

# Step wise mode I crack propagation in HEMA-NaMA hydrogels

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# Step wise mode I crack propagation in HEMA-NaMA hydrogels

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## Introduction

Hydrogels are used in many applications in the biomedical field, due to their peculiar properties such as good mechanical stability, permeability and bio- and blood- compatibility.



Fig. 1: Some hydrogel applications: skin layers, contact lenses, artificial intervertebral disc.

Performing experiments on HEMA-NaMA hydrogels, we want to investigate the behavior of the gel during crack opening and propagation.

## Aim of the study

New advances necessitate a better understanding of the mechanical behavior of the hydrogels.

## Results

We performed a standard single-edge notch test for 16 samples of 4 different stiffness. In each experiment the hydrogel showed a step-wise behavior of the crack during propagation.

E [Mpa]	ΔX [mm]		
	min	max	average
0.112	2.1	2.7	2.35
0.256	3.01	3.55	3.26
0.588	4.38	4.97	4.67
0.817	5.9	6.5	6.2

Fig. 2: Length of the steps for different stiff-ness of the hydrogel.

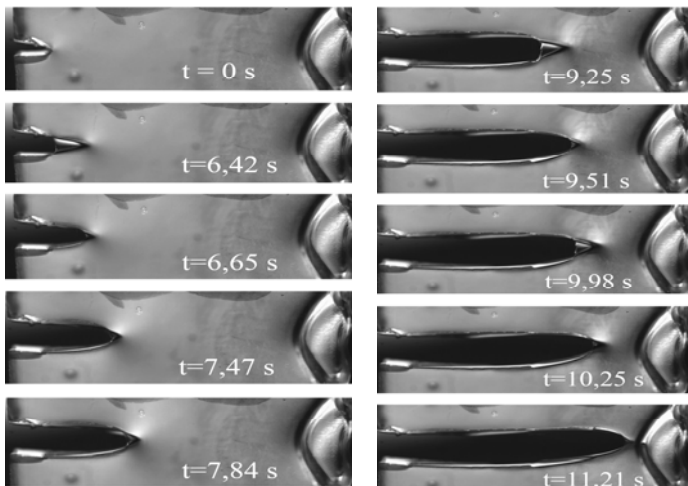


Fig. 3: Stepwise scheme for Mode I at each time step.

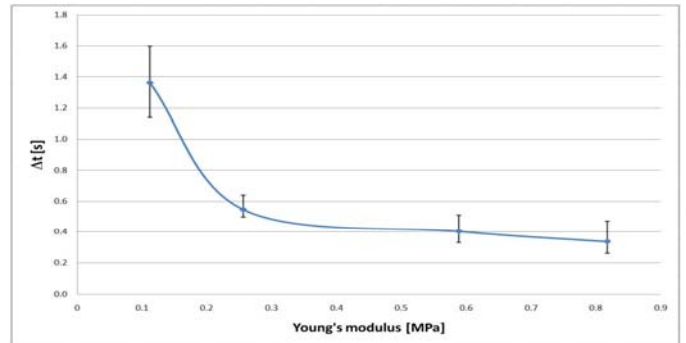
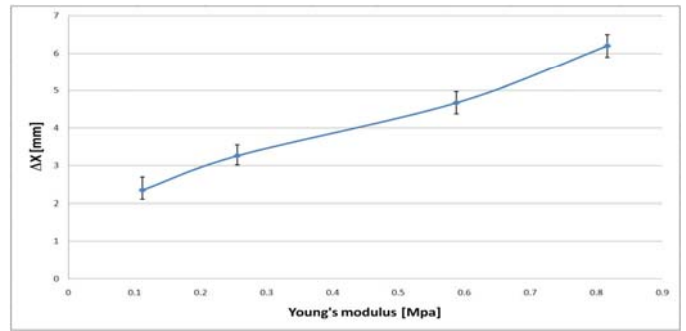


Fig. 4: Top: linear relation between the stiffness of the hydrogel and the average length of the steps. Bottom: hyperbolic relation between the stiffness and the time span during which the crack propagation pauses.

## Discussion

The cracking surface has a toothed appearance (fig. 5) as a consequence of the step-wise propagation coupled to some extent of plastic deformation. Both the distance of propagation in one step as the time span during which the propagation pauses between the steps depend on the Young's modulus of the gel (fig. 4). The former is positively correlated with the Young's modulus while the latter is negatively correlated with the Young's modulus.



Fig. 5: Tooth shape repeating along the lip of the crack .

## Conclusions

We showed that in HEMA – NaMA hydrogels a cracks does not propagate smoothly, but following a step wise scheme. This result also support numerical simulations of crack propagation in porous materials .