# Rheology of structured fluids

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# TA Instruments - a brief introduction

- TA Instruments (a subsidiary of Waters ltd.) is the worldwide leader in Thermal Analysis, Rheology and Microcalorimetry equipment

- TA Instruments is a manufacturer based in New Castle (Delaware) but has direct offices in more than 20 countries worldwide providing:
  - Sales
  - Application Support
  - Service Support

- TA has a long story in Rheology (in 1993 acquired Carri-Med and in 2003 Rheometrics)

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# Rheology equipment


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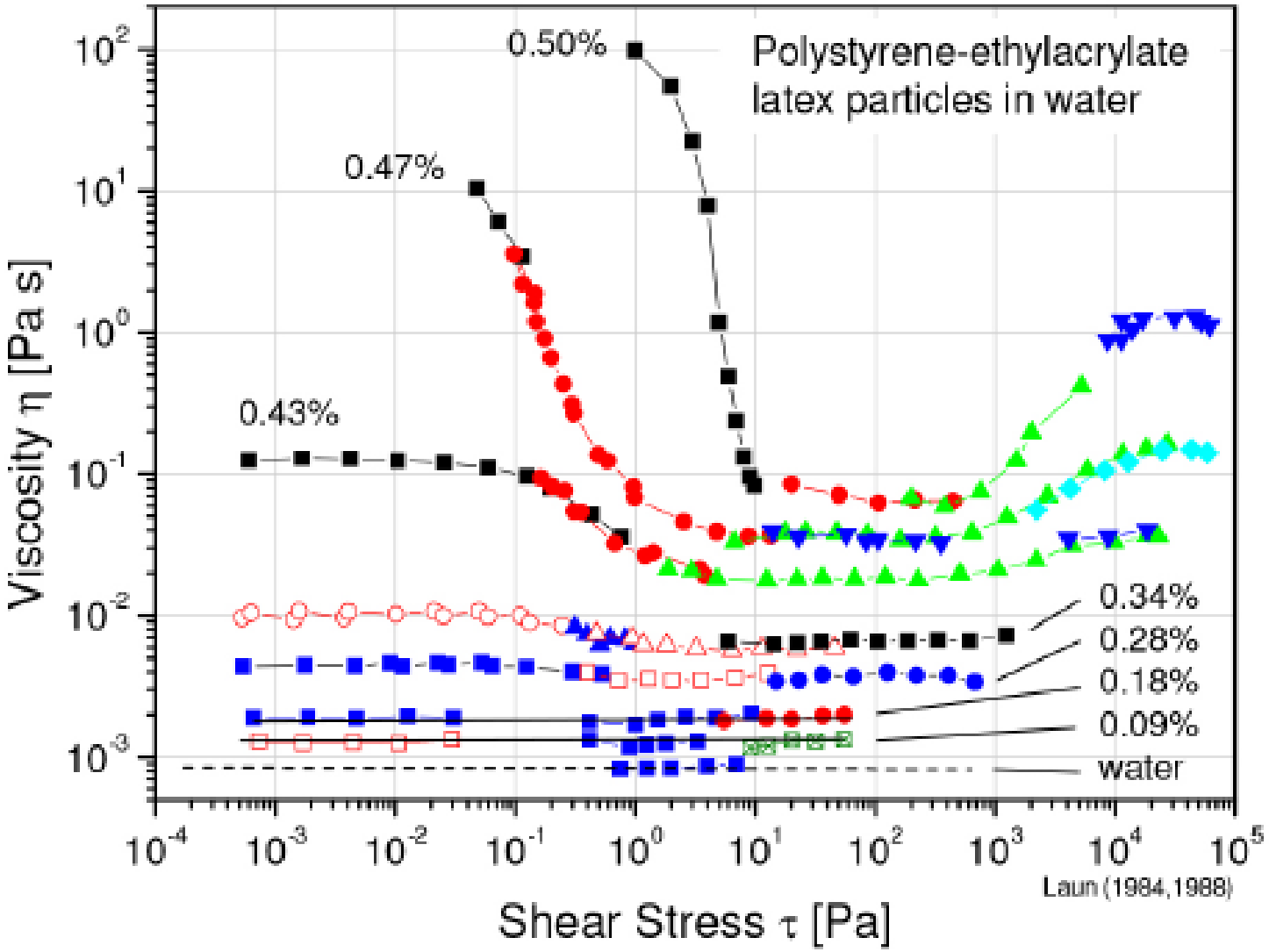
# Why characterize rheology of SF?

