VERSATILITY OF NATURE IN POLYMER MATERIALS

Fraunhofer Institute for Applied Polymer Research IAP

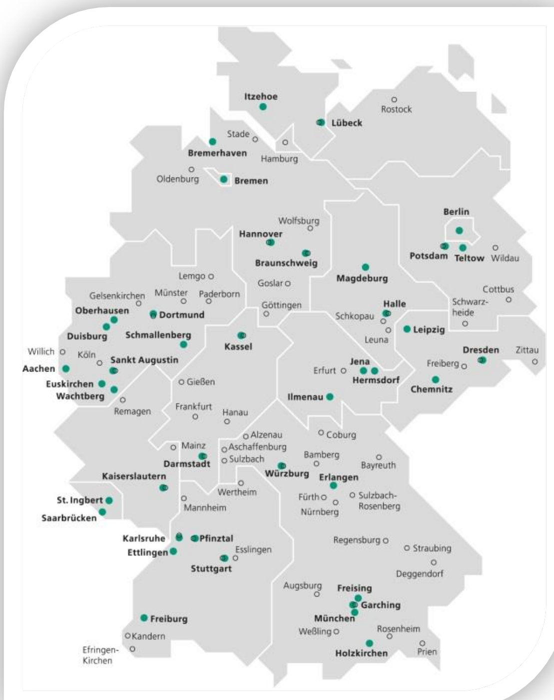
Functional Protein Systems / Biotechnology

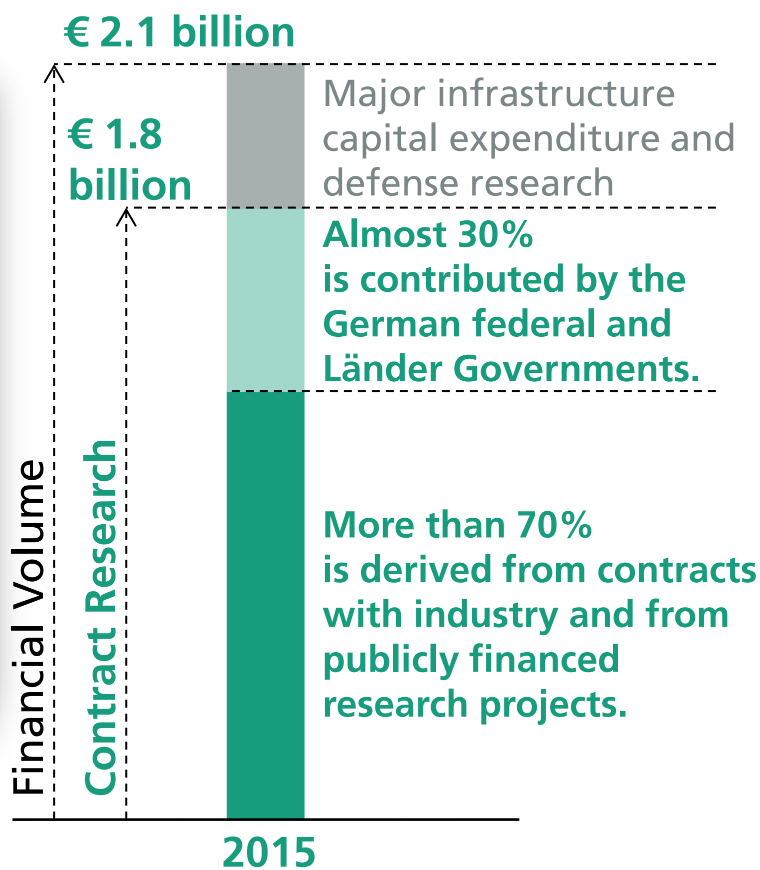
Dr. David Dietz

The Fraunhofer-Gesellschaft at a Glance

The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society.

