Mussel Inspired Oxidized Tannic Acid-PVP Hydrogel Adhesive for Enhanced Tissue Repair with Antioxidant and Pro-Regenerative Properties

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INTRODUCTION

Tissue adhesives inspired by marine organisms have been recognized as vital tools in wound healing and surgical applications, particularly in moist environments. The increasing need for adhesives capable of strong adhesion in liquid surroundings, while simultaneously promoting tissue regeneration, has been widely acknowledged.

In response to this demand, a lignin-based tissue adhesive has been developed for surgical applications under wet conditions. The formulation has been enriched with polyvinylpyrrolidone (PVP), tannic acid (TA), a natural source of catechol and gallol groups found in proteins secreted by marine organisms [1], and polyethyleneimine (PEI), which mimics cationic proteins [2]. The resulting adhesive has been designed to exhibit strong tissue adhesion, antioxidant properties, and support for tissue regeneration.

METHODS

The modified tannic acid solution was mixed with a PEI solution (0.5 mg/mL), followed by the sequential addition of modified lignin and 20% (w/w) PVP solution. Through rapid supramolecular interactions, gelation was achieved.
The resulting tissue adhesive was characterized by rheological analysis, adhesion strength testing using a tensile tester (ASTM F2255-05 standard), antioxidant assays, as well as contact angle measurements, FTIR spectroscopy, hemolysis, and hemostatic analyses.

In the poster, hydrogels containing modified lignin, PVP, TA, modified tannic acid (Tm), and PEI are labeled as PVP-α-y-c, where *α* indicates the PVP fraction (0.5 or 0.75), *y* refers to the type of TA used (T: TA, Tm: modified TA), and *c* denotes method A or B based on the order of component addition.

