MSE-471 TP6-8: Introduction to Rheometry and Experimental Techniques

Exploring the properties for your Gel

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Today's Objectives

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1. Revision to the Introduction of Rheometry
2. Data analysis, Rheological data, FIJI for image processing
3. Report discussion
4. Answer any questions you might have so far

1. What is Rheometry?

- Definition: Rheometry is the experimental study of how materials flow and deform under applied forces

- Purpose: Used to measure the rheological properties (e.g., viscosity, elasticity) of liquids, semi-solids, and soft solids

https://www.youtube.com/watch?v=_RSNSGkSqSw

Why study Rheology?

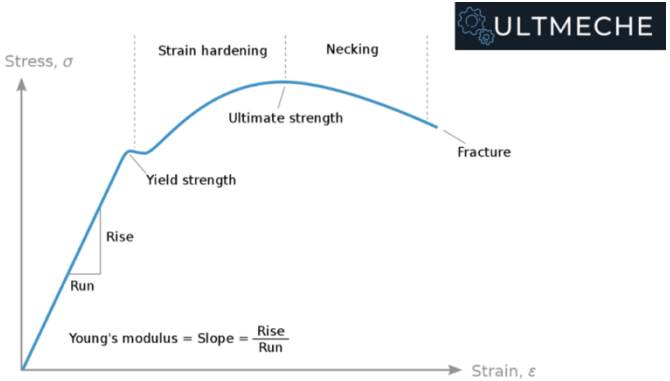
- Understand Materials Behavior:
  - Predict how materials (gel) will react under different conditions

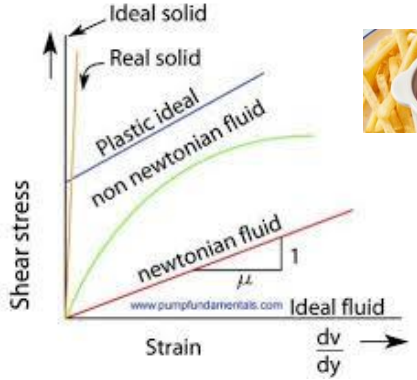
- Research applications
  - Explore properties in gel formation, cell mechanics, and tissue engineering
- Industrial applications
  - Pharmaceuticals
    - Developing biomaterials (ointments, gel, and creams)
  - Polymer Industry
    - Design and processing of plastics
  - Food Industry
    - Texture and consistency analysis of products (e.g., sauces, creams)

Rheological Properties: Types of behavior

- Viscoelasticity (e.g., gels, biological tissues)
  - Viscosity: Resistance to flow (e.g., honey vs. water)
  - Elasticity: Ability to return to original shape after deformation (e.g., rubber)

- Shear Stress (σ)/Strain (ε) -> Stress is the force applied/ strain is deformation experienced





https://www.researchgate.net/figure/Corr elation-of-shear-stress-and-strain-for-fluids-and-solids_fig12_291821947

Types of Rheometers & Experimental techniques

- Oscillatory Rheometers
  - By apply oscillatory deformation
- Steady Shear Testing
  - at constant shear rates
- Oscillatory Testing
  - by applying oscillatory deformation -> **Storage (G') and loss (G'') modulus**
- Creep and Recovery Test
  - Constant stress over time

