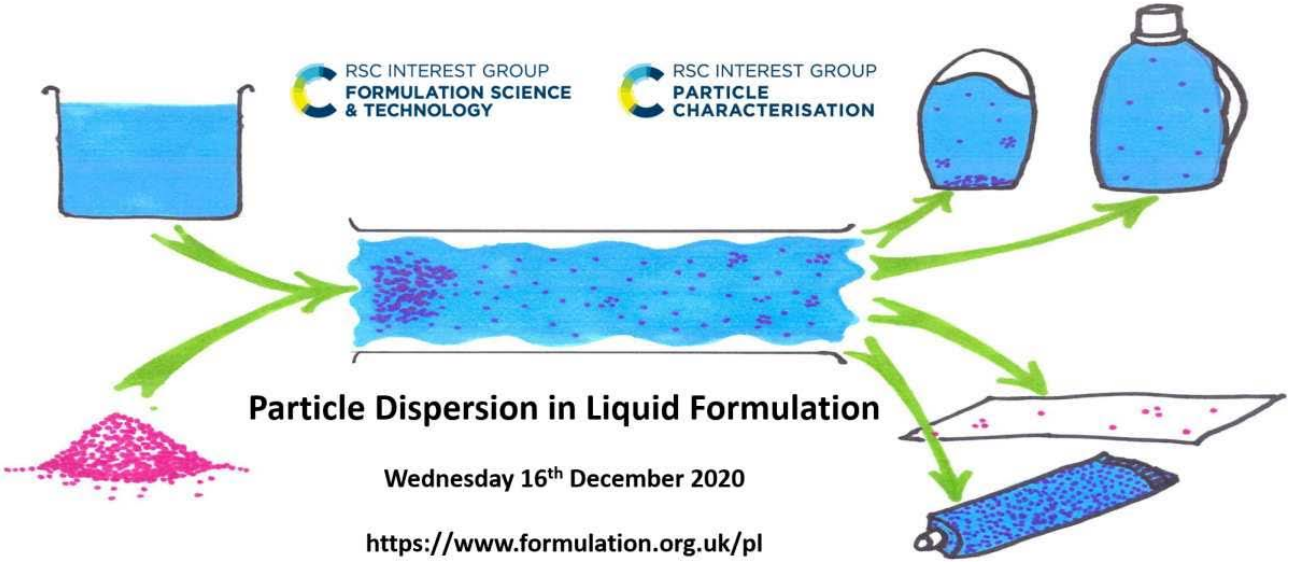

Colloidal Refractometry
for
Characterisation of Dispersions

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Colloidal Refractometry

Aim and Relevance

- Aim

to close the knowledge gap between solutions and dispersions in refractometry.

- Relevance

the possibility of a new particle sizing and microstructure determination technique by the advent of automatic refractometers.

An old Abbe refractometer

A new digital refractometer

Colloidal Refractometry

Refractive index of mixtures: solutions v dispersions.

- Refractive index of a pure sample, n.
- Refractive index of a mixture or a clear solution as a function of the solute volume concentration, ϕ, solute refractive index n_p, and solvent or continues phase's refractive index n_c can be written as:

$$n = n_c + \phi(n_p - n_c)$$

- What would be the refractive index of a dispersion or an emulsion in terms of the dispersed phase properties?
- How would the particle size feature in that expression?

