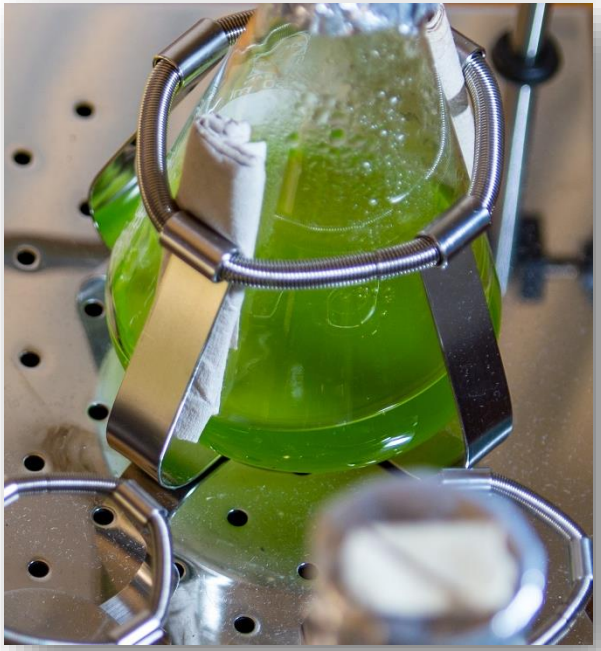
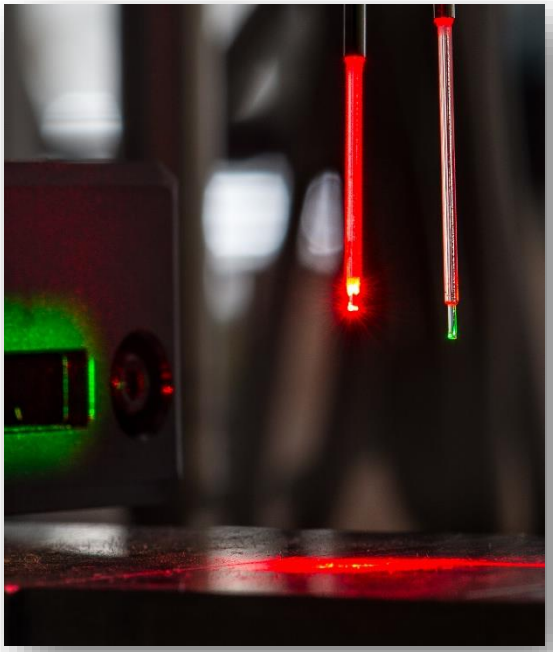
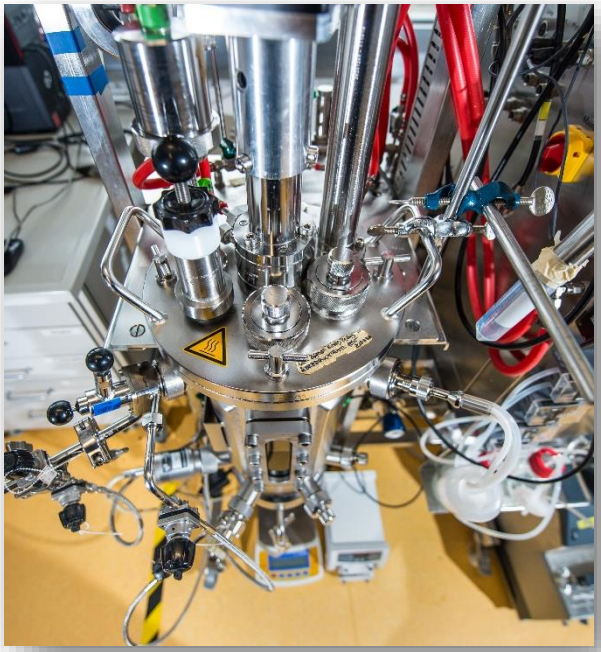
Photonendichtewellen(PDW)-Spektroskopie zur inline Überwachung hochkonzentrierter Bioprozesse

