Ultra Small Angle X-ray Scattering (USAXS) at UNICAT

National School on Neutron and X-ray Scattering

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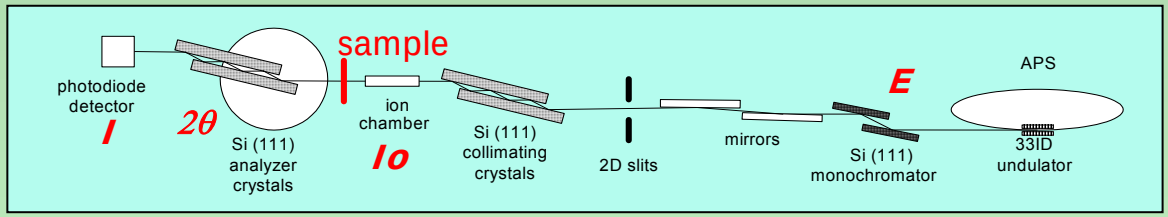
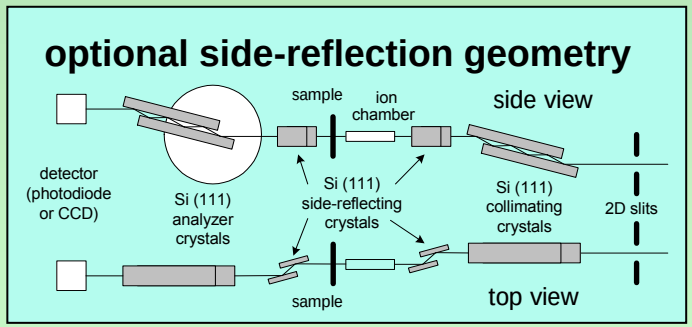
Advanced Photon Source

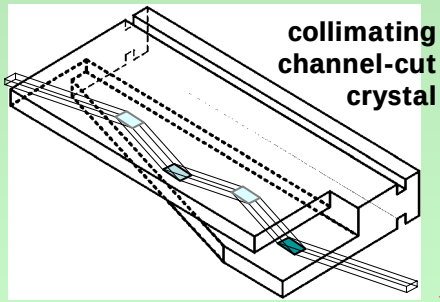
UNICAT USAXS Instrument

www.uni.aps.anl.gov/usaxs

Versatile USAXS (Bonse-Hart) facility for advanced materials research at APS Beam Line 33ID-D