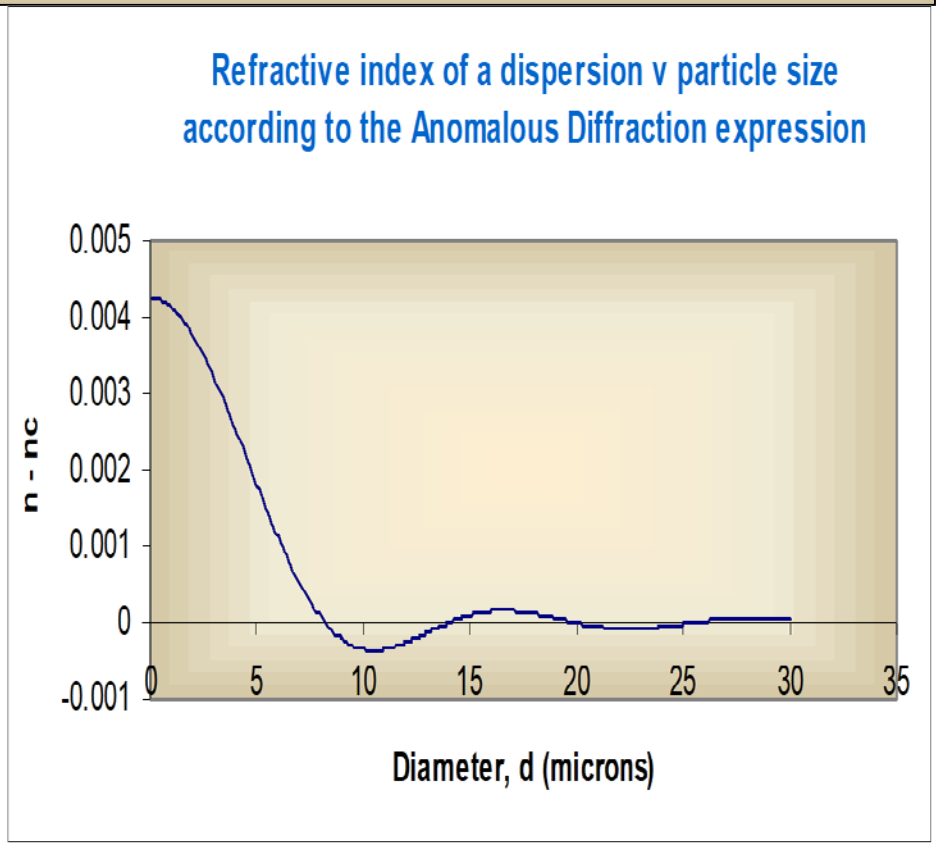
$$n = n_c + \phi(n_p - n_c) f(d_{x,y})$$

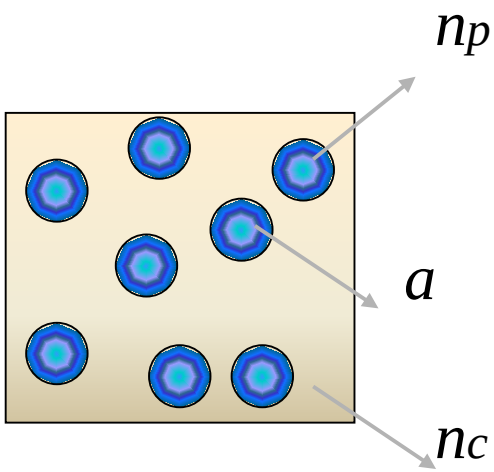
Colloidal Refractometry

The generalised refractive index equation: The anomalous diffraction approximation to Mie

$$n = n_c + \phi(n_p - n_c)\left(\frac{3\sin p}{p^3} - \frac{3\cos p}{p^2}\right)$$

$$p = 4\pi a(n_p - n_c)/\lambda_0$$





Colloidal Refractometry

Automatic critical-angle refractometers

- Position of a sharp light-dark demarcation for transparent liquids gives the value of n,
- Turbid dispersions give a diffused edge - gradual change rather than discontinuous,
- Differentiating the light intensity v position once or twice pinpoints the cut-off edge - hence n readout accurate to ë2x10^{-5},
- One or two drops of a neat liquid suffices to give a refractive index reading.
- We used a Bellingham-Stanley RFM340 for the measurements here.