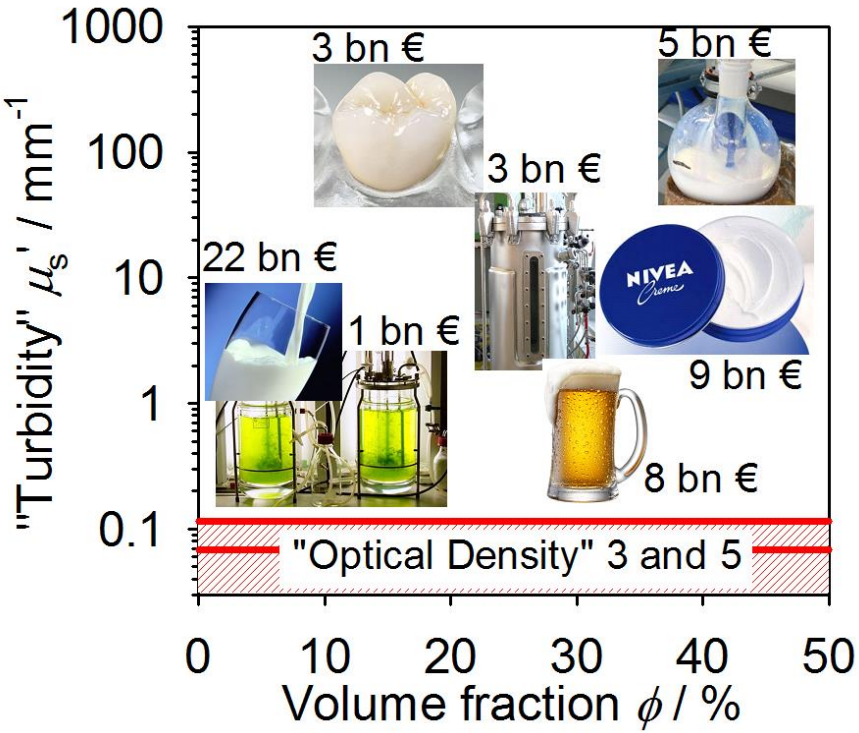




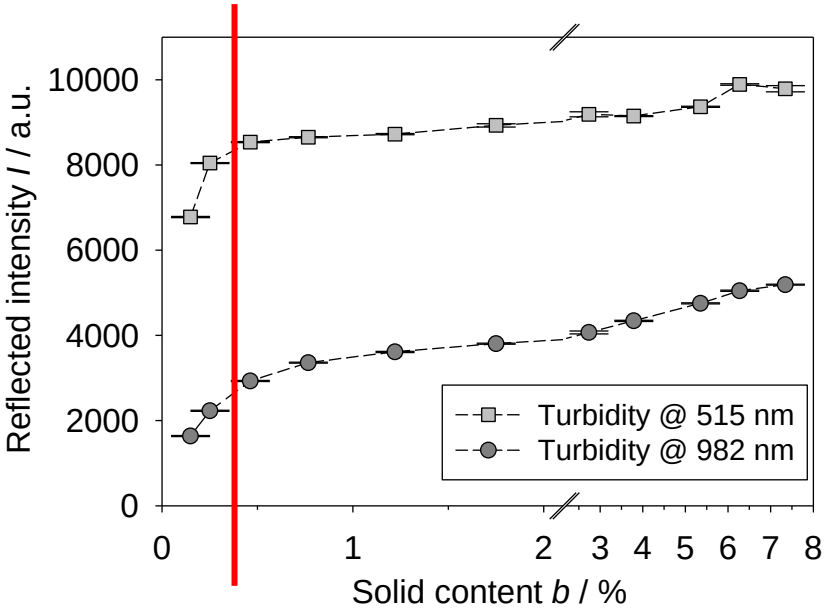


Dr. Anne Hartwig, PDW Analytics GmbH

Highly turbid liquid materials

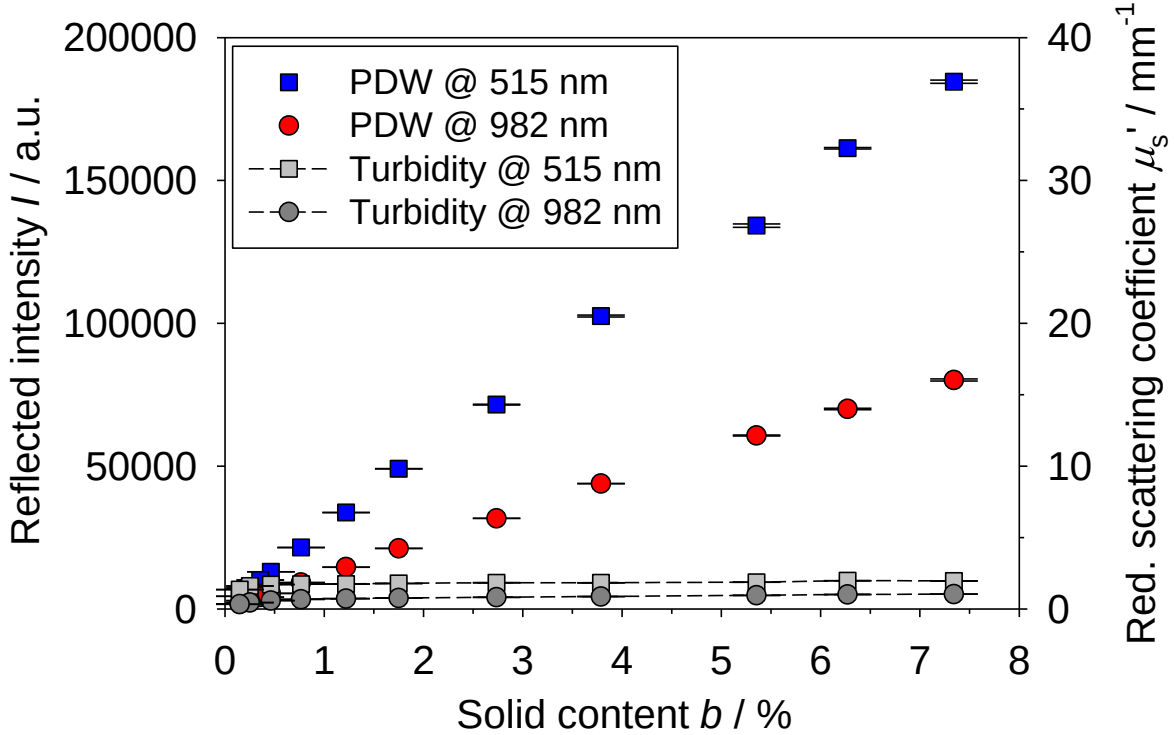


www.endress.com



www.globalspec.com

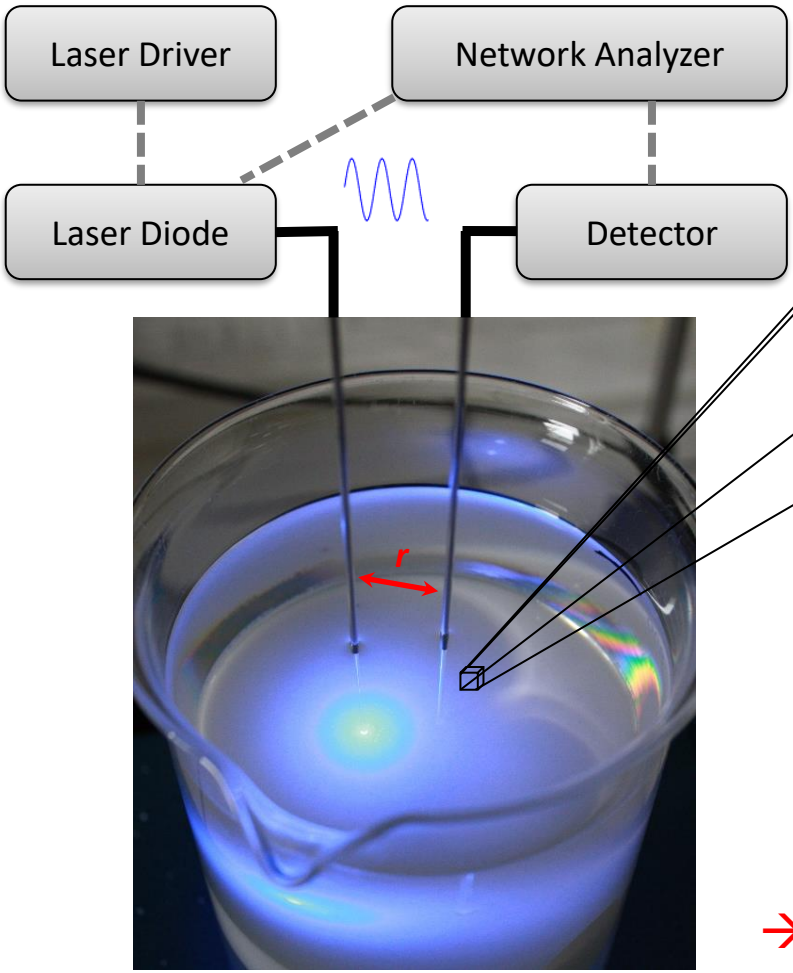
Highly turbid liquid materials

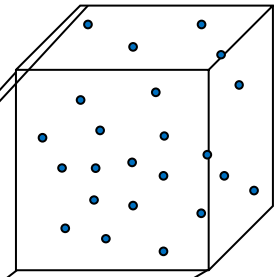


Münzberg, Hass, Reich et al. *ABC.* 409, 719-728 (**2017**)