- Structured fluids are everywhere (foods, cosmetics, pharmaceuticals, coatings)
- Emulsions, dispersions and foams (as well as multiphase systems) are often inherently unstable
- Their stability (or the strategies to improve their stability) is related to the viscosity of the liquid matrix and the interactions among the particles and between the particle and the matrix
- From a rheological point of view, several relationships between viscosity and shear rate/stress are possible:
  - Bingham, Shear thinning, Pseudoplastic, Shear thickening, Thixotropy

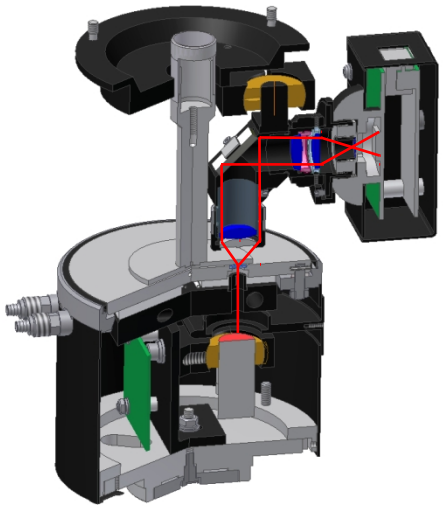
# Example: Plastic flow + dilatancy

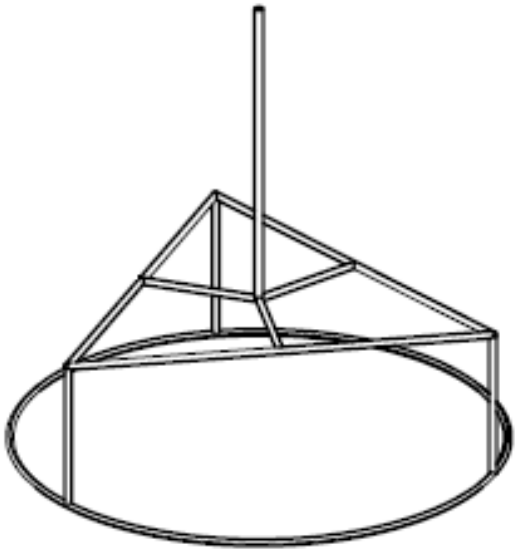


# Two "unusual" characterisations

- Laminar flow in the liquid matrix can have an effect on the "structure" of the dispersed phase
  - Small Angle Light Scattering (SALS) can study the orientation of particles

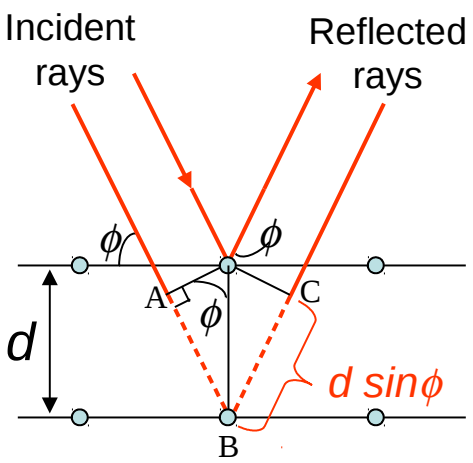
- Unstable dispersions can be studied from an interfacial point of view
  - Double Wall Ring (DWR) is an exclusive accessory to perform interfacial rheology studies