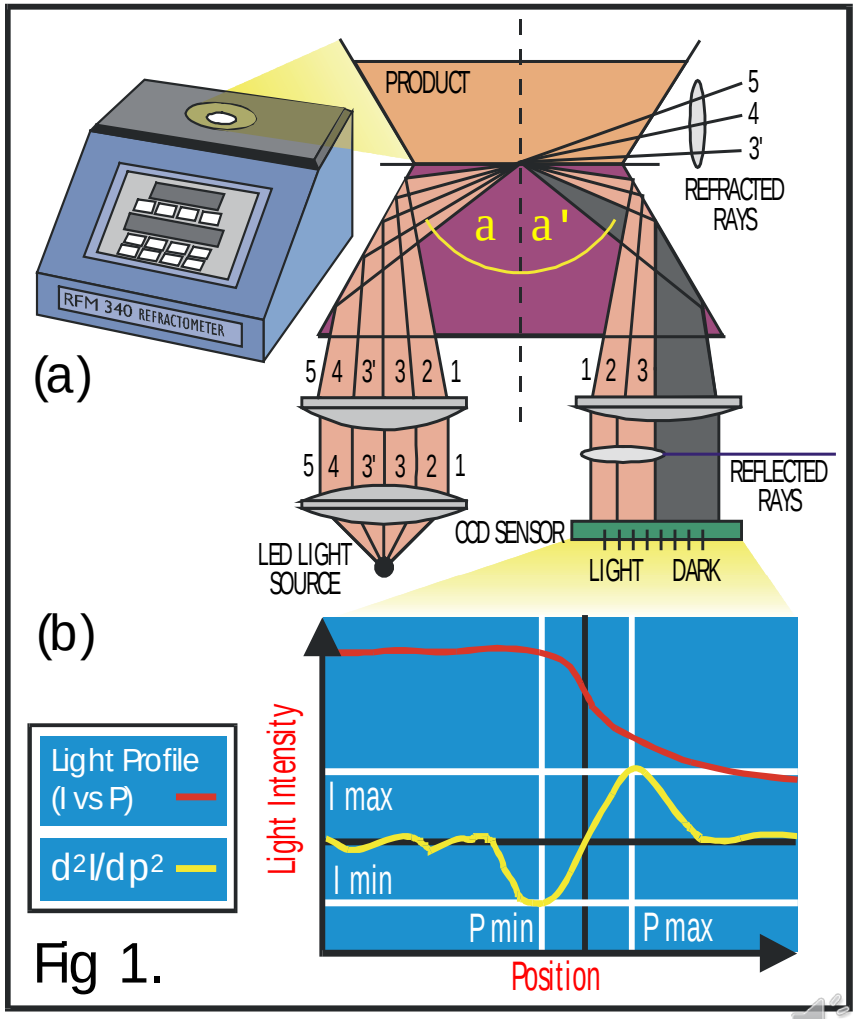
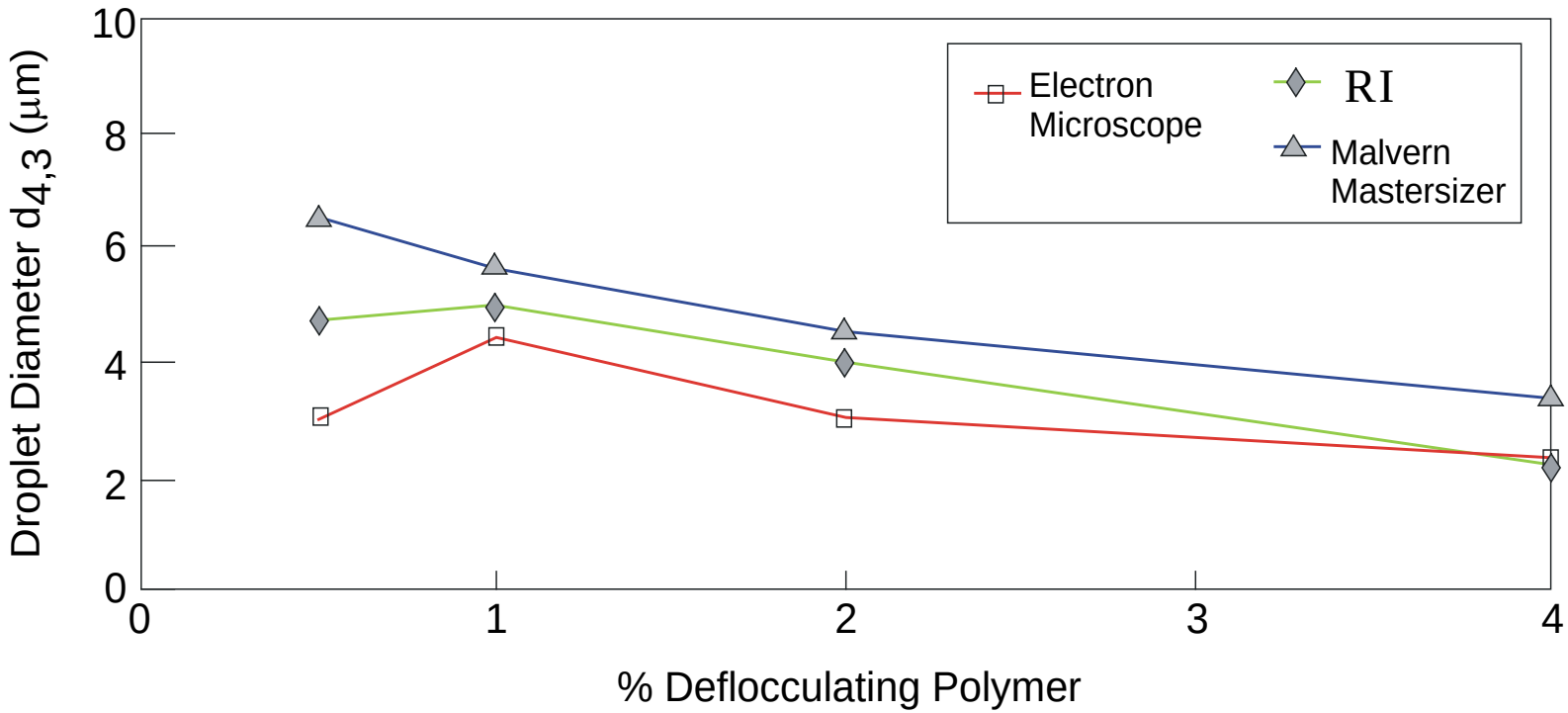