https://www.azom.com/article.aspx?ArticleID=18927

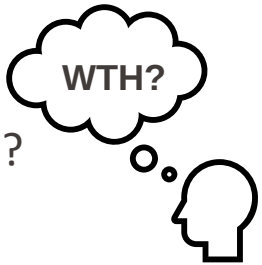
Demonstration

Experiments – Key steps

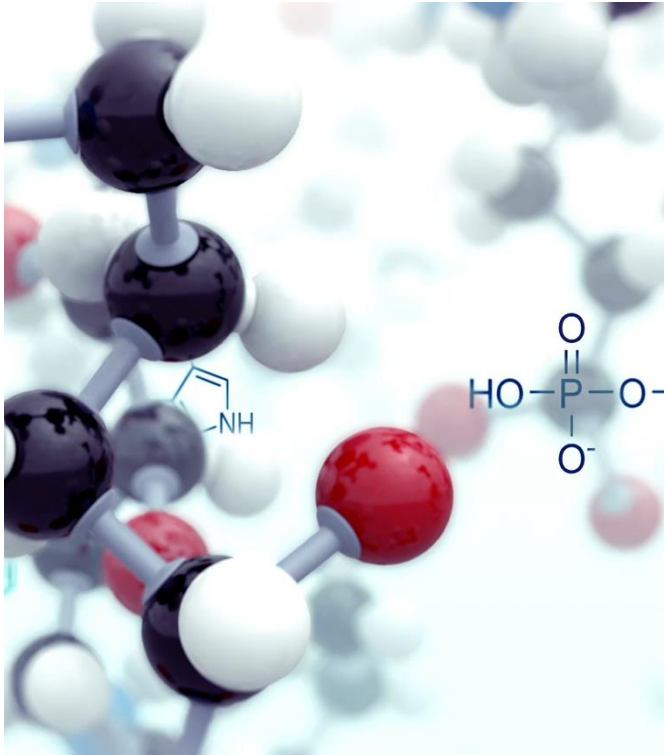
- Goals: optimizing gel properties for **tissue scaffolds** or drug delivery, studying **cell adhesion and migration** etc.

- Instrument Calibration: Essential for accurate data
- Sample preparation: ensuring **homogeneity, avoiding air bubbles**
- Data Interpretation: e.g., stress-strain curves, modulus data …

- How does such a difference affect your cell??

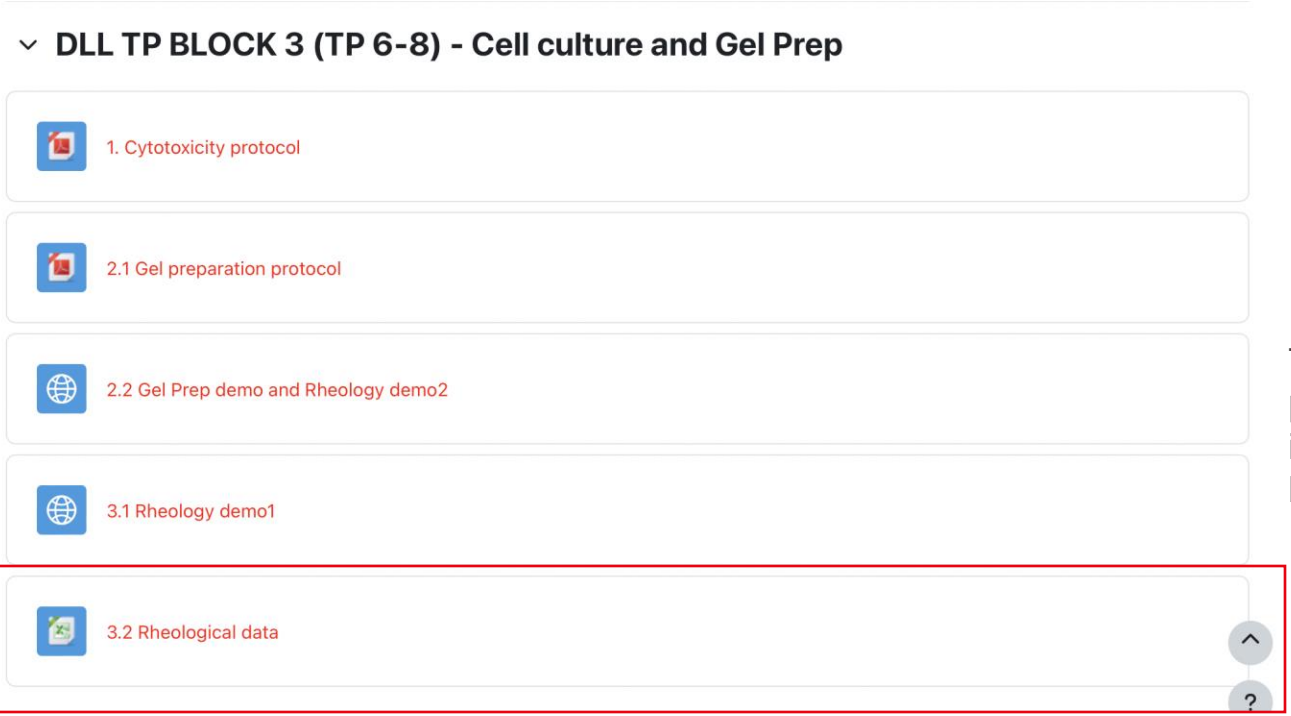


What influences Rheological Behavior?