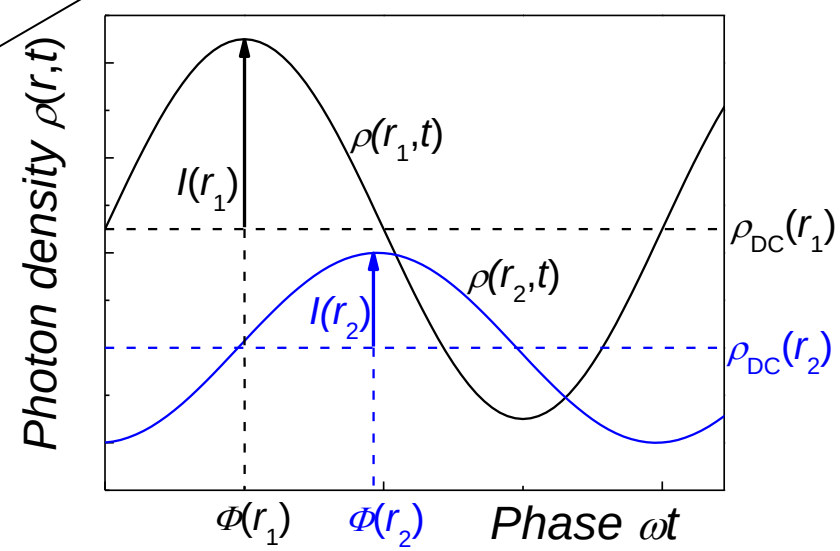
www.globalspec.com

PDW spectroscopy – Principle





Photon **D**ensity = number of photons per volume



→ Approach to separately determine absorption coefficient (μ_a) and reduced scattering coefficient (μ_s')

PDW spectroscopy – Concept

PDW Spectroscopy

Reduced scattering coefficient

μ_s'