Fig 1.

Colloidal Refractometry

Measuring L_α liposome de-flocculation in a surfactant system (liquid detergent)

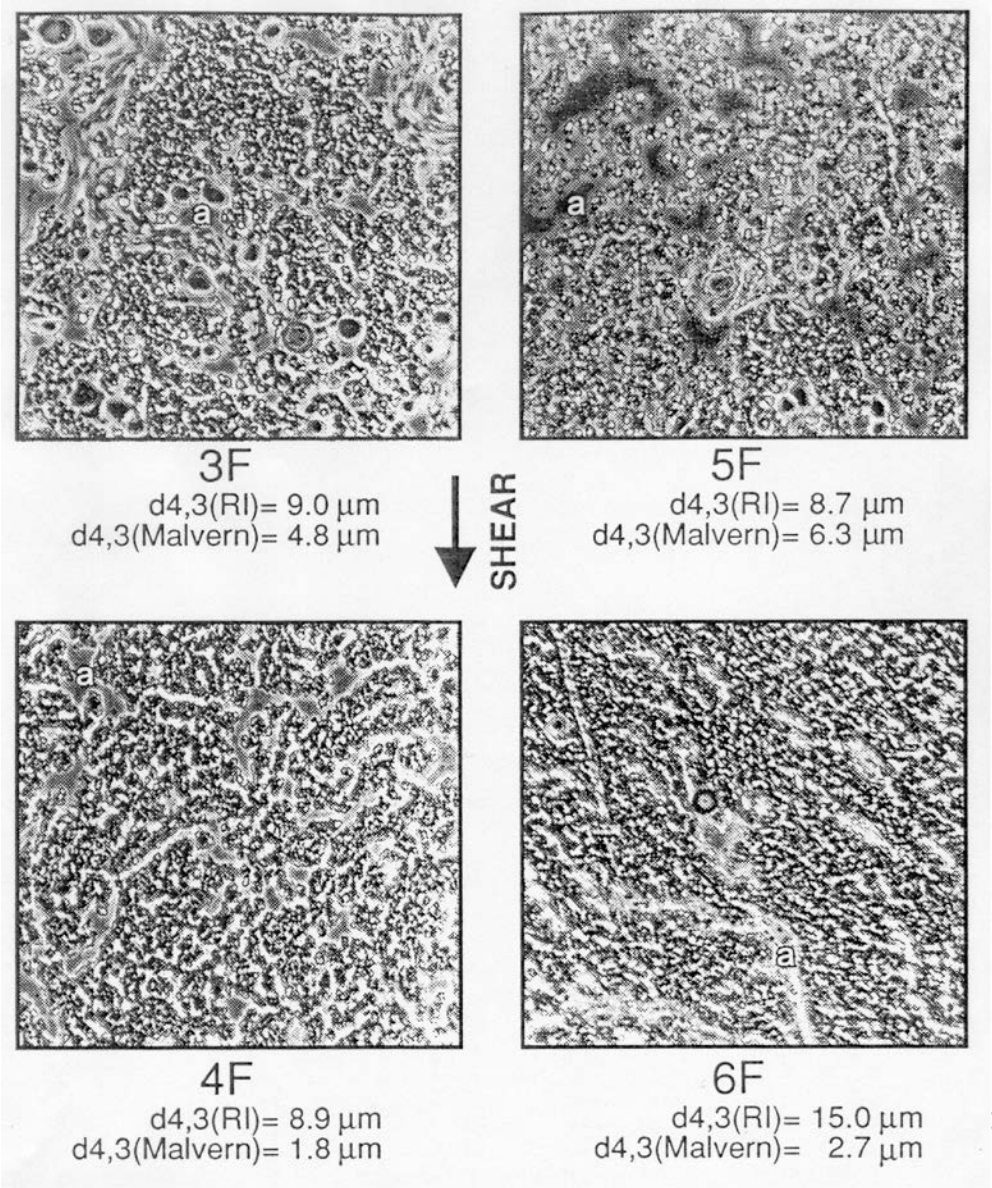


- The generalised refractive index (RI) equation appears to give the volume-surface average size, $d_{4,3}$, rather than other averages.