- Temperature: Higher temperature often reduces viscosity
- Shear rate: Materials may behave differently at varying shear rates (Newtonian vs Non-Newtonian fluids)
- Material composition: Molecular structure, particle concentration, and additives.

2.1. Data analysis Rheological data



Think about what parameters are you interested in for your biomaterials ☺

Data Interpretation

- Week 4 lecture slide, Page 9

Hydrogels

Hydrogels are 3D networks of cross-linked polymers

90+ % is water
Crosslinks can be covalent or non-covalent
Swelling occurs until in **equilibrium** with osmotic pressure

a (neutral) hydrogel experiences a thermodynamic force of mixing and a contractive force that become balanced once a hydrogel reaches its equilibrium swelling state

Pore size is dependent on the average molecular weight of polymer chain segments between adjacent crosslinks and acts as a selective barrier with regard to the permeability of substances

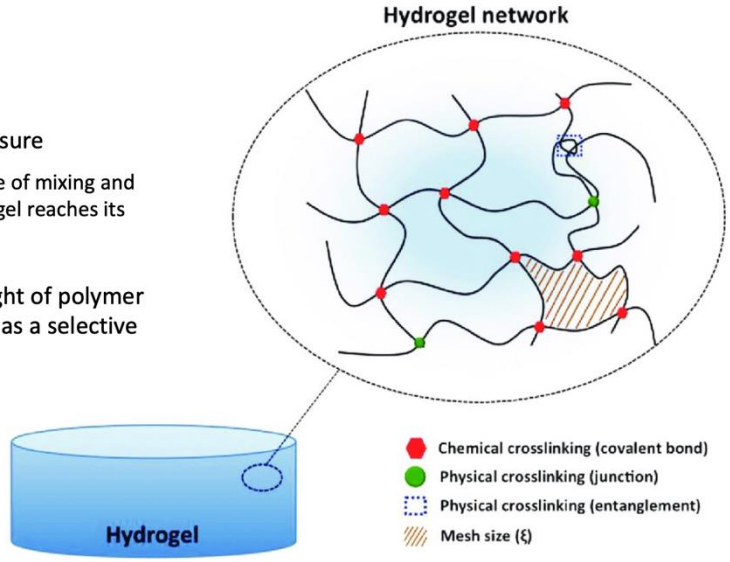
$$G = N_p kT = \frac{\rho RT}{\overline{M}_c}$$

E = 2G(1+v)

N_p is the number of polymer chains per unit volume

Mc = average molecular weight between cross-links

v = Poissons ratio



2.2. Image analysis - FIJI basic demon

- A powerful and widely-used open-source software for image processing and analysis in biological research

- Installation: Google ☺ https://imagej.net/software/fiji/downloads

Video demo:

- For this course: On Moodle (4.1. Image Processing FIJI demo)
- In-depth introduction: https://www.youtube.com/watch?v=y567dfZ_reI

2.2. Image analysis - FIJI basic demon

DLL TP BLOCK 4 (TP 9-11) - Cell staining and Nanolive

- 4.1 Image processing FIJI demo
- 4.1 Cell staining and image processing protocol
- 4.2 Nanolive imaging demo
- 4.2 Presentation on holotomographic imaging
- Demo cell images (2022)

3. Report Discussion

HERE COMES YOUR TITLE
NAME, FIRST NAME, SCIPER

ABSTRACT
Describes in the most minimal number of words what 1) this paper is about, 2) why it is important 3) what the key hypothesis was 4) what the main finding was with 5) which techniques and 6) how the conclusion is relevant for 7) future advances in biomaterials research.

INTRODUCTION
Describe shortly the background needed to understand your results and experiments later on, using what you have learned in class and during the TP. Highlight the role of hydrogels as scaffolds, what their main role toward cell culture is, and to which parameters cells are known to react. Then at the end present your hypothesis.