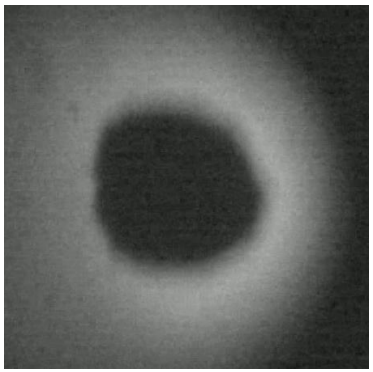


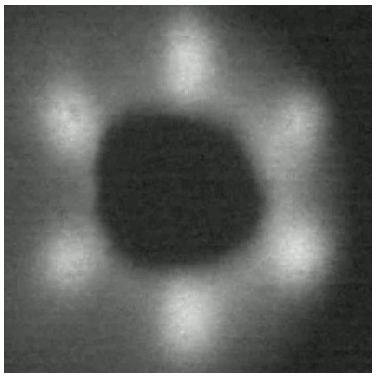


# SALS

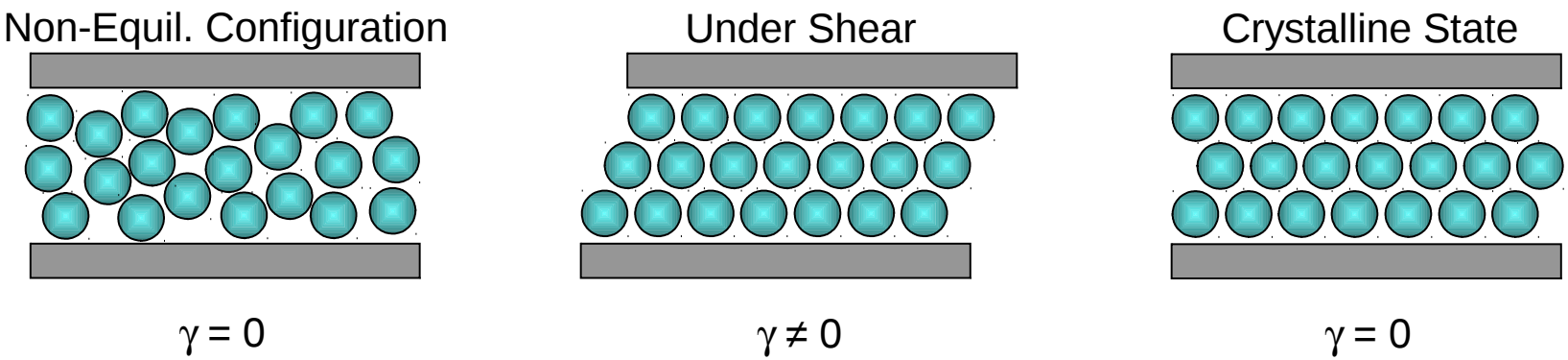
- A laser beam is shun through a sufficiently transparent dispersion
- Dispersed particles (diameter ranging from 1 to 4.6 micron) scatter the light and the resulting scattering pattern is collected by a camera
- When (if) the particles are oriented by the laminar flow, Bragg's law can be used to work back the orientation pattern





# Shear-Induced crystallization




- Sample: Silica particles (1 micron - monodispersed) concentrated in PEG
- Test method: Large Amplitude Oscillation (LAOS) at 100% or more of shear strain