Colloidal Refractometry

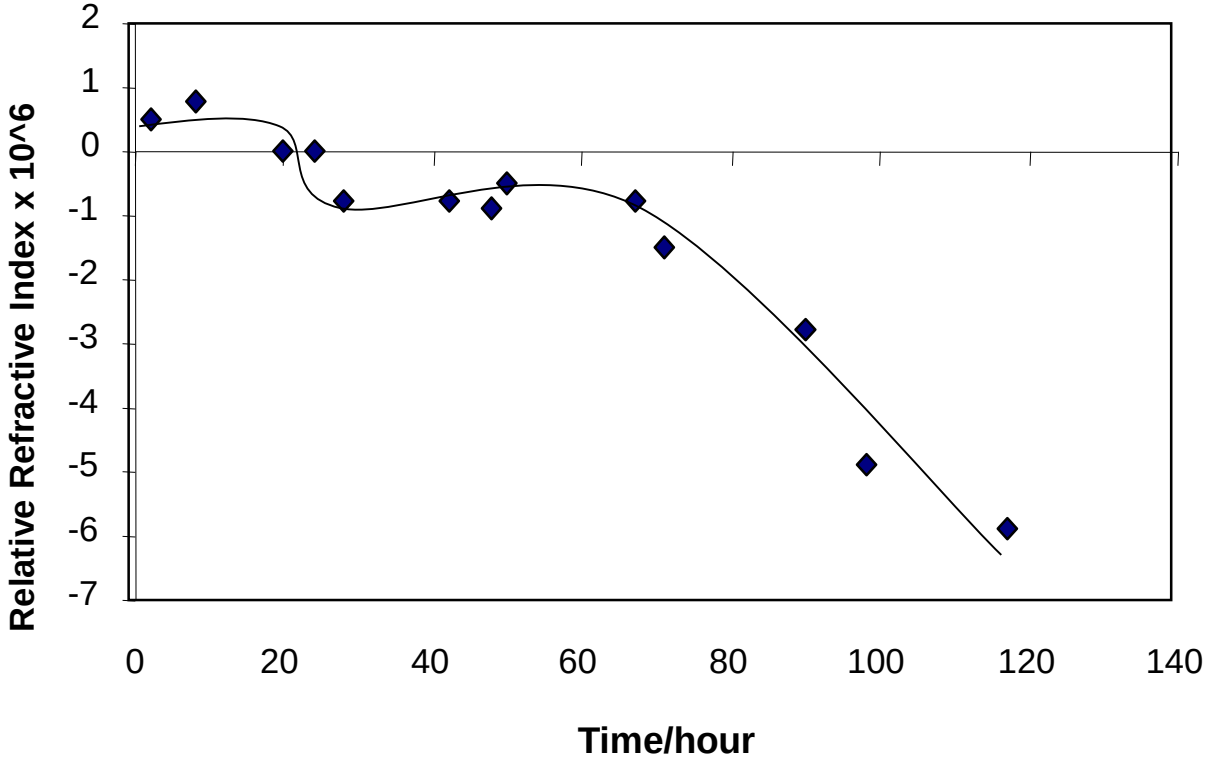
Primary v floc size in liposome dispersions

- Shear induced flocculation widens the discrepancy between the two methods, the Malvern Mastersizer and refractive index(RI).