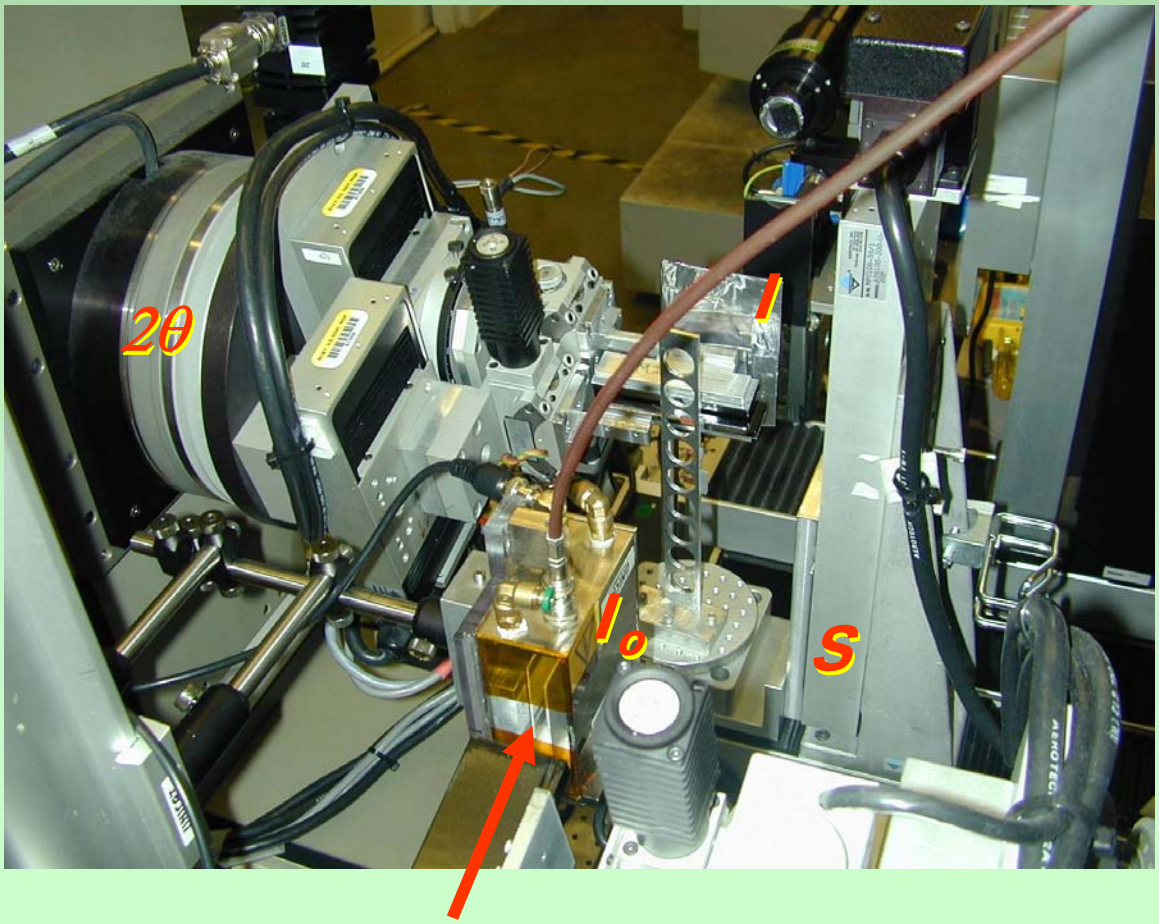






- Q range: 0.00015 ≤ Q, Å^{-1} ≤ 1
- X-ray energy tunability: 7 – 20 keV
- energy resolution: $\Delta E/E \approx 0.00015$
- energy harmonic content < 10^{-6}
- 0.5 x 2 mm^2 beam size, adjustable
- I_0 >10^{12} ph/s (10 keV) delivered to sample
- sample in air (ca. 1/4 m from detector)
- automatic sample changer/translation stage
- absolute determination of $d\Sigma/d\Omega(Q)$
- USAXS imaging

UNICAT Standard USAXS Setup

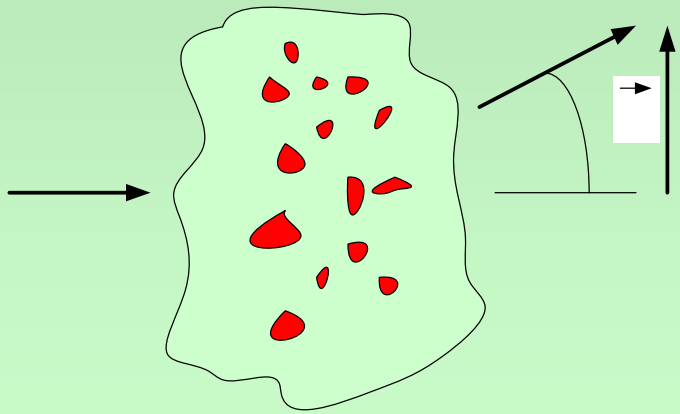


USAXS Experiments

Overview: Characterization of Particulate Matter in Dairy Products (i.e. Casein Micelles)