Nearly **24,000** staff





67 institutes and research units

FRAUNHOFER IAP

Prof. Dr. Alexander Böker
Director

Fraunhofer IAP at a Glance

- 220 employees, incl. PhD students, apprentices, etc.
- ca. € 20.2 million institute‘s budget
  ca. € 13.6 million external revenues
- research sites: **Potsdam-Golm**
  Schkopau
  Schwarzheide
  Teltow
  Wildau

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Research Divisions

Biopolymers

Dr. Johannes Ganster

biopolymers (cellulose, starch, lignin), biobased plastics (PLA, PHA, PA), fibers, blends and composites

Functional Polymer Systems

Dr. Armin Wedel

materials with specific optical and electronic properties, polymeric OLEDs, polymer electronic components, organic solar cells

Synthesis and Polymer Technology

Dr. Thorsten Pretsch

polymer synthesis and process development, microencapsulation/particle applications, function integrated polymer films, shape-memory polymers

Life Science and Bioprocesses

Prof. Dr. Alexander Böker

keratin fibers, biotechnological processes, protein conjugates, self-assembly techniques, "smart" materials for medical applications

Pilot Plant Center PAZ

Prof. Dr.-Ing. Michael Bartke

polymer synthesis and processing, scale up to ton scale

Polymeric Materials and Composites PYCO

Dr. Christian Dreyer

thermoset resins for applications in lightweight construction and micro- and optoelectronics

SILK PROTEINS

- silk proteins are widespread in insects
- best known examples spider, bombyx mori

Foto: Glen Peterson, Flickr

5000 years old Chinese patent

Foto: Pixabay

Annu. Rev. Entomol. 2010. 55:171–88

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LACEWING SILK PROTEIN

- Silk protein : N-[AS]$_8$-C called “flor2“
- Origin : Mallada signata - MalXB2

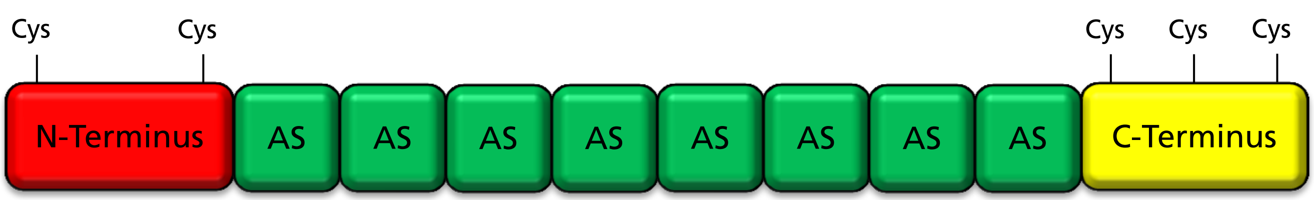
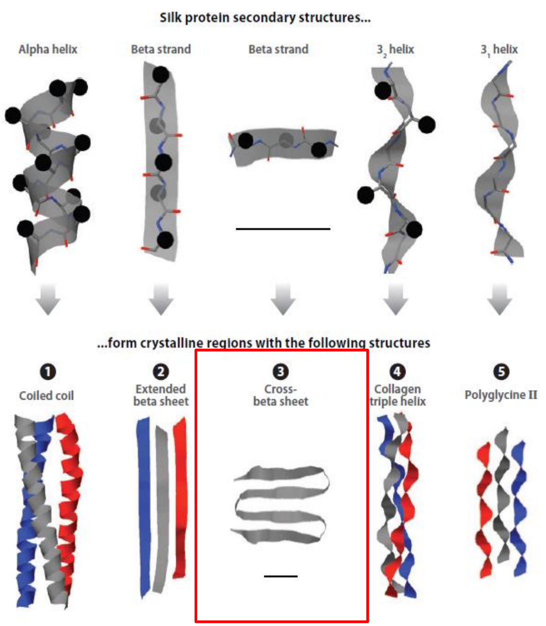


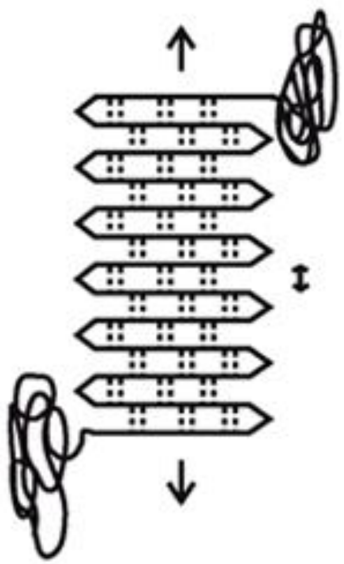
Abbildung nach: DOI: 10.1002/ange.201200591

LACEWING SILK PROTEIN

- Interesting protein due to its higher structure
  - cross-ß-sheet structure
- high flexural stiffness

