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Working group vision and contribution to catalaix

Biological materials designed from biomacromolecules are designed with high precision into hierarchical structures and exhibit unique properties. Biomacromolecular materials are 100% sustainable because they are constructed with low-energy processes in a programmed way for the defined life-time, can be fully degraded to functional building blocks and re-used in a metabolic pathways.

Nature's approach to sustainable biomacromolecular materials serves as inspiration source for our research. Polymers fabricated from conventional synthetic monomers developed so far have *low information content* (low chemical functionality, poor ability to self-assemble or limited degradability, etc.) and can be used for the fabrication of simple materials with limited functions and narrow applicability spectrum. Nature developed a multitude of molecular building blocks of different sizes and complexities with unique combination of chemical and structural cues carrying *high information content*. Such "programmed" monomers able to undergo specific non-covalent interactions (electrostatic, hydrophobic or π-π-stacking) along with polymerization, what is a key to bottom-up synthesis of complex polymer architectures with controlled size, shape and chemical structure. The identification and tailored modification of such bio-inspired molecular building blocks using **Open Loop** concept of **catalaix** to design polymers is a straightforward way to integrate a *molecular code* and achieve programmed polymer materials with new properties and functions.

Our main research hypothesis is that **synthesis of polymers from high-information content biological molecular building blocks of different size and complexity will lead to sustainable polymer materials with hierarchical structures and properties characteristic for living matter**: **recognition, selective binding, switchable adhesion, regeneration, controlled degradation or shape morphing etc. Catalaix** consortium with unique combination of scientific competences provides a perfect framework for the development of new generation of functional biobased macromolecules for **design of programmable and sustainable polymer materials for applications in building construction, plant protection and healthcare**.

Current & Previous Positions

Since 2009	**Lichtenberg Professor for Functional and Interactive Polymers** (W3), Institute of Technical and Macromolecular Chemistry, RWTH Aachen University, Germany
Since 2019	**Professor for Biobased Polymers** (part-time position), Maastricht University, Netherlands

Education

1997 – 2001	**PhD** with Prof. H.-J. Adler at Technical University Dresden
2001 – 2008	**Habilitation** with Prof. H.-J. Adler at Technical University Dresden
1998 – 2003	**Diploma of Chemical Engineering,** State University "Lvivska Polytechnika", Lviv

Fellowships and Awards

2007	**Georg-Manecke-Prize**, Gesellschaft Deutscher Chemiker (GDCh)
2009	**Lichtenberg Professorship,** VolkswagenStiftung
2018	**Innovation Prize**, Bioregions Germany
Since 2023	**Fellow**, Max Planck School "Matter to Life"

Contributions to the science system

Since 2011: consultant of Rector for educational and scientific relations with East Europe
2013-2015: chair of the Examination Committee for Chemistry Department RWTH Aachen University
Since 2013: member of the scientific advisory board of Institute of Textile Technology (ITA).
Since 2013: member of the scientific board of the DWI Leibniz Institute for Interactive Materials e.V.
2019-2021: member of the steering committee for the RWTH Profile Area "Production Engineering"
Since 2022: member of the scientific board of Aachen Maastricht Institute for Biobased Materials

Selected Projects

2010-2019	Lichtenberg Project "Nano- and Microgels for Design of Functional Materials"
2020-2024	Vice-Speaker of Collaborative Research Centre 985, "Functional Microgels and Microgel Systems"

Most important scientific contributions

1. Grabowski, F., Petrovskii, V. S., Fink, F., Demco, D. E., Herres-Pawlis, S., Potemkin, I. I., & Pich, A. Anisotropic Microgels by Supramolecular Assembly and Precipitation Polymerization of Pyrazole-Modified Monomers, *Advanced Science*, 2022, *9*(36), 2204853. **https://doi.org/10.1002/ADVS.202204853**
In this work for the first time bottom-up synthesis of anisotropic microgels was realized by simulation-guided synthesis approach based on polymerization and self-assembly of pyrazole-modified monomers.

2. Li X, Sun H, Li H, Hu C, Luo Y, Shi X, Pich A. Multi-Responsive Biodegradable Cationic Nanogels for Highly Efficient Treatment of Tumors, *Advanced Functional Materials*, 2021, 2100227. **https://doi.org/10.1002/adfm.202100227**
In this work we developed a modular synthesis route to obtain multicomponent nanogels for efficient combined chemo- and photo-thermal therapy of tumors

3. Li, X.; Ouyang, Z.; Li, H.; Hu, C.; Saha, P.; Xing, L.; Shi, X.; Pich, A. Dendrimer-decorated nanogels: Efficient nanocarriers for biodistribution in vivo and chemotherapy of ovarian carcinoma, *Bioactive Materials* 2021, 6, 3244-3253. **https://doi.org/10.1016/j.bioactmat.2021.02.031**
In this work for the first-time dendrimer-decorated nanogels were synthesized and used as carriers for chemotherapeutic drugs in tumor therapy.