- The sizes from RI agreed with the rheology and creaming behaviours of the dispersions.



Colloidal Refractometry

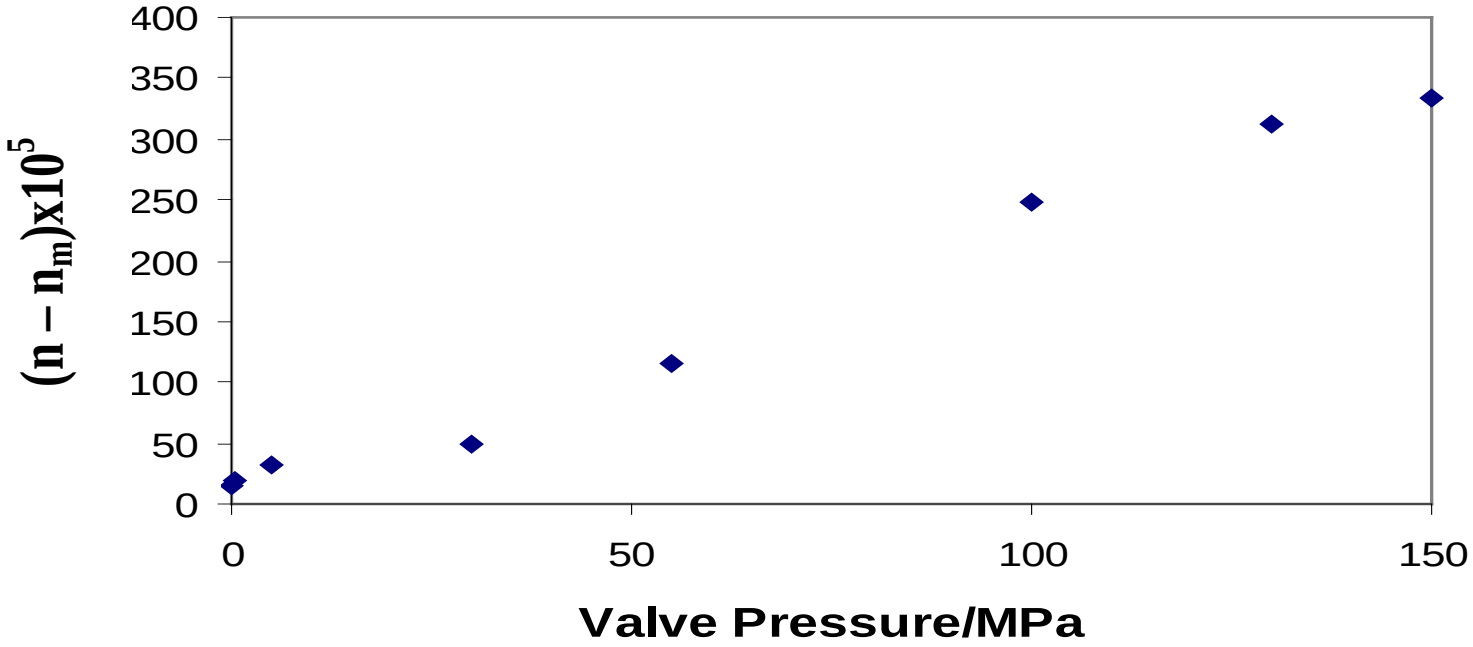
Measuring flocculation in polymer latices