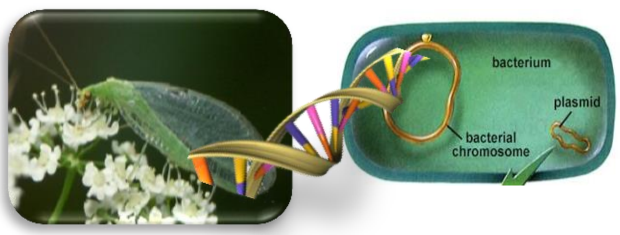


Annu. Rev. Entomol. 2010. 55:171–88



Biomacromolecules
2012, 13, 3730–3735

PROJECT SCHEDULE
PROCESS DEVELOPMENT



lacewing

E.coli

USP

DSP

Purified
silk protein

FNR
Fachagentur Nachwachsende Rohstoffe e.V.

AMSilk

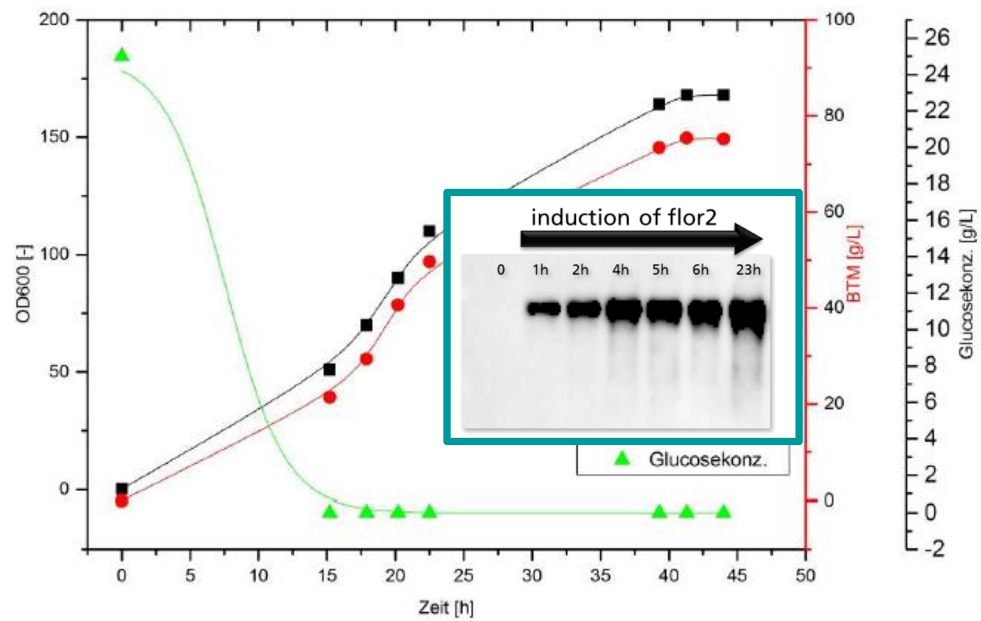
materials

UPSTREAM PROCESS

HIGH CELL DENSITY CULTIVATION (HCDC) WITH E.COLI BACTERIA – FLOR2-SYNTHESIS

- Control of various parameters pH, T, p, Stirrer, pO2, substrate feeding …

- HCDC with E.coli bacteria (flor2)
- BDM of 75 g/L



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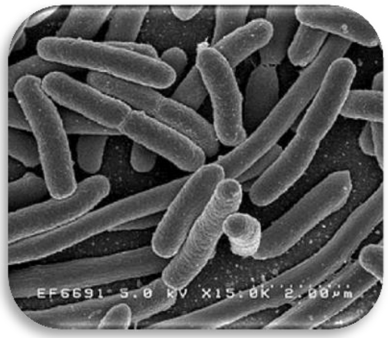
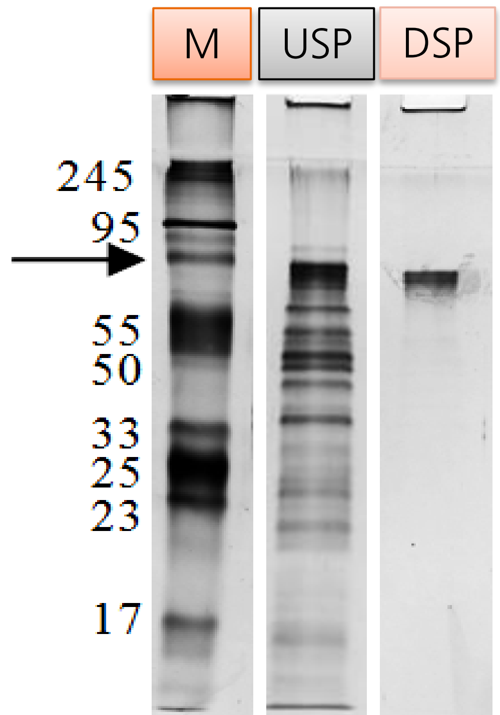
DOWNSTREAM PROCESS