Particle, droplet, cell characteristics

↓

Mie theory

Theory of dependent scattering

↓

Particle size ***d***

Absorption coefficient

μ_a

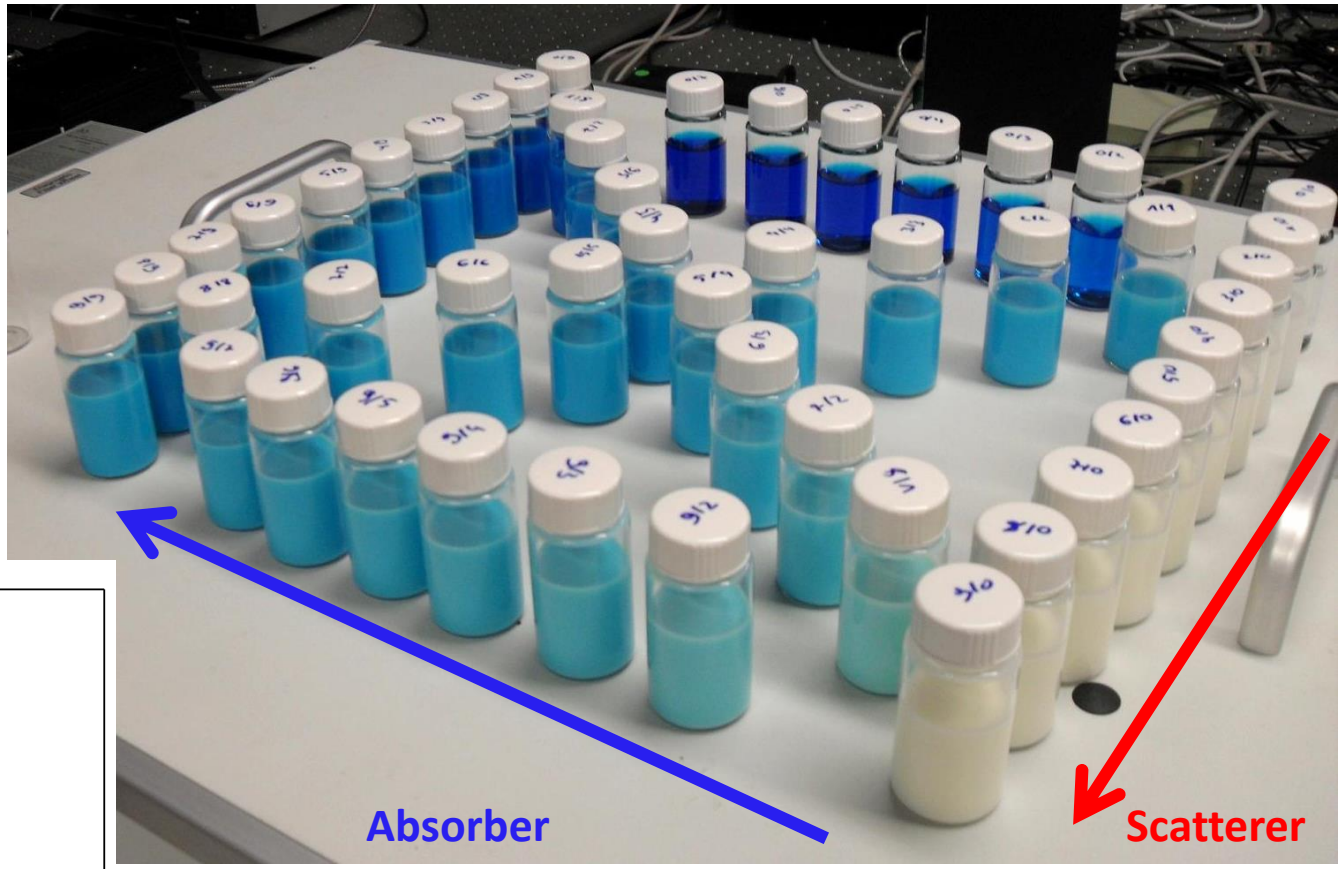
Colour

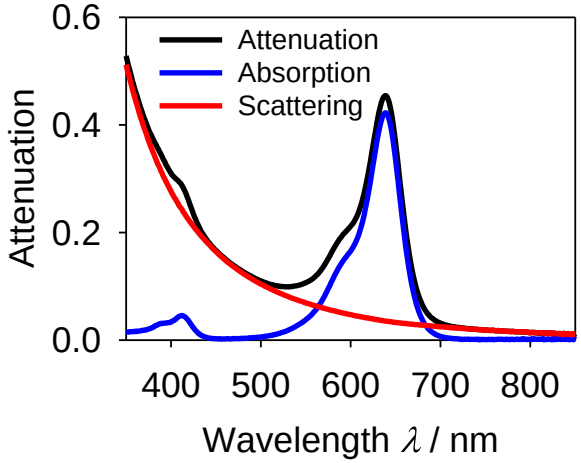
Chemical composition

Temperature

n, ϕ

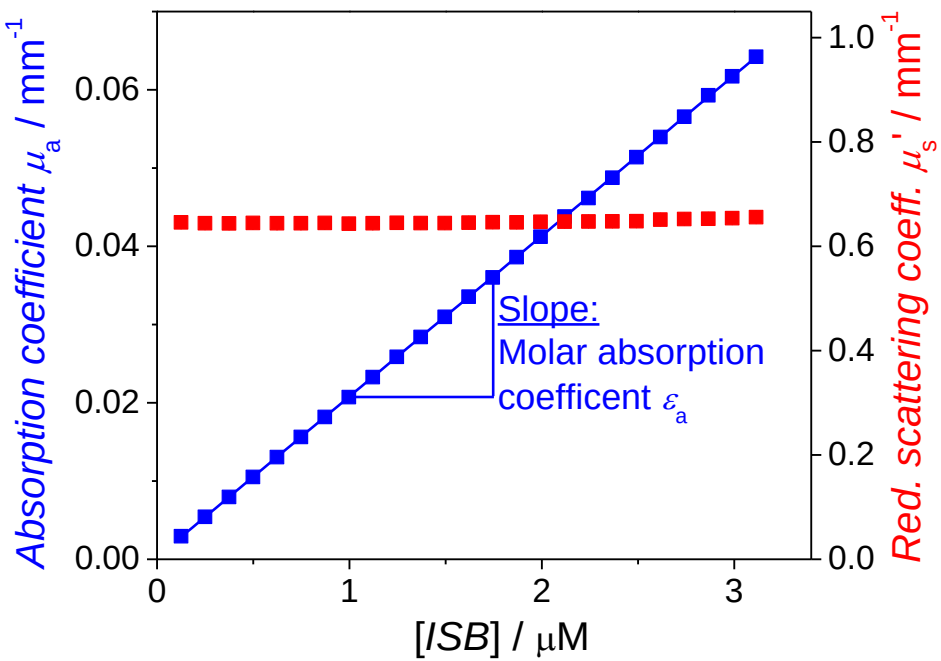
‚Optical Density' – Absorption and Scattering

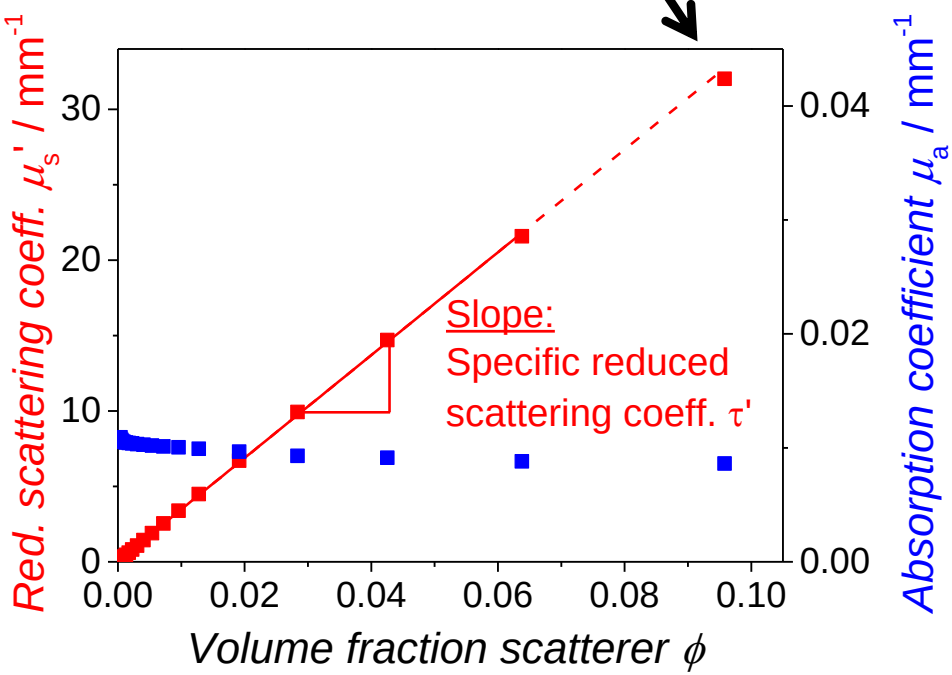




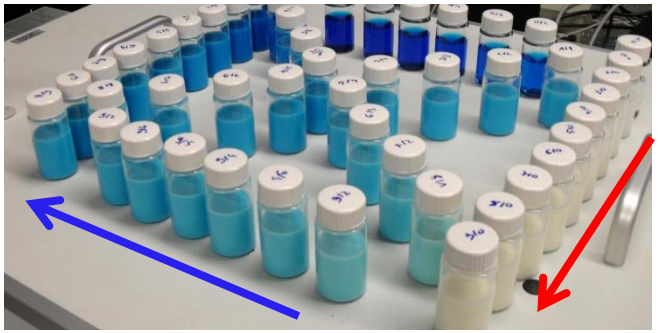
Separation of Absorption and Scattering Properties