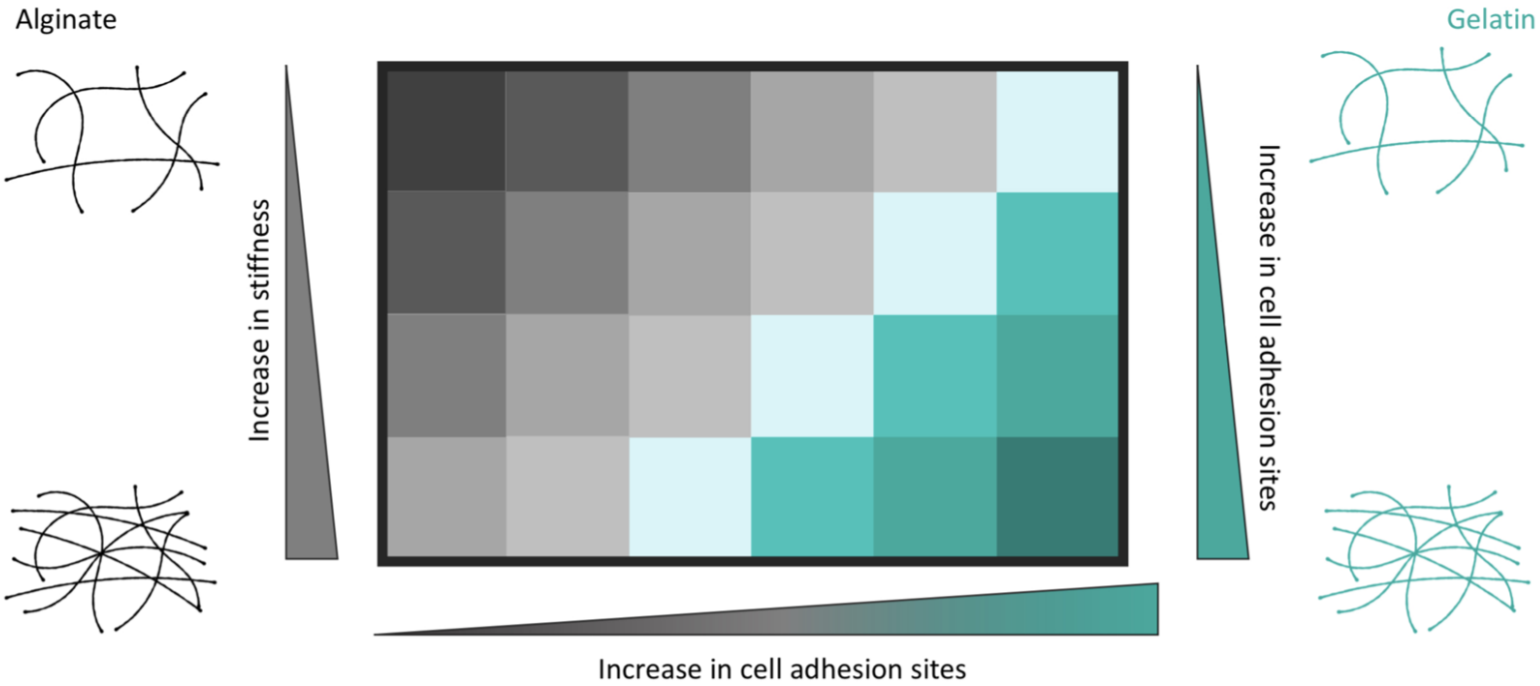
MAIN TEXT, EXPERIMENTAL RESULTS
You can use subcaptions to space the section in the main text. Build the report up in a way that the reader understands why you choose to do the experiments and which parameters are hypothesized to be important. Per section, clearly write what technique you use, how you designed the experiment (shortly), what are the results, and interpret the results. When you present a graph, figure, table etc, label these and refer to it in the text. Make sure all figures are labeled and have a good caption. NB: Figures need to have scale bars, legends, axes labeled, units etc.

CONCLUSION
Start with restating the main objective and hypothesis. Then present a conclusion based on your experimental data. Here you need to stay true to your experimental results. Do not over or underclaim.

DISCUSSION
In this section you go into further discussion of the results. Were they what you expected? Did anything go wrong in the experiments, are there surprising twists, how can you propose to resolve issues you encountered (if any). End with your recommendation for future experiments or repeats to strengthen or change or deepen your conclusion.

MATERIALS AND METHODS
You do not have to provide a full list of materials, but use this space to present the details of how you made your gels, and how you seeded the cells (how many, how long, etc).

REFERENCES


Alginate
Gelatin
Increase in stiffness
Increase in cell adhesion sites
Increase in cell adhesion sites