



## **Final Report – Závěrečná zpráva – Abschlussbericht**

### **Study on viscoelastic and flow properties of “smart hydrogels” in micro- and macroscale with respect to their application potential. (AKTION No. 82p6)**

Participants of the project:

- Scientists: Ing. Jiri Smilek, Ph.D., Brno University of Technology (BUT)  
Ing. Michal Kalina, Ph.D., Brno University of Technology (BUT)  
Ing. Jitka Krouska, Ph.D., Brno University of Technology (BUT)  
Ass.-Prof. Milan Kracalik, Ph.D, Johannes Kepler University Linz (JKU)
- Students: Ing. Richard Heger Brno University of Technology (BUT)  
Ing. Marcela Lastuvkova, Brno University of Technology (BUT)  
Ing. Tomas Velcer, Brno University of Technology (BUT)  
Lukas Göpperl, Johannes Kepler University Linz (JKU)  
Julia Felicitas Schwarz, Johannes Kepler University Linz (JKU)

The project AKTION No. 82p6 was realized in a period from 01. 07. 2018 to 31. 06. 2019 at the Brno University of Technology in Czech Republic and at Johannes Kepler University Linz in Austria. The main goal of the project has been study on the mechanical, flow and transport properties of smart hydrogels (especially based on polysaccharides) in micro-scale as well as macro-scale dimensions with respect to their potential application. The main results from this project are the database of viscoelastic properties of smart hydrogels measured by classical macrorheology as well as innovative microrheological techniques (dynamic light scattering and fluorescence spectroscopy).

In the first part of project realization, samples of investigated complex systems were prepared. These samples are based on hydrogel structure and are suitable for many biological applications. Different hydrogels matrixes based on biopolymers (e.g. agarose) has been prepared. The preparation of these systems was aimed to incorporate some active material into the structure of hydrogel to create a system of controlled release of nutrients. The viscoelastic properties of agarose hydrogels has been tuned by addition of different biopolymers (e.g. negatively charged alginate, hyaluronan etc.) as well as by the addition of positively charged biopolymer (chitosan).

The basic viscoelastic characterisation of fully swollen samples was determined using Rheometer Anton Paar Physica MCR 501. The measurement was done at  $30 \pm 2$  °C using a parallel plate system (PP25-SN6375, 25 mm diameter) at 1 mm gap. Viscoelastic measurements, oscillation – frequency sweep and strain sweep, were performed for each sample and the obtained values of moduli  $G'$  and  $G''$  were compared. Storage modulus  $G'$  is proportional to the extent of the elastic component and loss modulus  $G''$  is rational to the extent of the viscous component of the system. The flexibility of materials is measured by the magnitude of  $\tan \delta$  (the ratio  $G''/G'$ ), where  $\delta$  is a phase angle. If the value of  $\tan \delta$  is larger than 1, it means  $G''$  is higher than  $G'$ , the system behaves like a liquid. In contrary, if the value of  $\tan \delta$  is smaller than 1, it means  $G''$  is smaller than  $G'$ , the superabsorbent exhibits solid-like behaviour. Accordingly, the strength of the interaction or network structure is basically measured by the magnitude of  $\tan \delta$ . The smaller the  $\tan \delta$  is, the stronger 3D network is formed.

This project continues with bilateral cooperation between both involved universities. Thanks to the AKTION project, we developed promising cooperation between both institutions, which can lead to more scientific projects as well as manuscripts in impacted journals.

**It is one of the most important finding, why the project AKTION between Brno University of Technology and Johannes Kepler University should continue. Moreover optimized microrheological methods could be used for the characterization of other hydrogel systems if the extension of the project will be approved.**

## Involved persons

Person	Activity	Home university
Jiri Smilek	Project coordinator, work and research coordinator, the determination of viscoelastic properties, future cooperation, project administration	BUT
Michal Kalina	Presentation in Linz – introduction to the research on Brno University of Technology, faculty of Chemistry related to hydrogel matrixes	BUT
Jitka Krouska	Presentation in Linz – Diffusion techniques in the research of biopolymers and biocolloids reactivity	BUT
Milan Krcalik	Austrian project coordinator, presentation in Brno (Determination of network stability in smart stimuli-responsive polymeric systems using rotational rheometry), future cooperation	JKU
Richard Heger	Ph.D. student, 14 days internship in Linz. Determination of viscoelastic properties of hydrogels by oscillatory measurements.	BUT
Marcela Lastuvkova	Ph.D. student, 1 month in Linz. Measuring of mechanical properties of hydrogels from microrheological point of view. Comparison of microrheological data with macrorheological experiments	BUT
Tomas Velcer	Ph.D. student, 14 days in Linz. Preparation of hydrogels for the determination of viscoelastic properties.	BUT
Lukas Göpperl	Ph.D. student, 5 days in Brno, familiarization with instrumental techniques in Brno. Determination of microrheological properties of different hydrogels. Discussion on future internship and cooperation.	JKU
Julia Felicitas Schwarz	Ph.D. student, 5 days in Brno, familiarization with instrumental techniques in Brno. Determination of microrheological properties of different hydrogels. Discussion on future internship and cooperation.	JKU

Three lectures were given within the project framework. The first one was given by Dr. Michal Kalina at the Johannes Kepler University in Linz named **Introduction to the research on Brno University of Technology, Faculty of chemistry related to hydrogel matrixes**. The second one by Dr. Jitka Krouska at the Johannes Kepler University in Linz named **Diffusion techniques in the research of biopolymers and biocolloids reactivity**. Both presentations which was given in Linz has been orientated on the future cooperation and the audience has been formed from the Ph.D. students, scientists and colleagues from the group of prof. Sabine Hild (approximately 20 persons). Prof. Milan Krcalik presented the work of his team at Brno University of technology in front of Ph.D. students and scientists (approximately 15 persons) by presentation called **Determination of network stability in smart stimuli-responsive polymeric systems using rotational rheometry**.

## Project budget

Justification of project budget is attached and confirmed by economic department of Brno University of Technology, Faculty of Chemistry.