1 cm-cuevette: *OD* = 3000



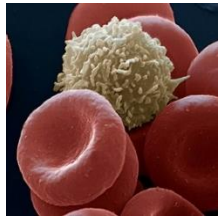


Absorber

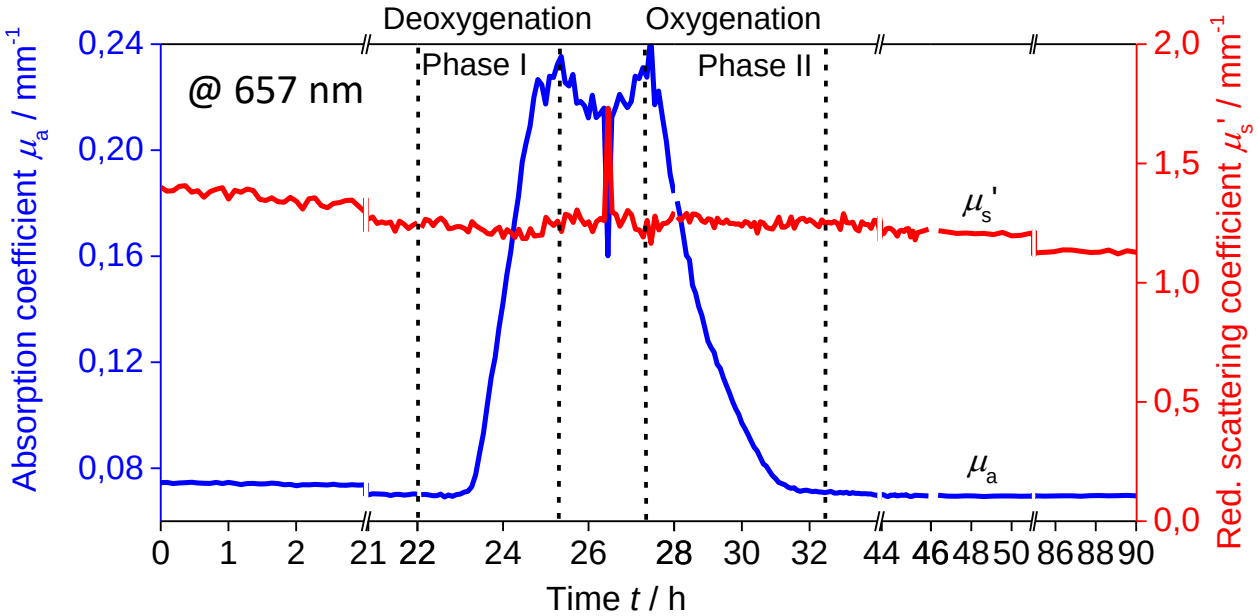


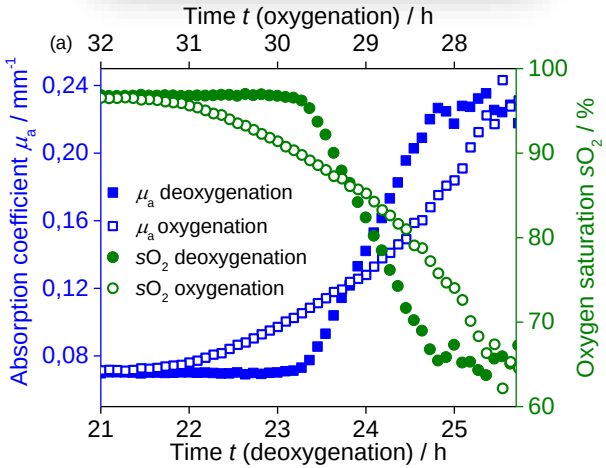
Scatterer

Biotech/Medicine: Oxygenation of Blood



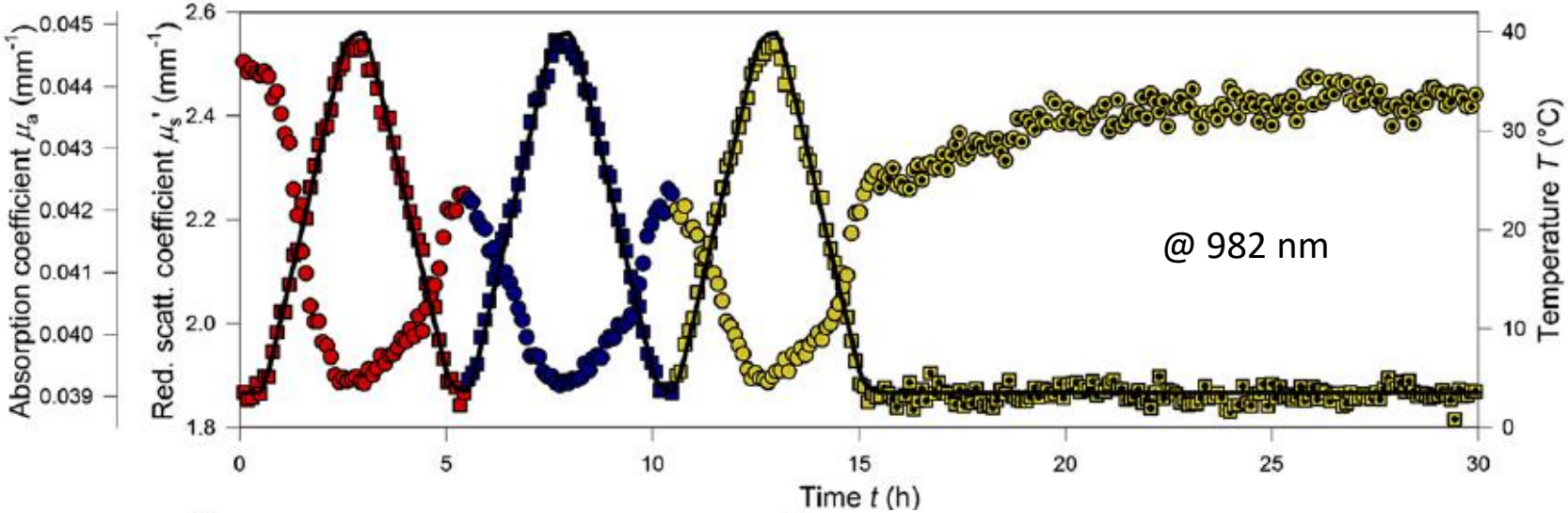
- Oxy- and deoxygenation of erythrocyte suspension as an example for process monitoring based on the absorption coefficient
- Stable reduced scattering coefficient indicates that lysis is not happening

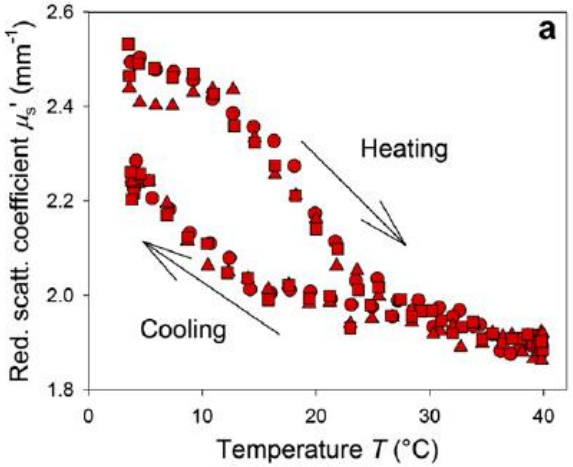


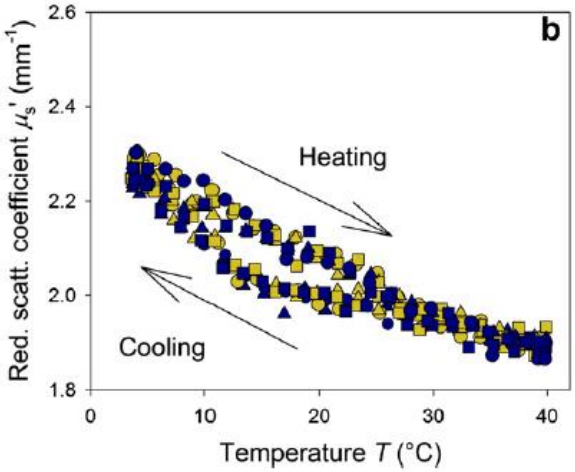


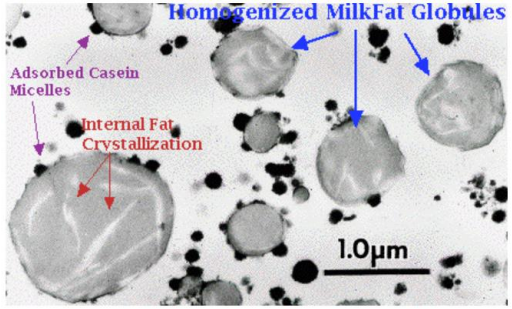
Hass, Munzke, Reich et al. *ABC.* 407, 2791-2802 (**2015**)