RESULTS AND DISCUSSION

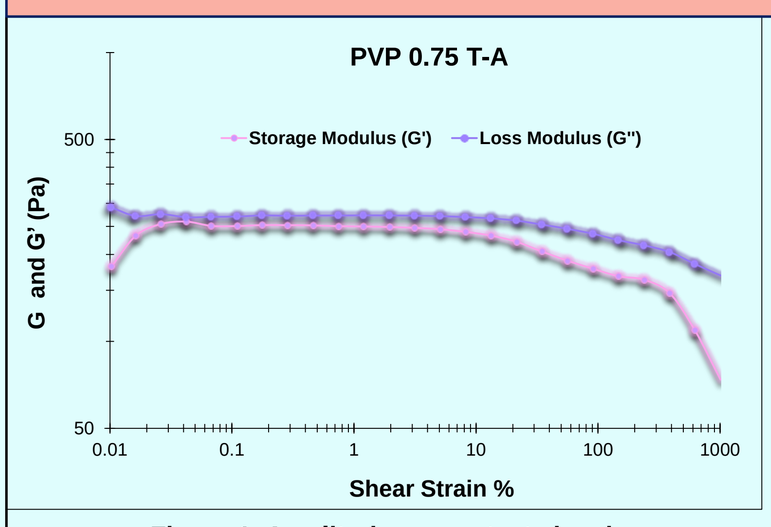

Figure 1. Amplitude sweep test showing storage (G') and loss (G") moduli

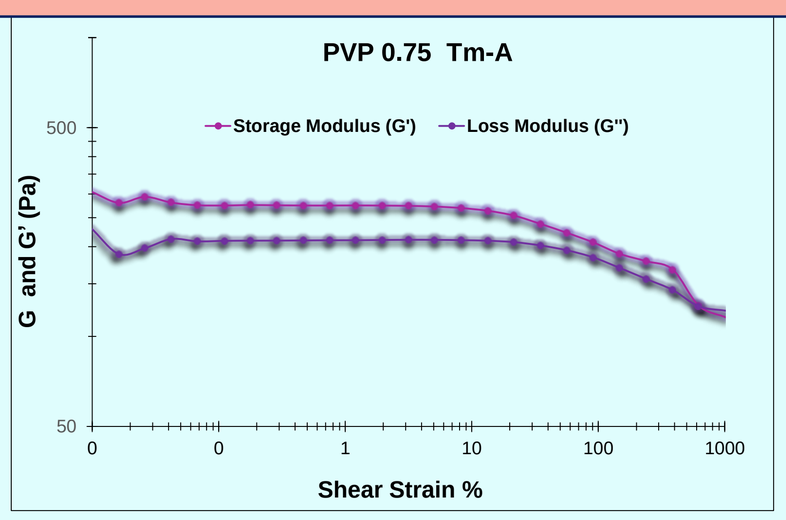

Figure 2. Amplitude sweep test showing storage (G') and loss (G") moduli

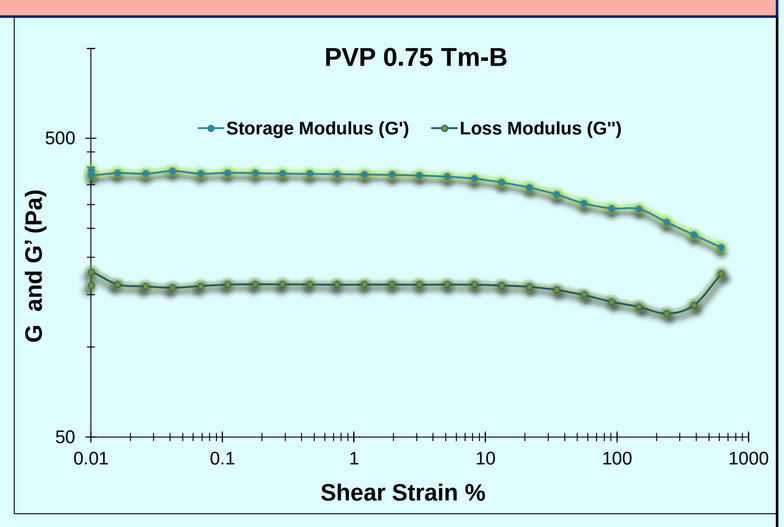

Figure 3. Amplitude sweep test showing storage (G') and loss (G") moduli

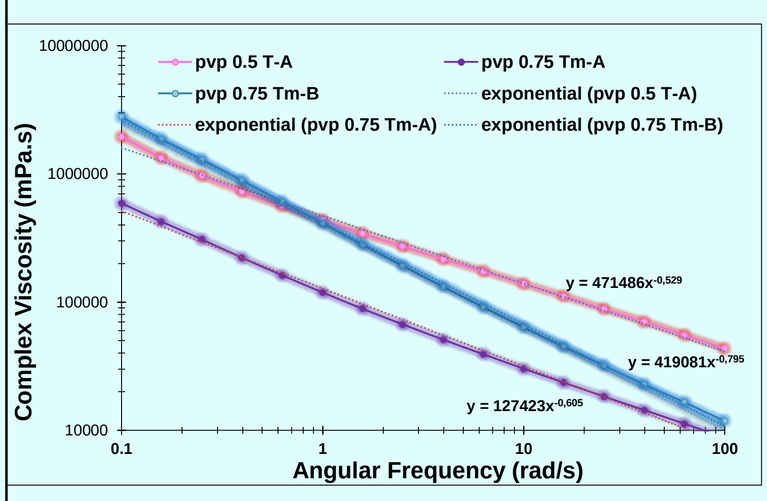

Figure 4. Frequency sweep test showing the complex viscosity of the hydrogels as a function of angular frequency (rad/s).

Figure 5. Images showing the hydrogel's injectability, stretchability, and adhesion to various surfaces including glass, and human skin.

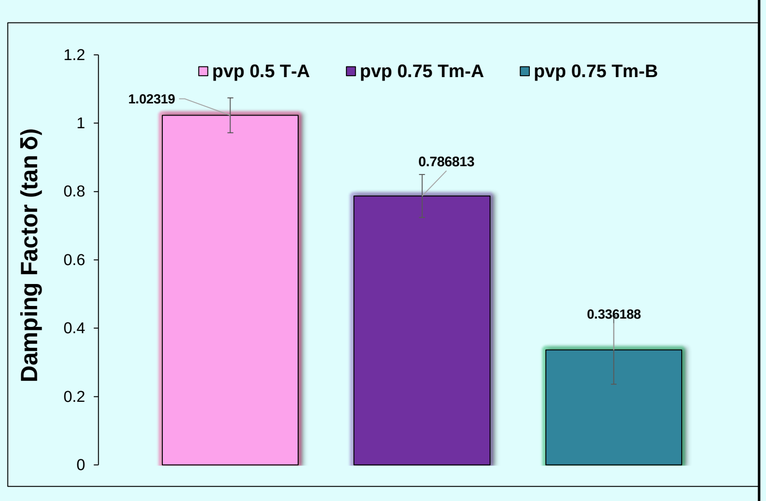

Figure 6. Damping factor (tan δ) values of different formulations, indicating the viscoelastic behavior.