PURIFICATION OF RECOMBINANT LACEWING SILK PROTEIN

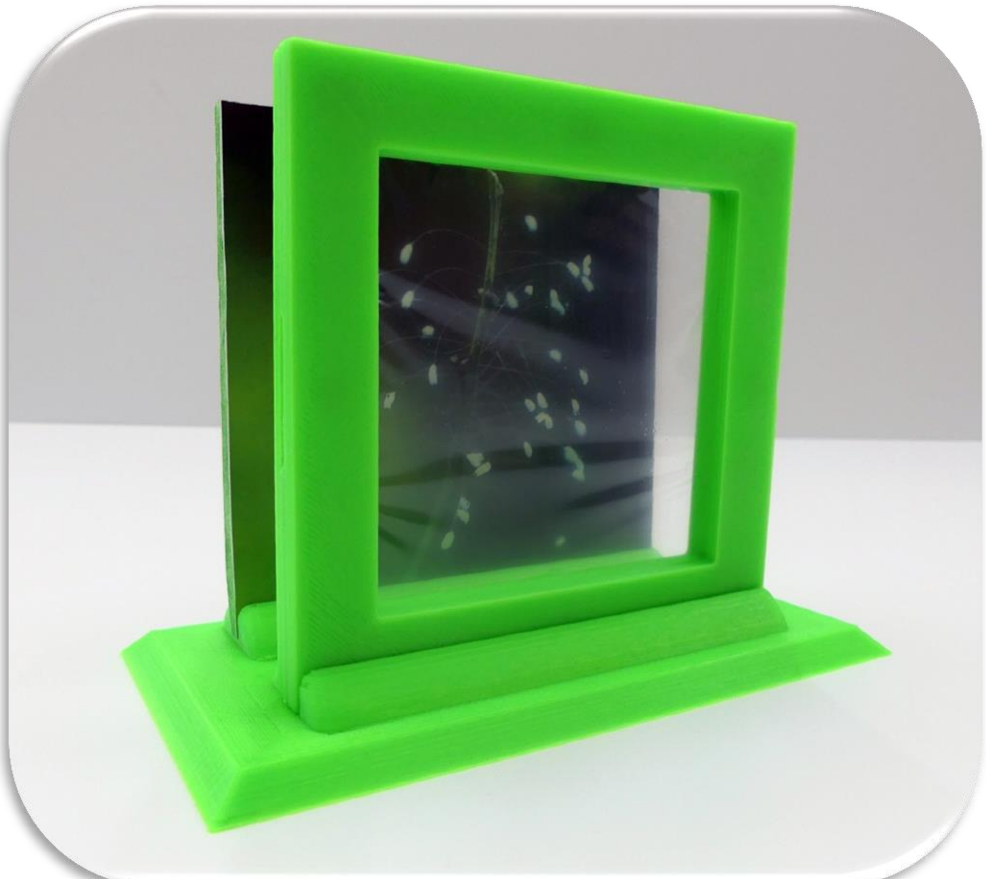


Wikipedia: E.coli,
Foto: NIAID

target protein

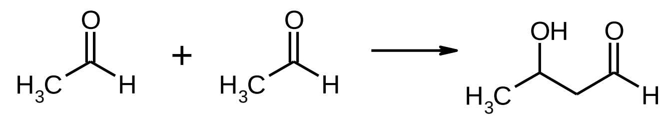


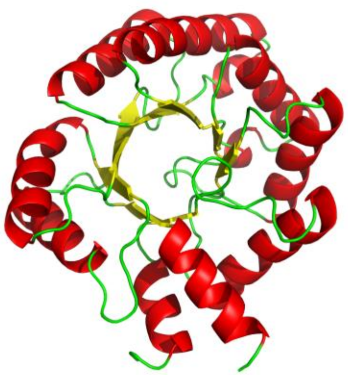
PROCESSING TO LACEWING SILK FILMS

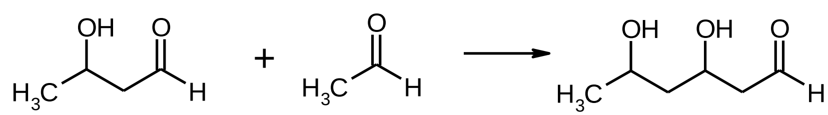


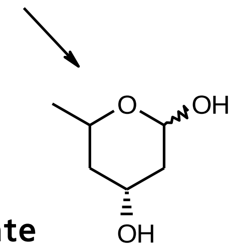
COMBINE ENZYMES AND POLYMERS – ENZYME IMMOBILIZATION OF DERA

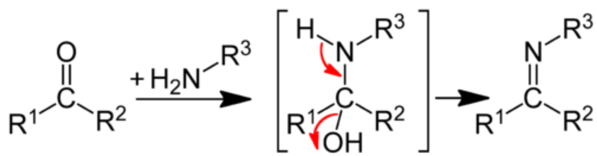
2-Desoxy-5-phosphate aldolase (DERA)











reaction via schiff base intermediate

DERA:

- aldehyde both as donor and acceptor (normally aldehyde and ketone)
- only aldolase which accepts two or three aldehydes in sequential manner
- works without cofactor
- synthesis of atorvastatin (decrease of cholesterol levels)
- problem: stability in contact with substrate/product

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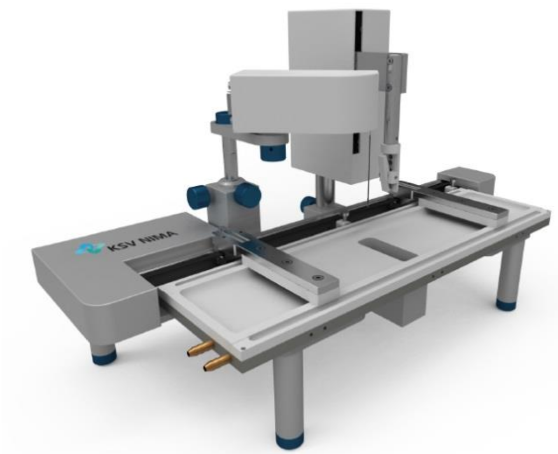
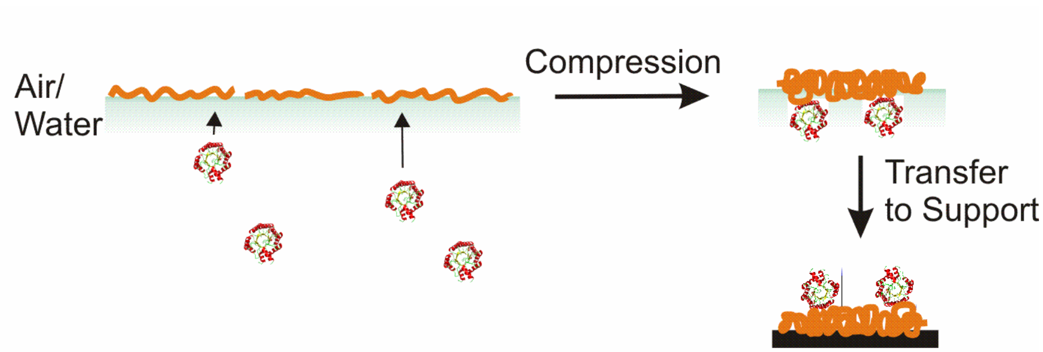
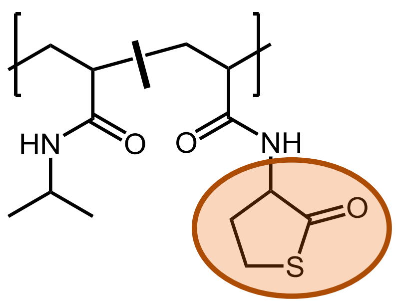
DERA IMMOBILIZATION VIA LANGMUIR SCHAEFER



Langmuir balance



P(NIPAAm-*co*-TlaAm)

