Stimulus-Responsive Hydrogels Based On Natural, Endogenous Starting Material

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Introduction

The main focus of this work is the synthesis of new, enzymatically degradable hydrogels based on natural and endogenous starting materials like aspartic acid (ASP). Polyaspartic acid (PASP) was used as the basic building block, which can be crosslinked with various diamines to form hydrogels. In literature they are already known as very biocompatible and stimulus responsive.[1-3]

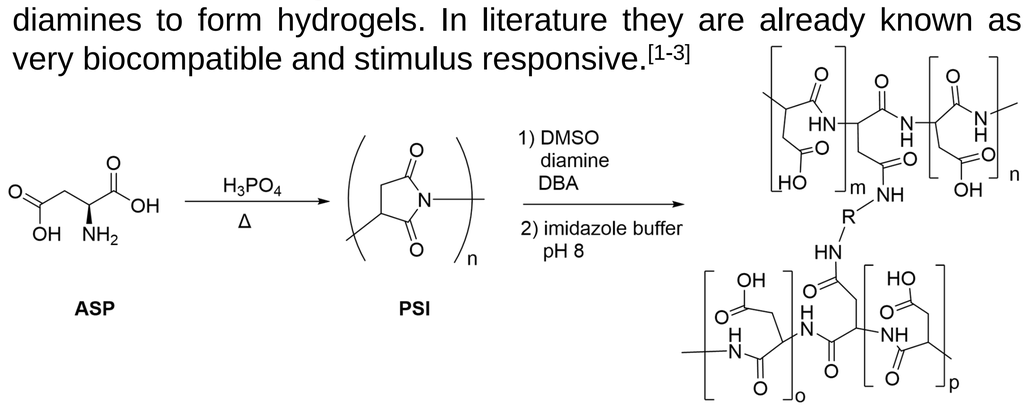


Figure 1: General synthesis of PASP-hydrogels.

Synthesis

A wide variety of diamines have already been successfully used as crosslinkers for the synthesis (fig. 2). The focus was on different chain lengths and the incorporation of different functional groups in order to investigate their influence on the properties of the gels.

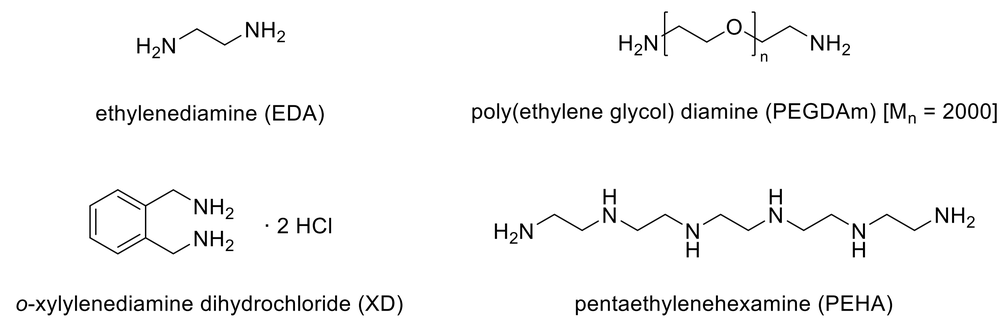


Figure 2: Successfully used crosslinkers for PASP-hydrogel-synthesis.

Results and Discussion

Chain Length of Polysuccinimide (PSI)

In the literature large and costly blenders are often used for synthesis of PSI due to the high temperatures and the required stirring force.[2] With a suitable reaction vessel, we succeeded in producing moderate PSI in two different ways. As expected, the chain length is increased by the use of solvents due to improved mixing.

Table 1: Weight average molar mass (M_w) of PSI

synthesis method	M_w [g mol^{-1}]
without solvent	14912,64
with mesytilene/sulfolane (7:3)	21991,40

Mechanical Investigations

Comparing the mechanical properties of the PSI- and PASP-EDA-gels, the influence of the additional OH-group in the structure of the hydrolyzed gels can be clearly seen. The OH-group ensures that the gel is stiffer and fractures earlier than the more elastic PSI-gel due to additional water absorption.

