

Soft Matter exercise, Chapter 7: Gels

1. Sol-gel process

What is the difference between a sol and a gel?

2. Gel

You would like to develop a gel that acts as a moistener for example of wounds on arms and hands where wounds get compressed and sheared frequently.

- What type of gel would you choose and why?
- What material would you use?
- Why does the gel swell if you put it in water?
- How would you tune the mechanical properties?

3. Percolating network

You would like to generate a rigid, percolating network.

- What type of monomers would you use?
- If you have a monomer with 4 neighboring points, how many generations would you have to grow to form at least 1000 bonds, assuming the probability for a bond to form is 0.4?
- If you have a monomer with 2 neighboring points, how many generations would you have to grow to form 1000 bonds, assuming the probability for a bond to form is 0.4?
- You would like to rigidify the gel without changing the distance between adjacent covalent crosslinks. What would you do?

4. Crosslink rate

In a certain chemical cross-linking reaction involving a monomer that can react at three sites, the degree of reaction, f , obeys the second-order rate law

$$\frac{df}{dt} = k(1-f)^2$$

where k is the rate constant and equals $4 \times 10^{-4} \text{ s}^{-1}$. Calculate

- the time at which a sol transitions into a gel
- the time after which 75% of the reaction is complete
- the time after which 75% of the monomers are incorporated into the percolating network.

5. Self-healing hydrogels

You designed a self-healing hydrogel that contains 80 wt% water.

- How would you design the crosslinks of this hydrogel to ensure that it has self-healing properties?
- You realize that the hydrogel starts to flow very quickly even if you stress it minimally. This hampers the use of this hydrogel as damper. You are asked to improve the mechanical properties to ensure that the hydrogel flows only if higher stresses are applied while maintaining the self-healing properties and without significantly changing the E-modulus. What would you do?
- What is a relaxation time?
- How would you characterize the relaxation time? Describe the working principle of this technique.

6. Thermo-responsive polymers

Why is poly(N-isopropylacrylamide) (PNIPAM) thermo-responsive?