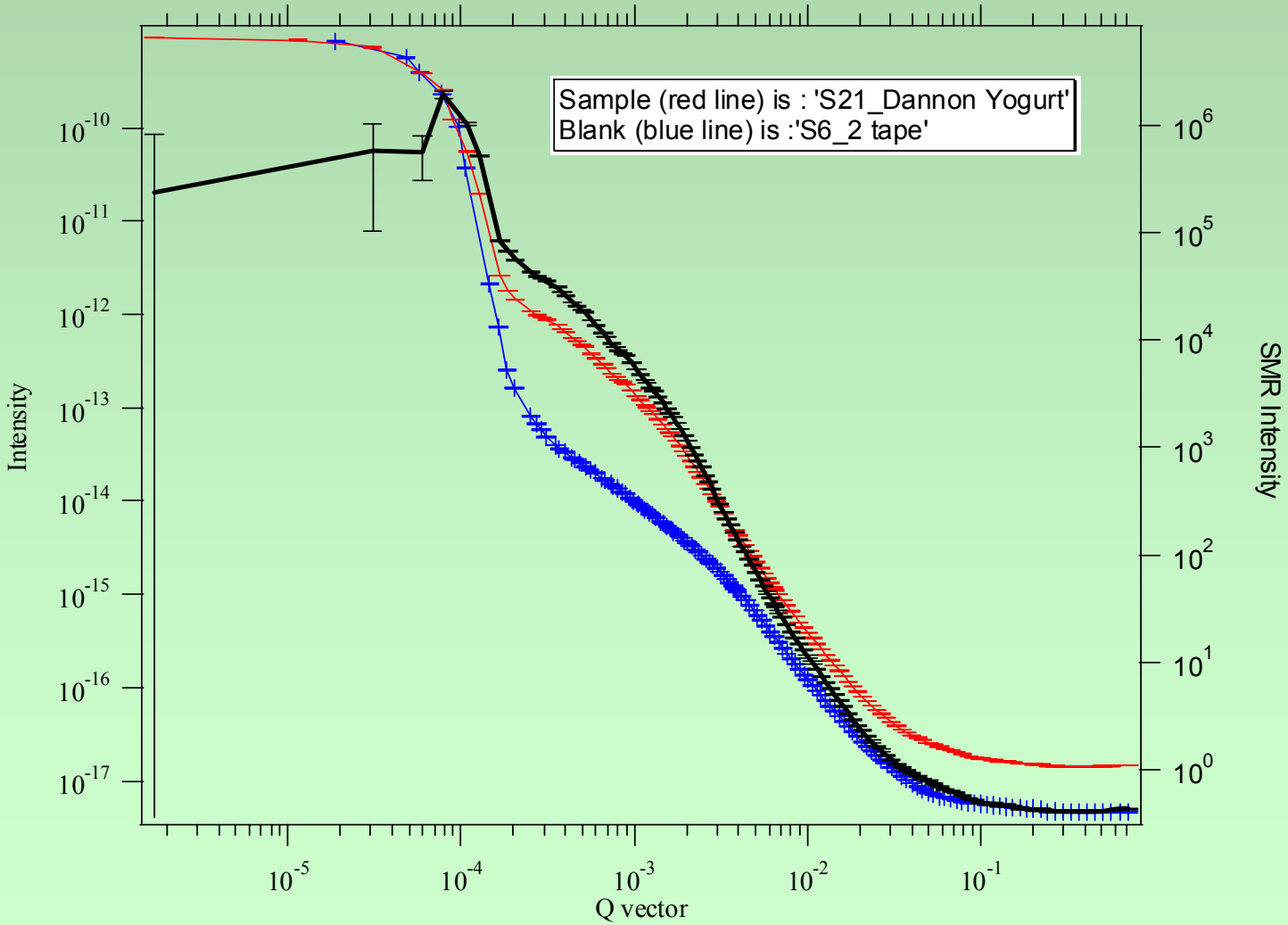
- 3M Scotch Tape Blank (Background Correction)

- Mozarella Cheese
- Parmesan Cheese
- ***Dannon Yogurt***
- Homemade Yogurt
- Kraft Mayonaise

