Azide-PEG-SG Hydrogel Characterization through Rheological Assessments

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Background

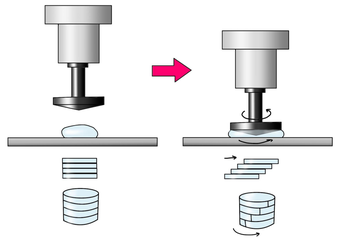
Hydrolytically degradable hydrogels are promising vehicles for drug delivery and other biomedical applications because they can provide highly aqueous environments for biomolecule viability. Degradation can be manipulated for dosage purposes as well as alleviating the need to remove implants post drug depletion. Literature has determined that hydrogel devices undergo shear thinning in in-vivo conditions, and thus mechanical characterization of proposed hydrogel compositions must be determined prior to in-vivo testing.

Objective

This study seeks to address whether hydrolytically degradable hydrogels are mechanically suitable delivery vehicles for tolerogenic extracellular vesicles (EV). The mechanical character of these gels will be determined through rheological assessments and analysis of the storage and loss moduli of each respective material.

Methods

This study was conducted using a rheometer, which measures the viscoelastic behavior in response to applied forces. A conical geometry was used to provide a constant shear rate independent of the materials distance from the center.



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Mechanical Characterization

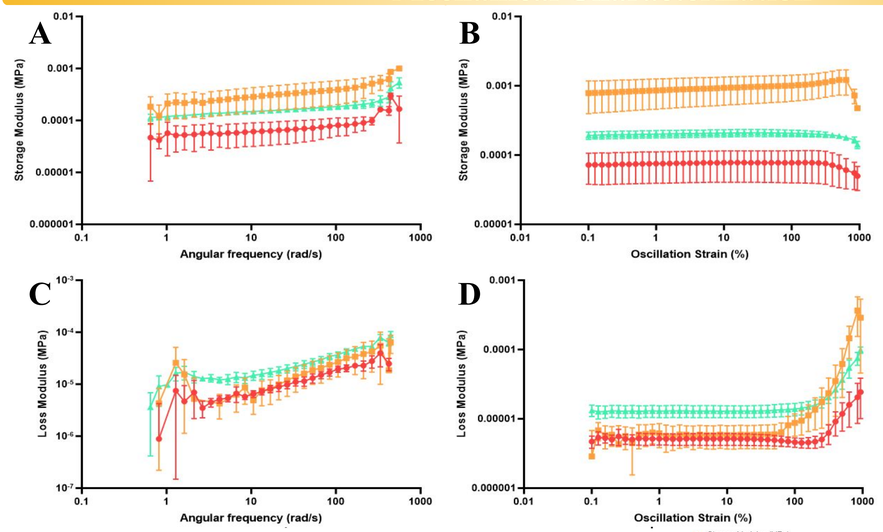

Fig 1. (A) Storage modulus of each gel plotted against angular frequency **(B)** Storage modulus of each gel plotted against the oscillation strain. **(C)** Loss modulus of each gel plotted against the angular frequency. **(D)** Loss modulus plotted against the oscillation strain.

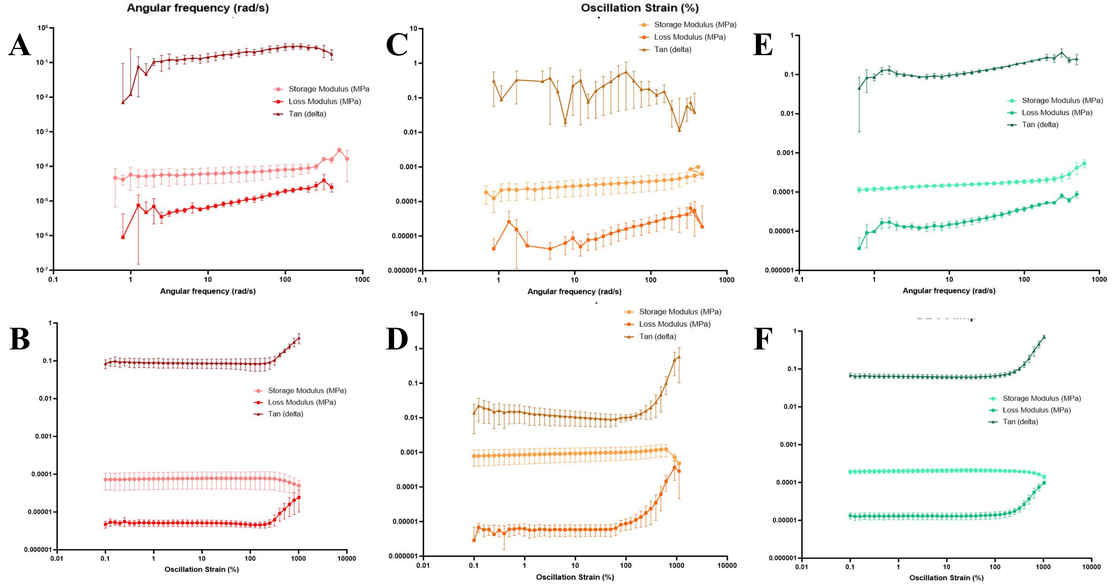

Fig 2. (A) Frequency sweep conducted on PEG-DTT. **(B)** Amplitude sweep conducted on PEG-DTT. **(C)** Frequency sweep conducted on PEG-VPM. **(D)** Amplitude sweep conducted on PEG-VPM. **(E)** Frequency conducted on PEG-DBCO. **(F)** Amplitude sweep conducted on PEG-DBCO.

Results

The storage and loss moduli of each sample were plotted using in amplitude and frequency sweeps and compared in Figure 1. The PEG-VPM hydrogel composition was evidenced to be the most elastic, or "solid-like" as its storage modulus was greatest during both the frequency and amplitude sweeps. This can be attributed to its greater molecular weight and subsequently denser polymer network. PEG-DBCO proved to be the most viscous, or "liquid-like" sample, as it yielded the greatest loss modulus over both sweeps. This can likely be attributed to it's lower molecular weight, which would allow for less dense cross linking and thus more liquid behavior. Looking at Figure 2, where the linear viscoelastic region of each sample is demonstrated by each sweep analyses and the plot of the complex modulus of each sample, PEG-DBCO is confirmed to be the most viscoelastic sample, as it has the greatest linear viscoelastic region of the three samples tested. PEG-VPM is also validated as the stiffest material, as it has the shortest viscoelastic region of the three groups. Greater storage moduli indicate a material's ability to withstand and recover from forces, which indicate potential compatibility for non-degradable implant use. However, greater loss moduli could improve diffusion of degradable implants.

Future Steps

The anticipated degradation analyses included in the proposal for this project were not completed due to constraints related to access to the rheometer used for mechanical testing. Future testing will include conducting the degradation analysis initially planned by quantifying and comparing rheological data on gels that have been allows to swell over time. Further testing will also include running the same rheological and degradation analyses on gels with extracellular vesicles (EVs), which are the deliverables these gels compositions are designed to secrete over time. The impact of the integration of EVs into each hydrogel composition will then be compared to the mechanical properties of the samples without EVs, and analyzed accordingly.

References

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