Applications of hydrogels

Last Day:  polyelectrolyte gels
   Polyelectrolyte complexes and multilayers
   Theory of ionic gel swelling

Today:  hydrogels in biomedical/bioengineering applications
   Linking gel mesh size to diffusivity of solutes

Reading:  -


ANNOUNCEMENTS:
Last time
Applications of hydrogels in bioengineering
Hydrogels applied to drug delivery
On/off drug release using PE hydrogels

Two strategies:
Drug delivery

Kinetics of drug release from hydrogels using swollen-on/collapsed-off mechanism

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Please see:
Drug delivery

Mesh size of hydrogel networks

\[(<r_0^2>)^{1/2} = N_c^{1/2}a\]

- \(N_c\): Number of segments between cross-links
- \(a\): Statistical segment length

\(P_{\text{gel,opening}}^*\)

\(P_{\text{gel, volume}}^*\)

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Connection between mesh size and diffusion coefficient of entrapped molecules
Controlling diffusivity for responsive drug delivery: treatment of diabetes

Glucose oxidase + \text{Glucose} \rightarrow \text{Gluconic acid} + \text{H}_2\text{O}_2

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Controlling diffusivity for responsive drug delivery: treatment of diabetes

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Drug delivery

Response of gel microparticles

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Drug delivery

Glucose sensitivity

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Diffusion rate changes in responsive microgels

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Drug delivery

Chemical functionality in hydrogels can be utilized for responsive hydrogels

Mechanisms of environmental responsiveness in hydrogels:
Chemical functionality in hydrogels can be utilized for responsive hydrogels

Figure by MIT OCW.

(Takahashi et al. Macromol 32, 2082-2084 (1999))
Immunoisolation/encapsulation of living cells
Formability: photoencapsulation

In sterile culture media:

Cyclohexyl phenyl ketone:

\[
\text{CH}_2\text{CH} = \text{C} - \text{O} \left(\text{CH}_2\text{CH}_2\text{O}\right)_n \text{C} - \text{CH} = \text{CH}_2
\]

\[
\text{UV } \text{hv} \rightarrow
\]

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Formability: photoencapsulation

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Hydrogels for tissue engineering
Motivation for hydrogels as tissue scaffolds:
Hydrogels are readily modified with biological recognition sites.

Incorporating biological recognition:

- Adhesion sequence: WGRGDSP
- Photopolymerization
- Peptides

NR6 fibroblast adhesion on PEG-RGD hydrogel (no cell adhesion on ligand-free hydrogels)

- Collagenase sequence: GWGLGPAGK
- Photopolymerization
- Peptides

In situ formability: strategies for macroporous structures

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In situ formability: example: ‘printable’ gels

Chilled/heated printing heads provide 4-70°C dispensing

Temperature-controlled stage

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Further Reading