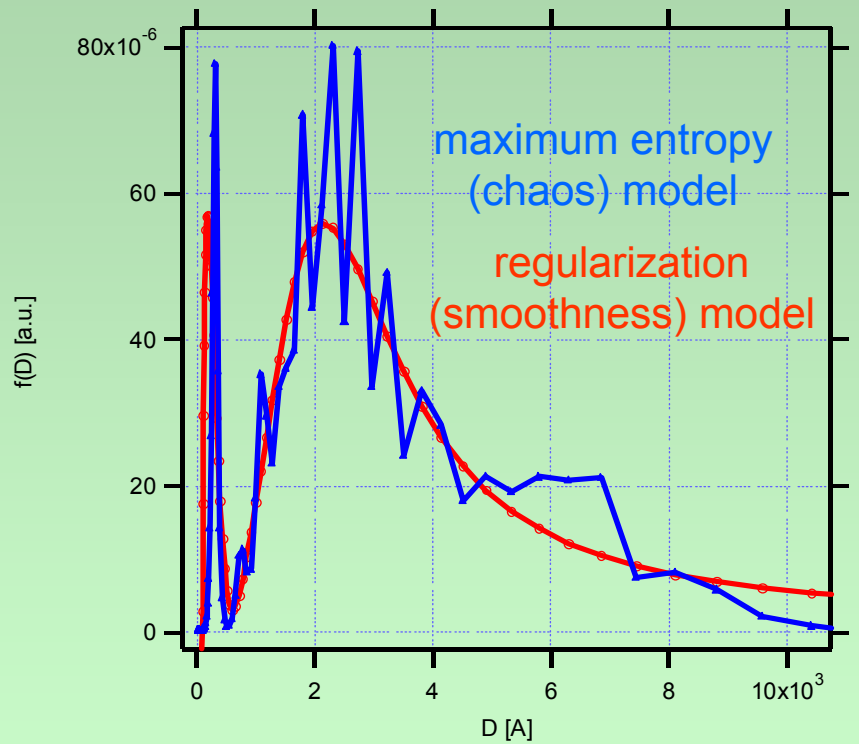


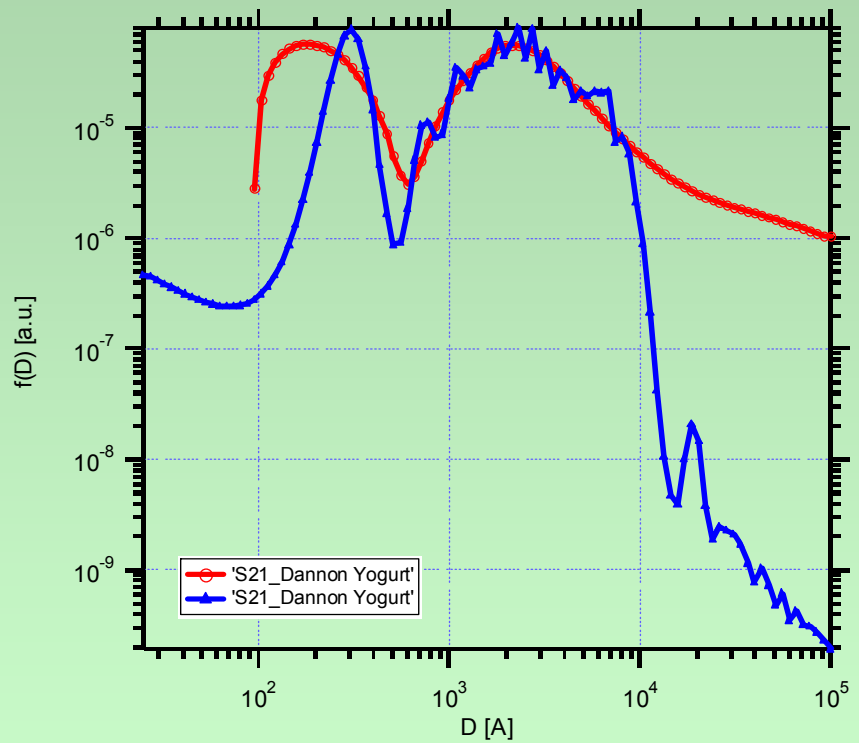
$$\frac{d\Sigma}{d\Omega}(\vec{Q}) = \left| V_p^{-1} \int_{V_p^{-1}} \rho(\vec{r})\, e^{-\vec{Q}\cdot\vec{r}}\; d^3\vec{r} \right|^2$$

USAXS Data of Dannon Yogurt



Size Distribution (2 models) of Micelles in Dannon Yogurt





$$\frac{d\Sigma}{d\Omega}(Q) = |\Delta\rho|^2 \int_0^\infty |F(Q,r)|^2 \, V(r) f(r) \, dr$$