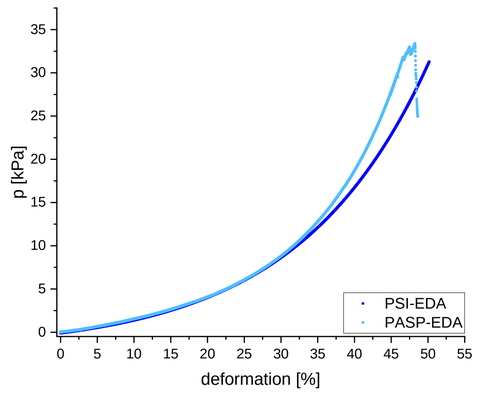
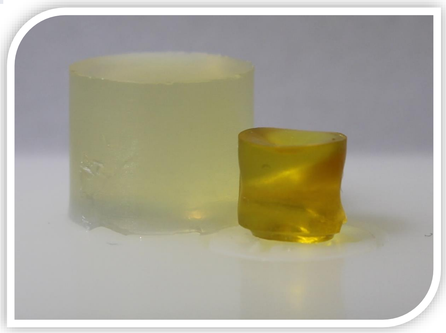


Figure 4: Comparison of the mechanical properties of PSI- and PASP-EDA-hydrogels.



Swelling Character

It was shown that EDA as a short crosslinker leads to form-stable gels with good swelling properties. Longer crosslinkers, on the other hand, lead to lower degrees of swelling, since the resulting gels are less stable and decompose more easily.

In addition, the free OH-groups of the PSI chains are further apart and can therefore contribute only little to stabilization. Short and sterically less mobile crosslinkers such as the XD also lead to gels that are less form-stable and have a low degree of swelling.

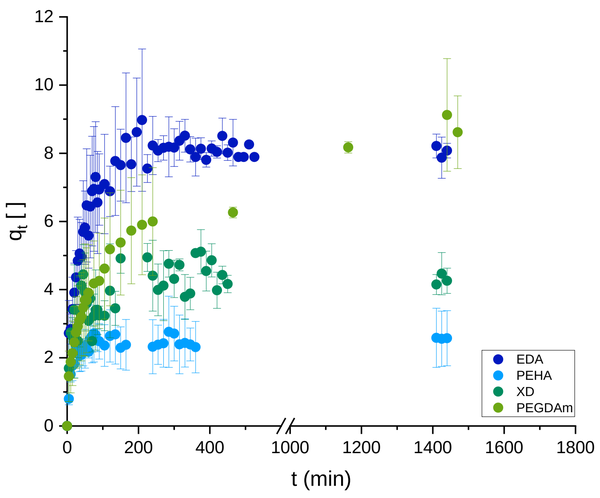


Figure 3: Swelling studies with different crosslinkers.

Stimulus-Responsive Properties

The pH sensitivity of PASP-gels is partly related to the limited solubility of PSI in acidic environments. Moreover, above a pH of 4 deprotonation of the carboxyl groups of the PASP chains begins. Juriga *et al.* observed a sudden increase in the swelling curve at a pH of about 4.[4]

This value corresponds approximately to the pK_s value of the side chain of *α*- and *β*-aspartic acid with a value of 3.90. The jump can also be explained here by the deprotonation of the carboxyl groups. Below the pK_s value of PASP, the gel shrinks and swells only in the deprotonated form.[4] In our work, this behavior could be clearly attributed to the PASP structure and does not originate from incorporated modifications or the crosslinker.

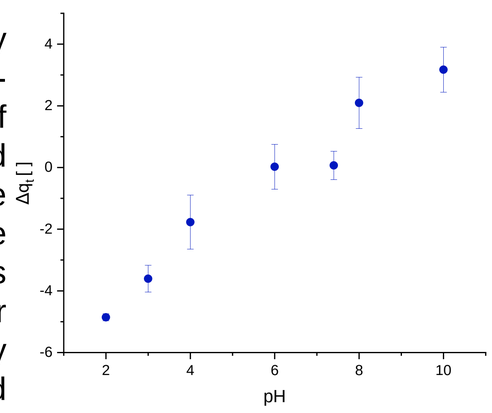


Figure 5: pH-dependent swelling degrees of PASP-EDA-hydrogels.

Summary and Outlook

- ✓ successfull synthesis of new PASP-diamine-hydrogels
- ✓ comprehensive characterization
- ✓ evidence of stimulus responsive character of PASP-structure
- ➢ synthesis of more new PASP-gels crosslinked with amino acid structures
- ➢ enzymatic degradation
- ➢ biocompatibility
- ➢ influence of PSI chain lenght

References

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Acknowledgment

Financial support by the Federal Ministry of Education and Research (BMBF) within RESPONSE „Partnership for Innovation in Implant Technology“ is gratefully acknowledged.

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