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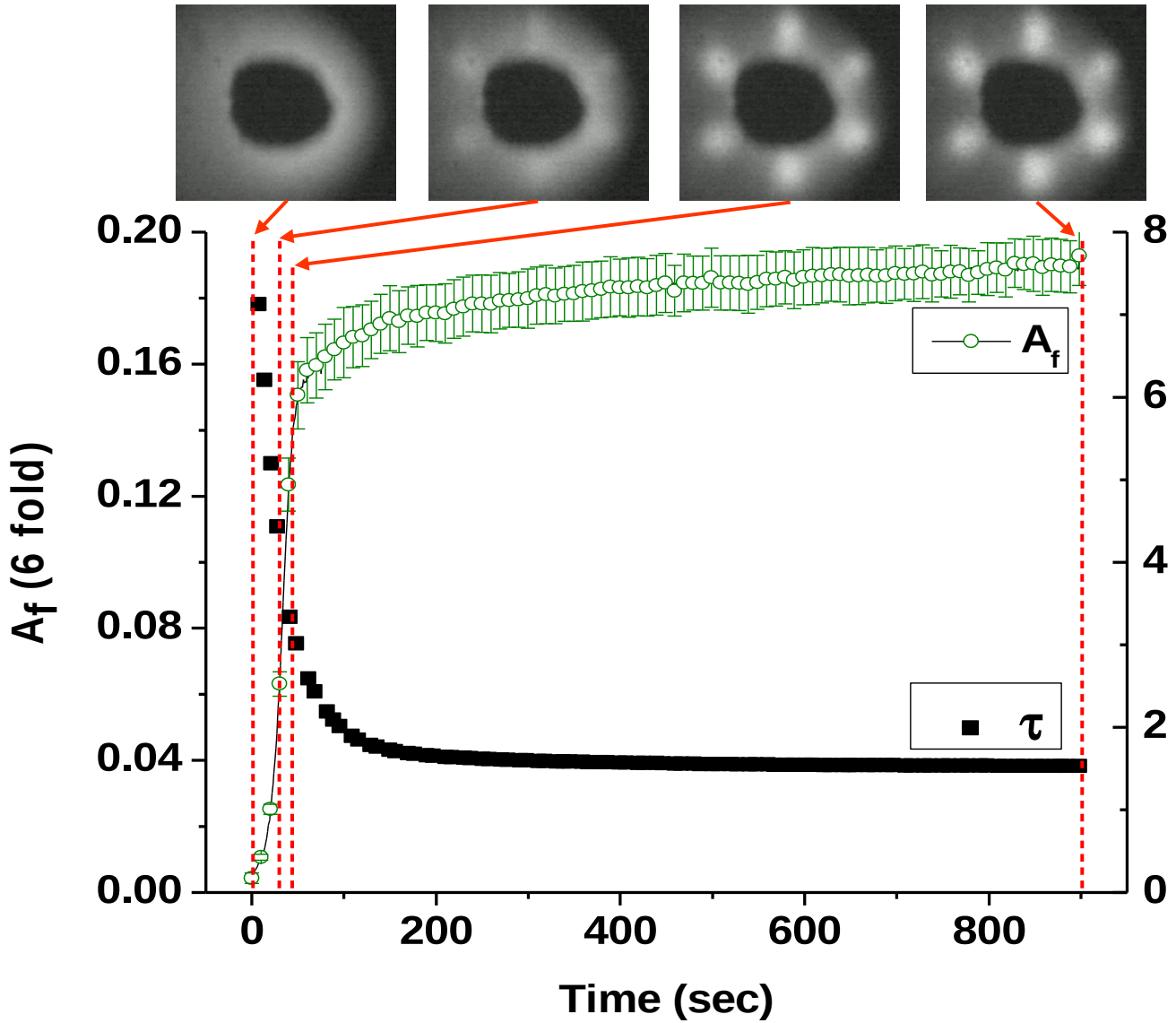
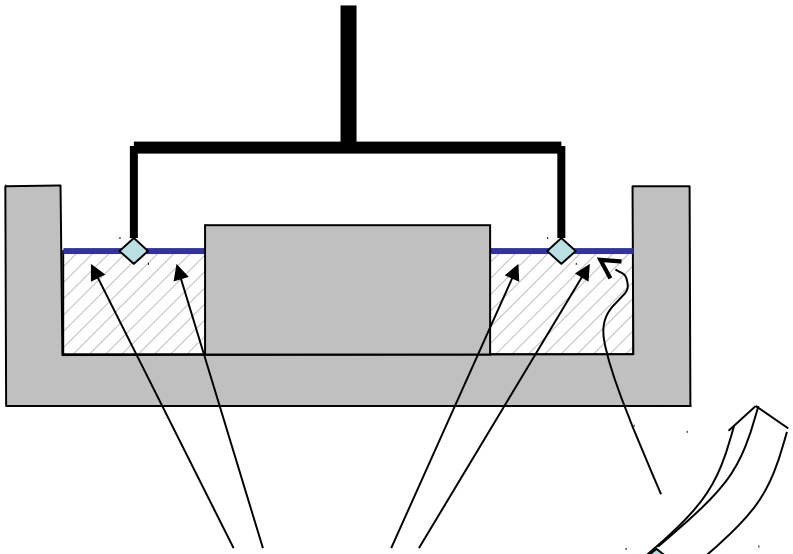
# Shear-Induced Crystallization



