory is supposed to be valid for polydisperse concentrated dispersions with low surface conductivity and thin double layer. The new theory give the same result as O'Brien's theory in the dilute system. At the same time this new theory predicts quite different values of electroacoustic signal in concentrated systems. We have shown that our new theory satisfies Onsager's and Smoluchowski's principles at low frequency at any volume fraction. At the same time "hybrid O'Brien's theory" which employs O'Brien's relationship and cell model theory for the dynamic electrophoretic mobility does not meet Onsager's and Smoluchowski's principles at low frequency for concentrated systems. We came to the conclusion that it happens because of the O'Brien's relationship.We have tested both theories with equilibrium dilution experiment using silica Ludox and rutile R-746 from Dupont. The test with silica Ludox TM confirmed that our theory gives correct volume fraction dependence within a whole available range of the volume fraction up to 30%vl, whereas O'Brien's relationship leads to the significant (100%) deviation from the experimental data. Equilibrium dilution test with the stable rutile dispersion proved that our theory gives the correct particle size dependence within volume fraction range from 1.1% vl up to 45.9% vl, as well as volume fraction dependence. We have shown that this new theory yields almost constant ζ -potential (± 10% variation) within the whole volume fraction range. Polydispersity of the rutile sample was not a significant factor, at least comparing with volume fraction and particle size. We also calculated ζ -potential using "hybrid O'Brien's theory" which employs O'Brien's reciprocal relationship and our cell model theory for electrophoretic dynamic mobility [9-11]. This theory produces ζ -potential about 4 times smaller (300% error) than expected at the highest volume fraction of 45.9%vl. There is some reasons to believe that situation would be even worse for the original O'Brien theory with Levine cell model. It misses an additional volume fraction dependence related to the conductivities ratio. If we take into account only volume fraction effect and neglect particle size dependence for dynamic electrophoretic mobility error reaches almost 1000%. We would like to stress that our new electroacoustic theory has been created so far for CVI only. It is not clear yet how to apply it to ESA effects. Required modifications will depend on the design of the instrument including ratio of masses of the chamber and the sample. This ratio determines an appropriate frame of references. At the same time the basic physical framework should work for ESA effect as well as for CVI. We would like to stress that according to our knowledge commercially available electroacoustic spectrometer based on ESA principle-Acoustosizer of Colloidal Dynamics, applies empirical correction for calculating ζ -potential from the ESA signal. It follows directly from the recent review published by Prof.Hunter who is one of the Acoustosizer authors [1]. This correction is nessecary because, as Prof.Hunter admits, their theory was valid only up to 5%vl. This empirical correction works and reduces dramatically error of the Acoustosizer in some concentrated systems. Unfortunately, this empirical corrections mask results of theoretically justified calculations