Food: Milk Fat Crystallization in Fresh Milk









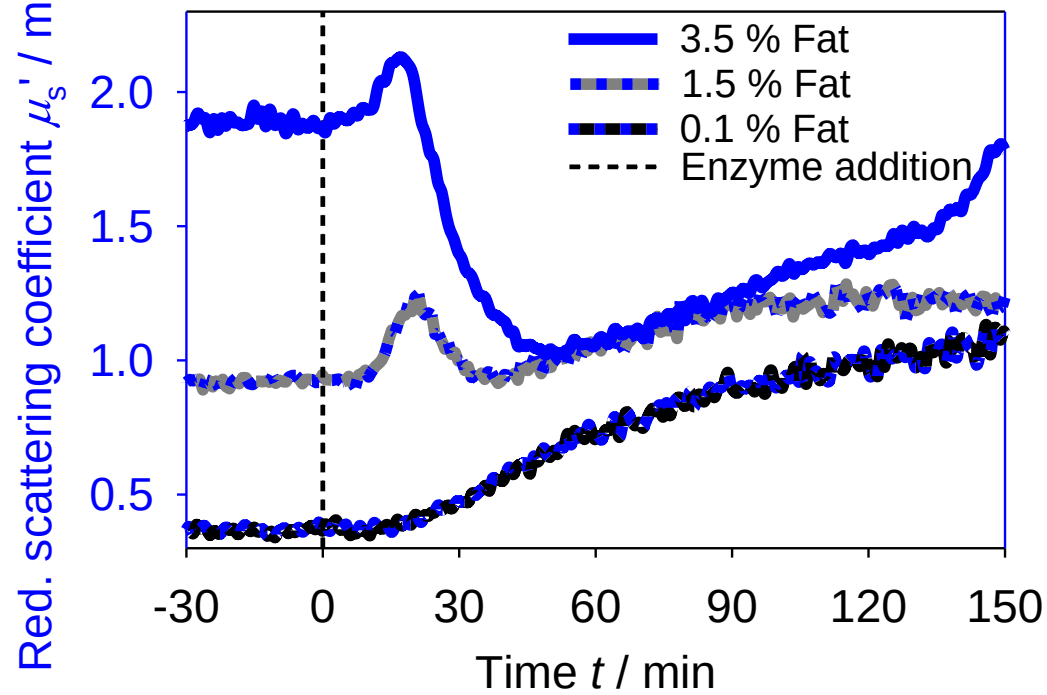
www.uoguelph.ca

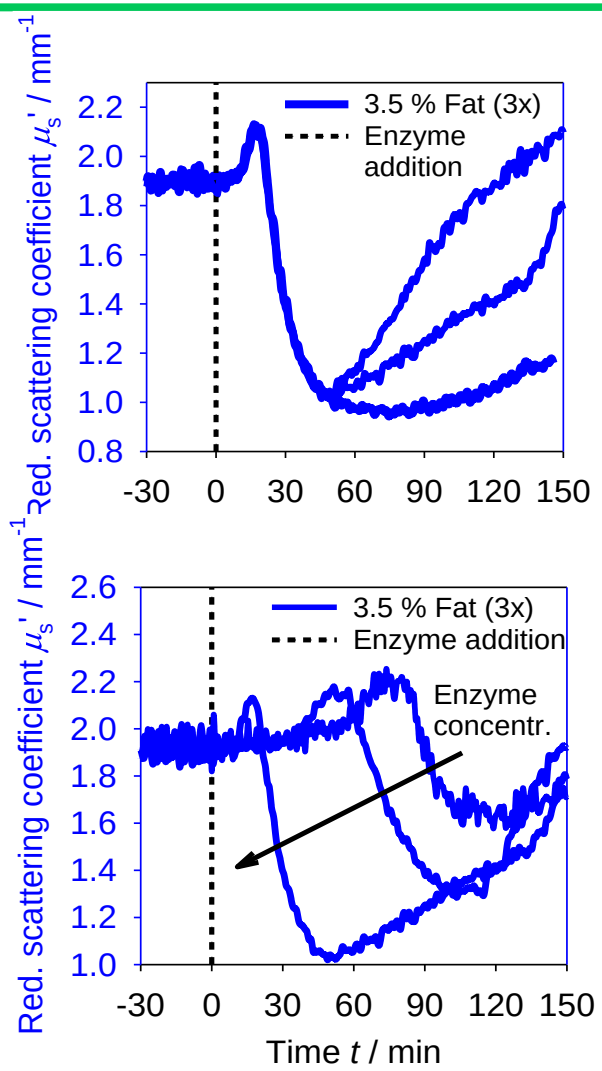
R. Hass, O. Reich, et al. *Int. Dairy J.* 26, 120-126 (**2012**)

From milk to cheese: enzyme induced gelling (Chy-Max)