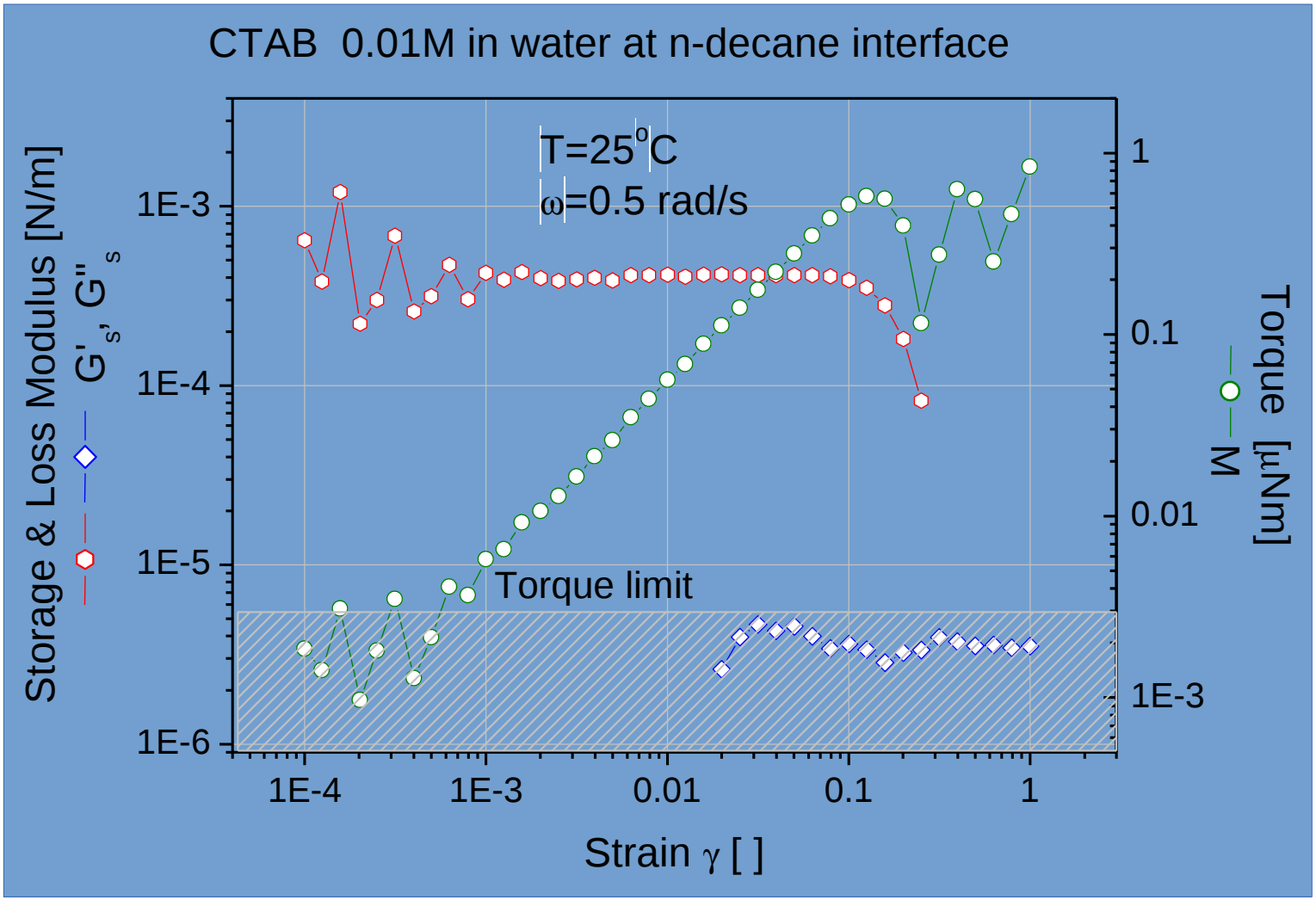
# DWR and interfacial rheology

- The properties at the interface between two liquids or a liquid and air are strongly affected by the presence of a dispersed phase
- If segregation occurs at the interface, rheology can provide useful information on the kinetic of the phenomenom
- Double Wall Ring (DWR) is an innovative geometry that sums all the benefits of previous systems such as DuNouy Ring and Bicone



