The Interfacial Tension Of Colloidal Suspensions

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Motivation

- Colloidal dispersion are ubiquitous
  - Magnetic recording materials
  - Printing inks
  - Inorganic and organic pigments
  - Paper Coating
- Interfacial tension plays a very important role in determining the properties and processing of the colloidal suspensions.
Literature Data

- Surface tension of aqueous silica suspension
- Suspension structures are liquid-like or gas-like
- Particle size is from 6 nm to 60 nm.

Current Experiments

- Measure the surface tension of SiO$_2$ and TiO$_2$ suspension at various concentrations using pendant drop method and DeNuoy ring method
- Measure interfacial tension of the suspensions in silicone oil.
Zeta Potential of Titania Dispersion

The zeta potential of titania dispersion as a function of pH and concentration of aluminum nitrate.

Interfacial Tension of Silica Dispersion Using Pendant Drop Method

Note: the size of the particles is from 100µm to 600 µm
Interfacial Tension of Titania Dispersion Using Pendant Drop Method

Note: The size of the particles is from 50µm to 300µm
Surface Tension of Titania Dispersion Using Ring Method

Note: the size of the titania particles is from 50µm to 300µm
Physical Explanation

\[ \gamma = \frac{\partial G}{\partial A} \]

\( G = \) Gibbs free energy at the interface.
\( A = \) The interfacial area.

Schematic representation of colloidal particles at the interface.
The interactive energy between two particles $\Delta W$ is:

$$\Delta W = 2\pi\gamma Q^2 K_0(qL)$$

Plot of the interaction energy between two immersed colloidal particles of the same radius, $r$. The plot was calculated using the values: $\gamma = 72$ dyne/cm, $\Delta\rho = 1$ g cm$^{-3}$, $\psi = 60^\circ$. 

Schematic of two particles placed at an interface.
Physical Explanation (cont.)

- For pendant drop method, the curvature is large, fewer particles can be packed at the interface.

- For ring method, the interface is flat, more particles can be packed at the interface.
Questions for Future Work

• How important is the electric double layer (pH value) in determining the surface tension?
• How does the size and polydispersity of the particles affect the surface tension?
• How would the addition of surfactants change the surface tension?
Conclusions

• Interfacial tension of a colloidal dispersion can be a strong function of the particle concentration
  - decreases with the increase of the concentration at low weight percents
  - increases with the increase of the concentration at higher weight percents.
  - Pendant drop and DeNuoy ring can give different results.
Pendant Drop Method

The pendant drop method determines the profile of the bubble at hydrostatic and interfacial equilibrium, calculate the surface tension from the measurement of the shape of the drop.

RHI 2001 Imaging Goniometer System
Ring Method

\[ \sigma = \sigma^* \cdot F = \frac{P}{2\pi \cdot (R_i + R_a)} \cdot F \]

\( \sigma \) = real surface tension value  \( P \) = maximum force at the ring
\( \sigma^* \) = measured surface tension value  \( R_i \) = radius at inner side of the ring
\( F \) = correction factor  \( R_a \) = radius at outside side of the ring

The correction factor \( F \) include the weight of the liquid is lifted by the ring.