1. Proteolysis 2. Syneresis

Hydrolysis – Aggregation – Gelling

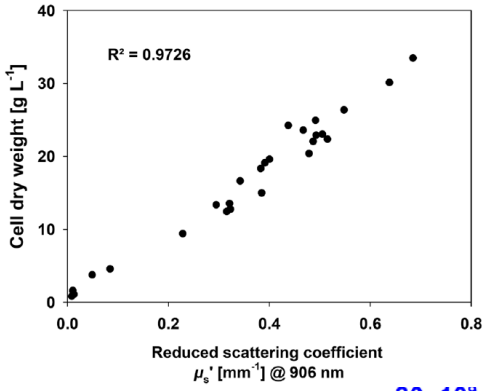


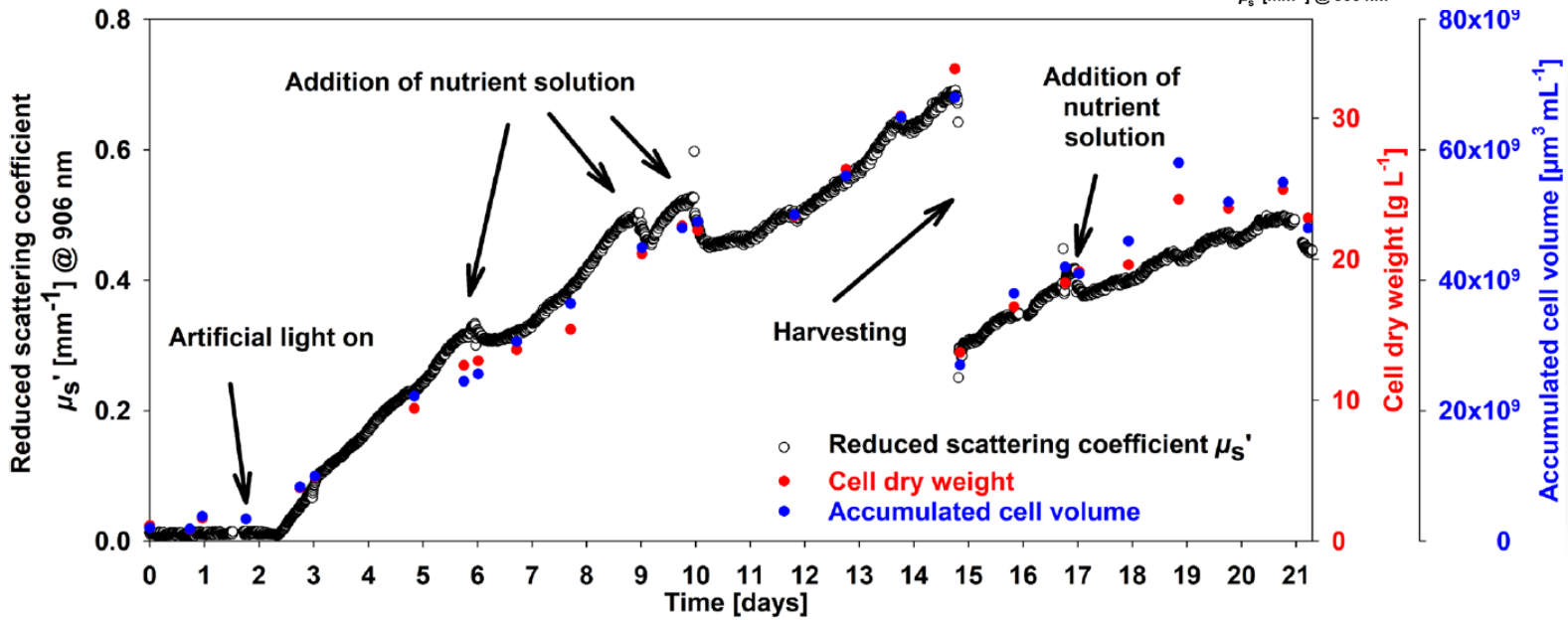


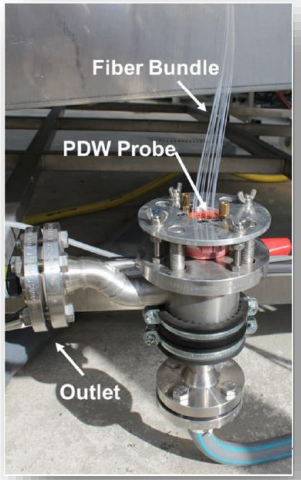
Hass, Munzke, Reich et al. *ABC.* 407, 2791-2802 (**2015**)

Algae Cultivation: Inline Biomass Measurements

- PDW spectroscopy in recirculation loop of MUTL PBR
- Cultivation of *Scenedesmus rubescens*
- Inline growth rate determination







M. Sandmann, R. Hass, et al., *BMC Research Notes* 15:54 (**2022**).

Algae Cultivation: Inline Biomass Measurements

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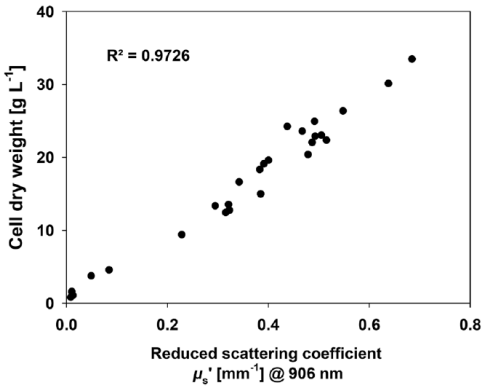
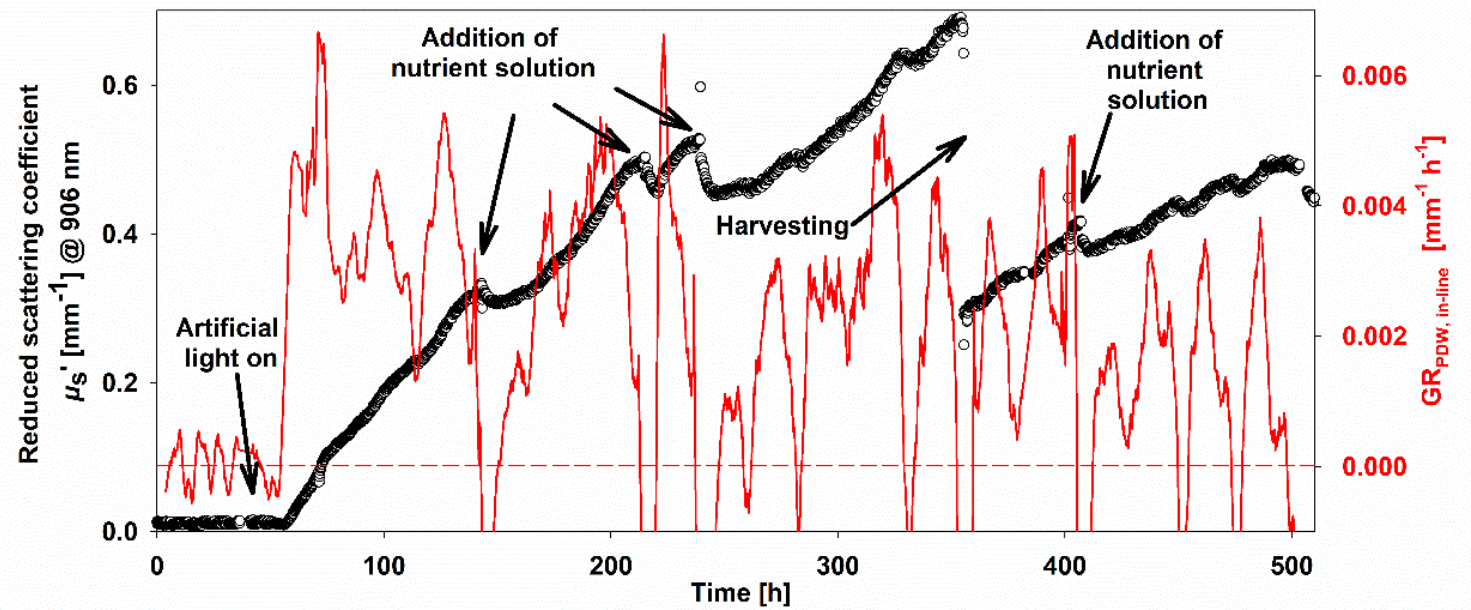
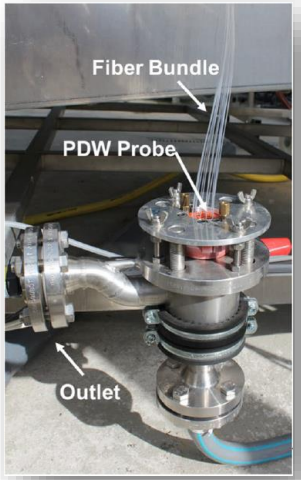
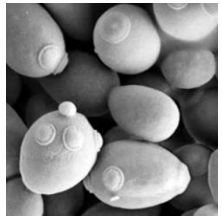