$$F(Q,r) = 3(Qr)^{-3}\left[\sin(Qr) - (Qr)\cos(Qr)\right]$$

Schematic of Casein Micelles

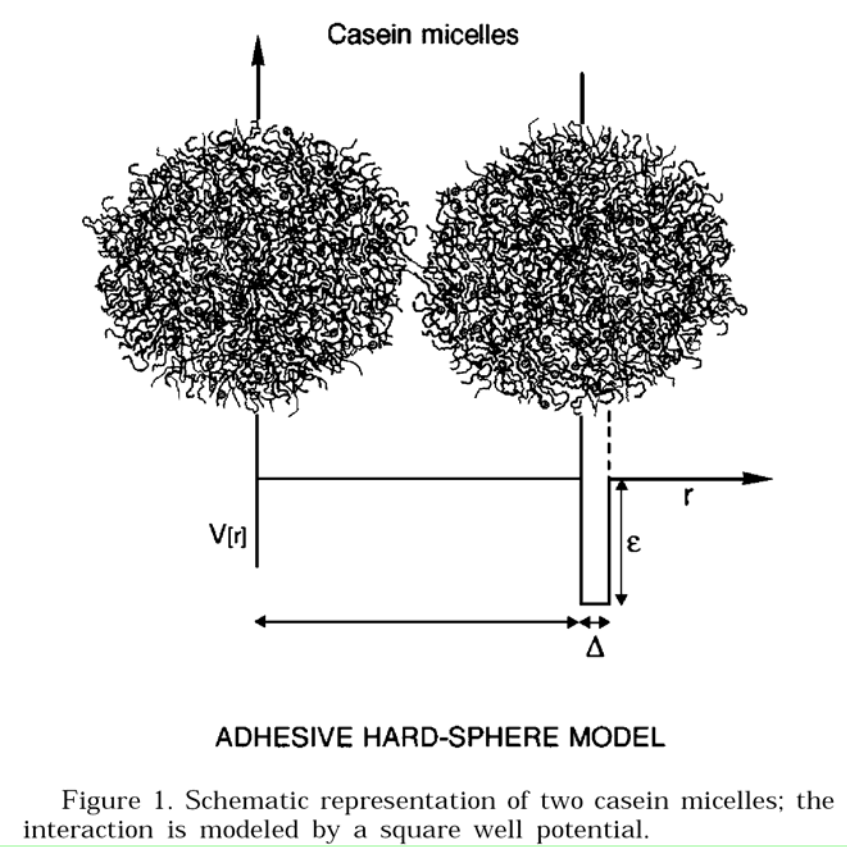
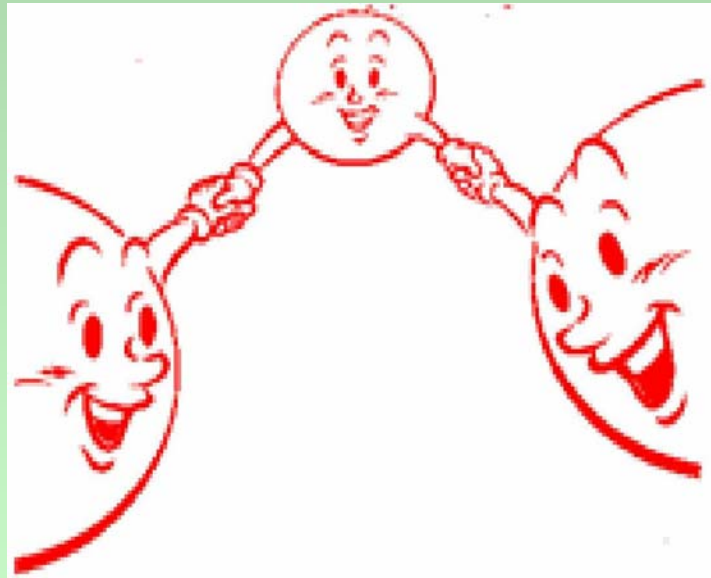