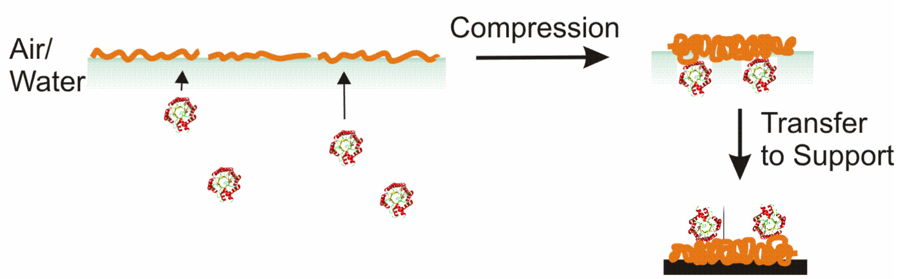


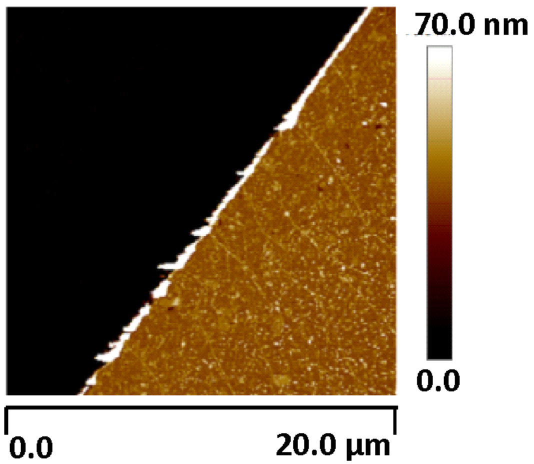
<u>Thiolactone:</u>

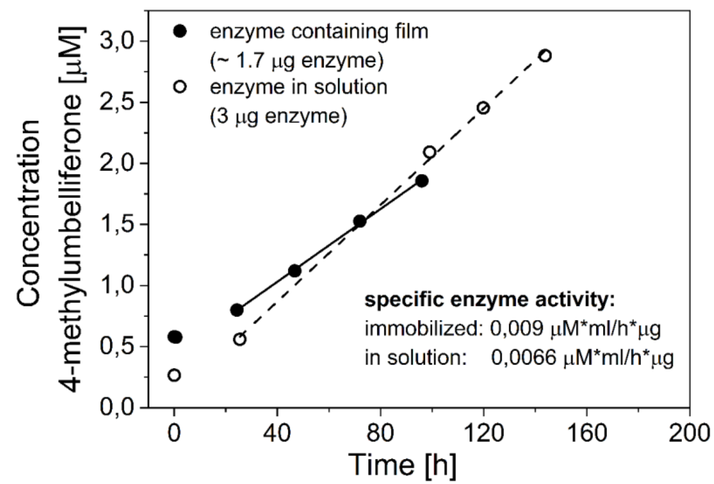
- hydrophobizes polymer
- Reactive towards lysines
- Hydrolyzable
  → hydrophilization and crosslinking

Reinicke et al. *ACS Appl. Mater. Interf.* **2017**, DOI: 10.1021/acsami.6b13632

DERA IMMOBILIZATION VIA LANGMUIR SCHAEFER







Reinicke et al. *ACS Appl. Mater. Interf.* **2017**, DOI: 10.1021/acsami.6b13632

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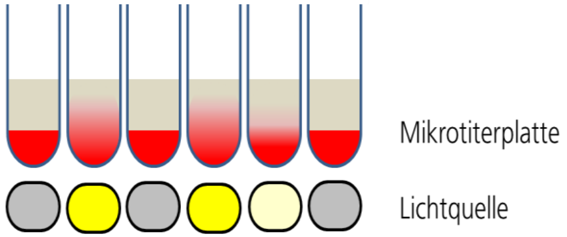
POLYMERS FOR BIOPROCESS DEVELOPMENT - SMARTPHOTOPLATE

Development of a non-invasive, light-inducible substance relase in microtiter plates for scale-down and high-throughput

Principle:



- Target substance is incorporated in a light-responsive polymer
- Release by light induction, depending on light intensity

Application:

- Induction
- Feeding
- pH-control

→ HTS
→ Strain development
→ Scale-Down

GEFÖRDERT VOM
Bundesministerium für Bildung und Forschung

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Thank you for your attention!

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Department: Functional Protein Systems / Biotechnology

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