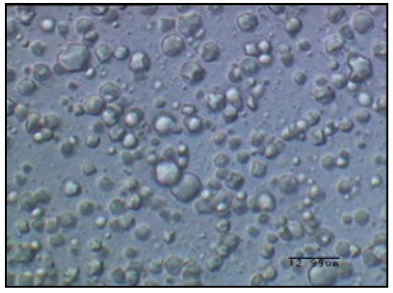


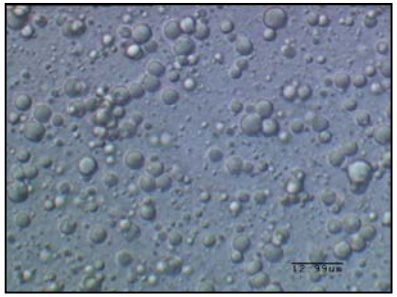
- The change in the refractive index of a polyvinyl toluene latex with time during the slow aggregation by addition of NaCl.

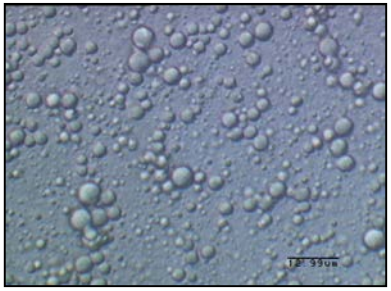
Colloidal Refractometry

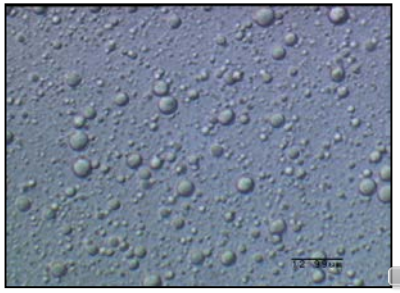
Increase in refractive index with homogenisation of full-fat milk as fat globules become smaller