4. Aischa Al Enezy-Ulbrich, M., Malyaran, H., Dirk de Lange, R., Labude, N., Plum, R., Rütten, S., Terefenko, N., Wein, S., Neuss, S., Pich, A. Impact of Reactive Amphiphilic Copolymers on Mechanical Properties and Cell Responses of Fibrin-Based Hydrogels, *Advanced Functional Materials*, 2020, 2003528. **https://doi.org/10.1002/adfm.202003528**
We demonstrated that reactive amphiphilic copolymers can be used to modulate mechanical properties and cell responses of fibrin hydrogels

5. Xu, W., Rudov, A., Oppermann, A., Wypysek, S., Kather, M., Schroeder, R., Richtering, W., Potemkin, I. I., Wöll, D., Pich, A. Synthesis of Polyampholyte Janus-like Microgels by Coacervation of Reactive Precursors in Precipitation Polymerization*Angewandte Chemie*, 2020, *132*(3), 1264–1271. **https://doi.org/10.1002/ange.201910450**
Polyampholyte Janus-like microgels with anisotropic charge distribution were synthesized for the first-time by coacervation-guided precipitation polymerisation

6. Tan, K. H.; Xu, W.; Stefka, S.; Demco, D. E.; Kharandiuk, T.; Ivasiv, V.; Nebesnyi, R.; Potemkin, I. I.; Pich, A. Selenium Modified Microgels as Bio-Inspired Oxidation Catalysts, *Angew. Chem. Int. Ed.* 2019, 58, 9791-9796. **https://doi.org/10.1002/anie.201901161**

Inspired by the natural enzyme glutathione peroxidase, microgels modified with Se exhibiting high catalytic activity in oxidation reactions were synthesized

7. Thies, S.; Simon, P.; Zelenina, I.; Mertens, L.; Pich, A. In Situ Growth and Size Regulation of Single Gold Nanoparticles in Composite Microgels, *Small* 2018, 50, 1803589–7. **https://doi.org/10.1002/smll.201803589**

For the first time controlled growth of single gold nanoparticle in microgel was demonstrated.

8. Meurer, R. A., Kemper, S., Knopp, S., Eichert, T., Jakob, F., Goldbach, H. E., Schwaneberg, U., Pich, A. Biofunctional Microgel-Based Fertilizers for Controlled Foliar Delivery of Nutrients to Plants, *Angewandte Chemie*, 2017, *56*(26), 7380–7386. **https://doi.org/10.1002/anie.201701620**

In this pioneering work we demonstrated the proof-of-concept for the application of microgels modified with anchor peptides in iron delivery to plants.

9. Berger, S.; Zhang, H.; Pich, A., Microgel-Based Stimuli-Responsive Capsules, *Adv. Funct. Mater.* 2009, *19*, 554-559. **https://doi.org/10.1002/adfm.200801203**

For the first time microgels were used as colloidal building blocks to synthesize capsules with tunable permeability

10. Richter, A.; Türke, A.; Pich A. Controlled Double-Sensitivity of Microgels Applied to Electronically Controllable Chemostats, *Adv. Mater.* 2007, 19(8), 1109-1112. **https://doi.org/10.1002/adma.200601989**

This work shows the first example of application of microgels as active components in stimuli-responsive valves

Patents

1. H. Roth, A. Pich. M. Wessling, *Membrane system, method for its manufacture and its use*, EP19203626, **2019**.

Methodology for the fabrication of microgel-modified hollow membranes.

2. A. Greiner, S. Jockenhöfel, A. Pich, *Endovascular stent grafts and methods of using said stent grafts*, US2020/0078161A1, **2020**.

Adaptive hydrogel-coated stent grafts with controlled porosity.

3. M. Paven, V. Tascher, S. Hobeika, T. Eckel, S. Mentizi, I. Pochorovski, A. Deniz, S. Buschmann, A. Pich, *Polyphosphazene and Molding Compound Containing the Polyphosphazene*, **2021**, WO2021/043654A1.

Development of novel polymer flame retardants for polycarbonates