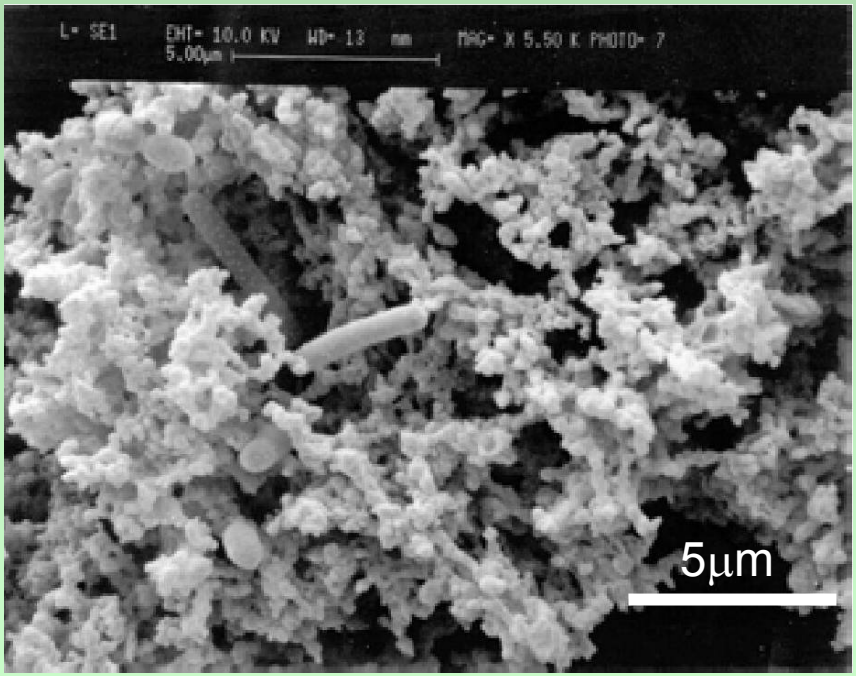
Figure 1. Schematic representation of two casein micelles; the interaction is modeled by a square well potential.

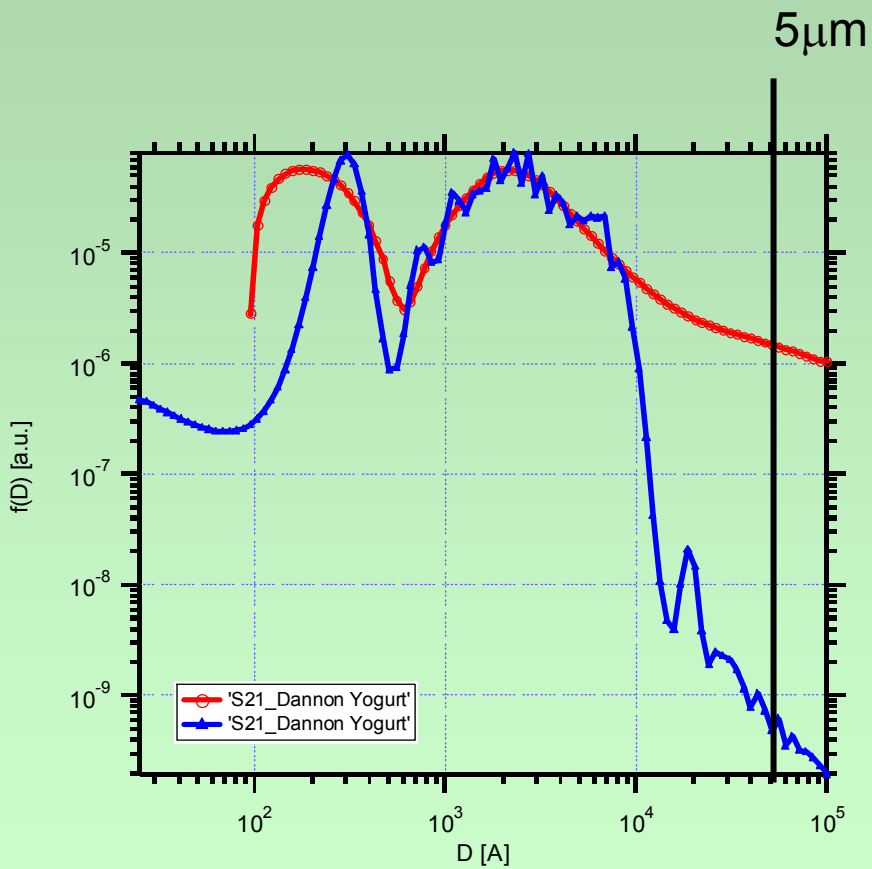
CG de Kruif, J. Dairy Sci. 81:3019-3028 (1998)



KB Qvist, Danisco Presentation at the Nordic Rheology Society, Iceland (2004)

SEM Micrograph of Casein Micelle Agglomerate





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