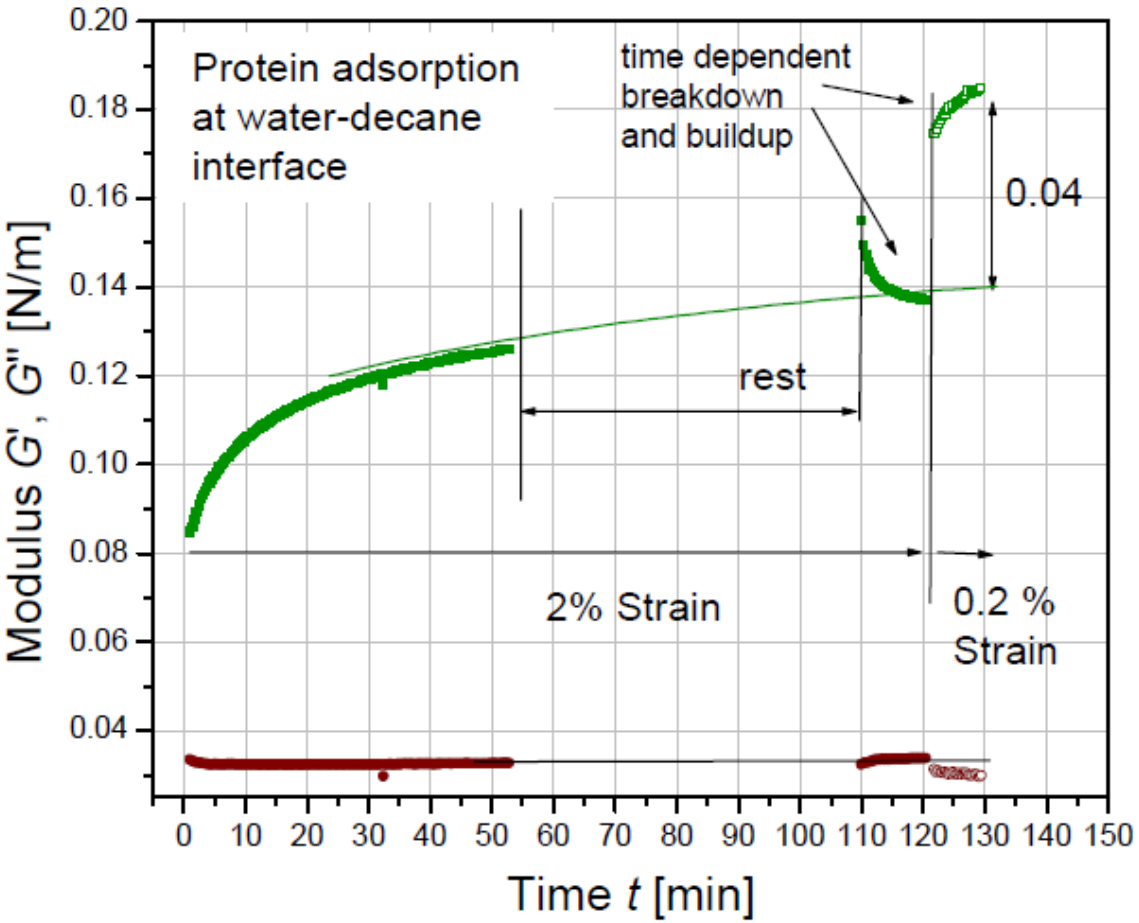
# Structure of the interface

- Sample: CTAB (Cetyltrimethylammonium bromid) in water vs. n-decane



# Kinetics of segregation

- Sample: Aβ42 prion - insoluble protein in water vs. n-decane



# Conclusions

- As structured fluids have complex rheological behaviours, it is important to have different approaches and techniques of characterisation

- Apart "standard" characterisation (flow curves, LVR, creep) other properties can be assessed through hyphenated techniques (SALS) and specific geometries (DWR)

# Grazie!

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