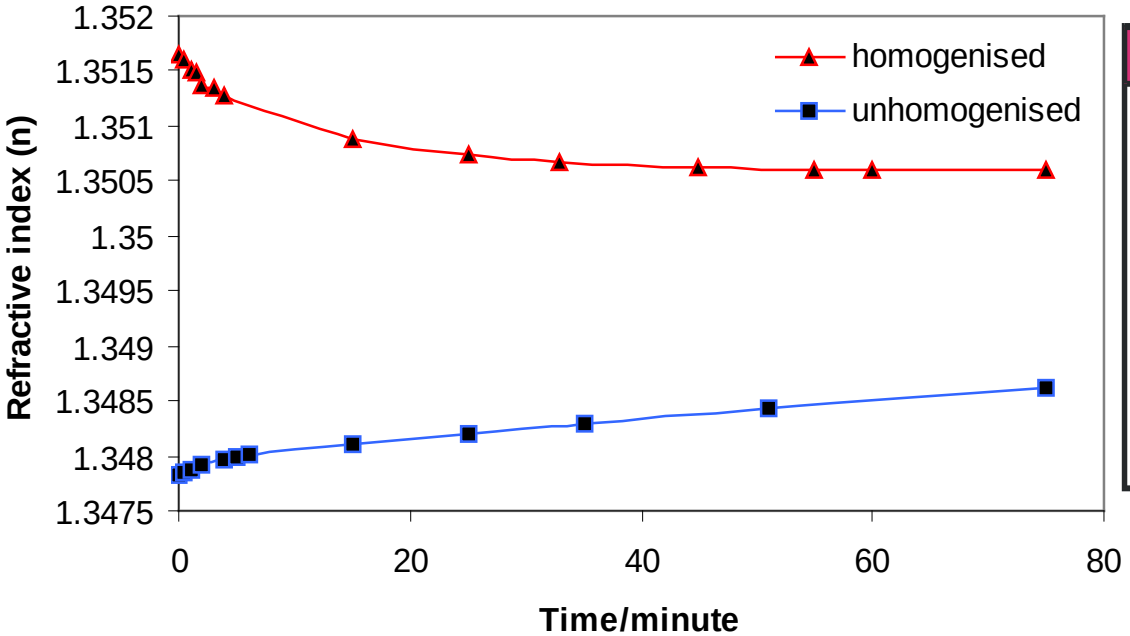


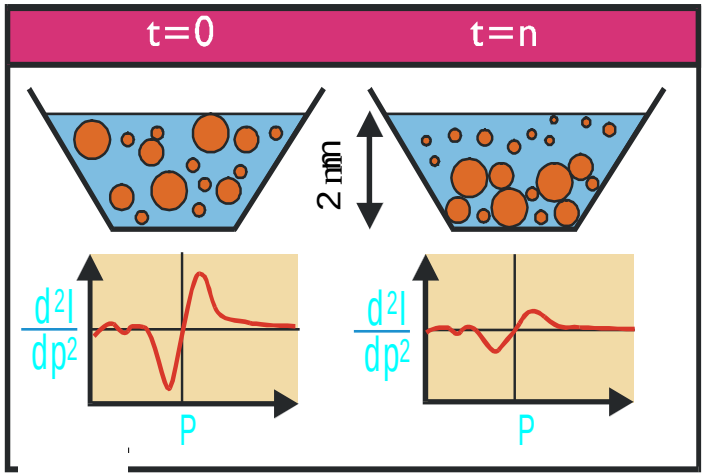


Colloidal Refractometry

Fast forecasting of creaming/sedimentation

- Kinetics of creaming for two full-fat milk samples studied by measuring the change in refractive index with time.





- A few drops of the sample remains on the smapling space of the prism where light penetrates only a few micron deep and records particle movement and change in concentration in a micrometre size space. To see such changes macroscopically will need days.

Colloidal Refractometry

Acknowledgement and References

- Unilever Research Port Sunlight for permission to present the work.
- Dr. Gerry Meeten (Schlumberger Research Cambridge) for guidance and advice,

- Mohammadi M S, Colloidal Refractometry, The Art of Microstructure Characterisation, Chapter 7 in 'Particle Sizing and Characterisation", volume 881in the ACS Symposium Series, 2004'.

- This reference gives the historic perspective, background theory and application of the new method with full references to the original work.