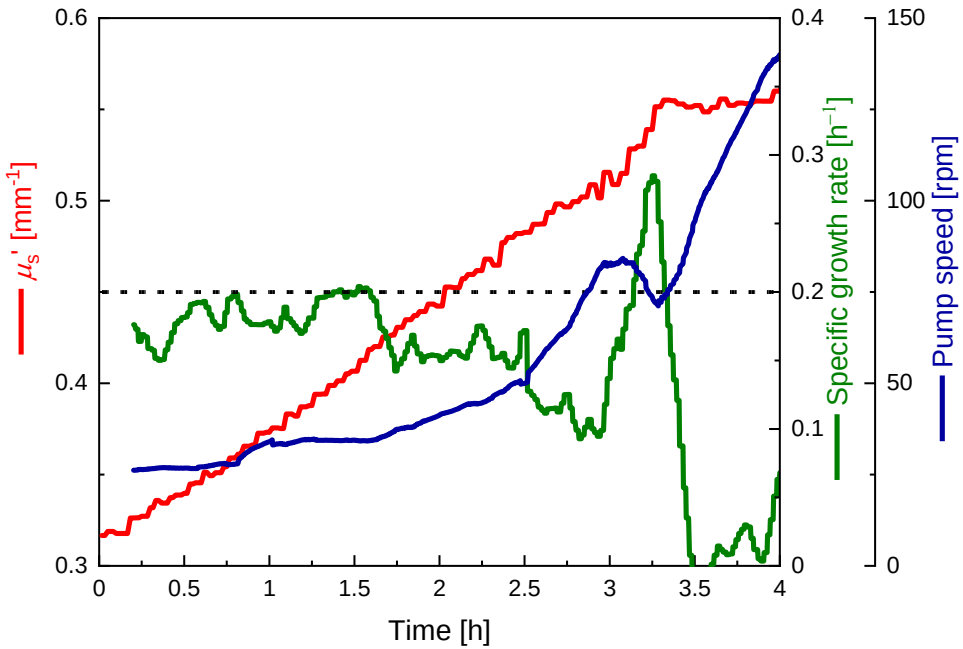


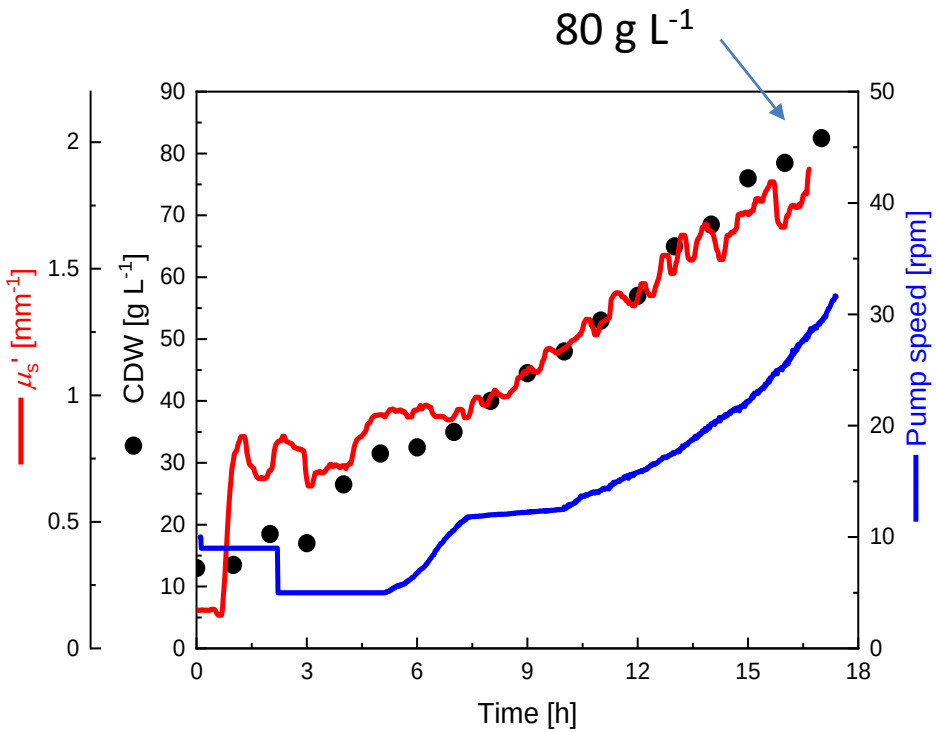
M. Sandmann, R. Hass, et al., *BMC Research Notes* 15:54 (**2022**).

Yeast Cultivation: Real-time growth control



- Cultivation of yeast
- Control of glucose feed (pump speed) to growth rate set point determined by PDW spectroscopy





PDW Spectroscopy as Processes Analytical Technology (PAT)

- Calibration-free
- Two parameters at the same time:
  - Absorption coefficient (μ_a) → *colour, chemical composition, temperature*
  - Reduced scattering coefficient (μ_s‘) → *particle, droplet, or cell characteristics*

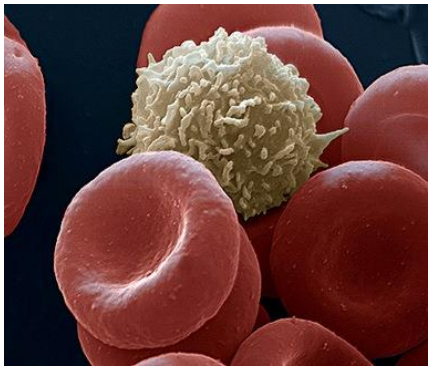
  → “absolute” optical properties of the turbid liquid
- Wavelength range 400 – 1000 nm
- For highest turbidities/concentrations (> 40 vol%)
- Inline real-time Particle Sizing in the range of 50 nm – 500 µm

PDW Spectroscopy as Processes Analytical Technology (PAT)

Chemistry

Food

Cosmetic



Biotech/Medicine

Commercial R&D

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