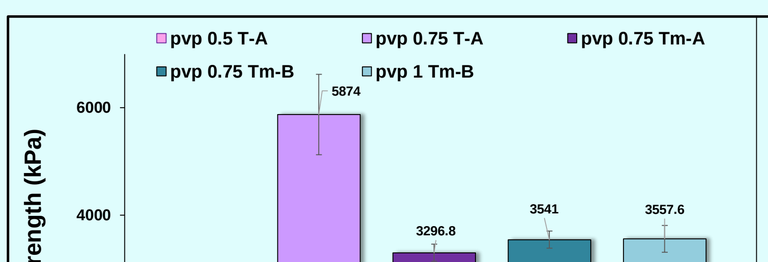

Figure 7. Dry adhesion strength of the hydrogels measured by lap shear test (ASTM F2255-05).

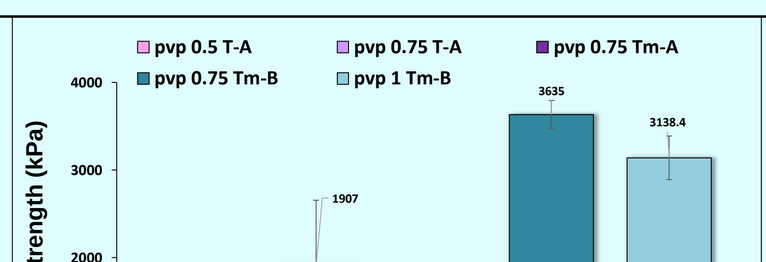

Figure 8. Wet adhesion strength of the hydrogels measured by lap shear test (ASTM F2255-05).

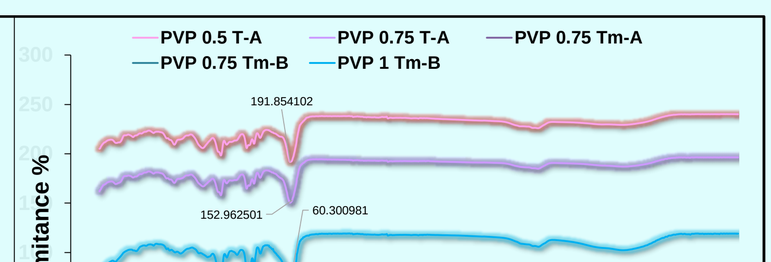

Figure 9. FTIR spectra of different formulations

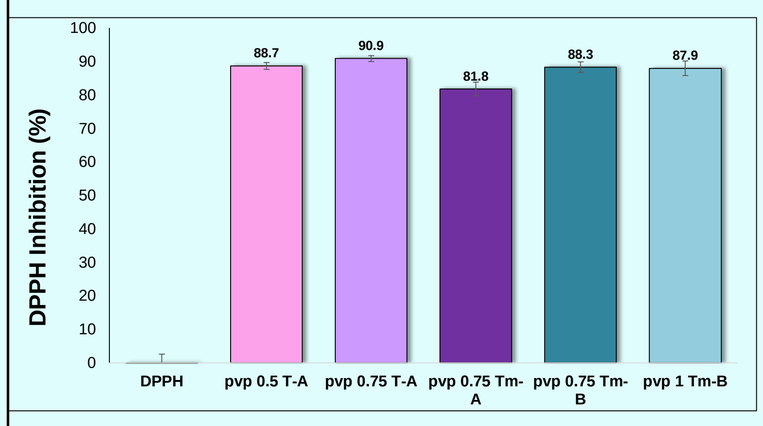

Figure 10. Antioxidant activity of the hydrogel samples evaluated by DPPH assay

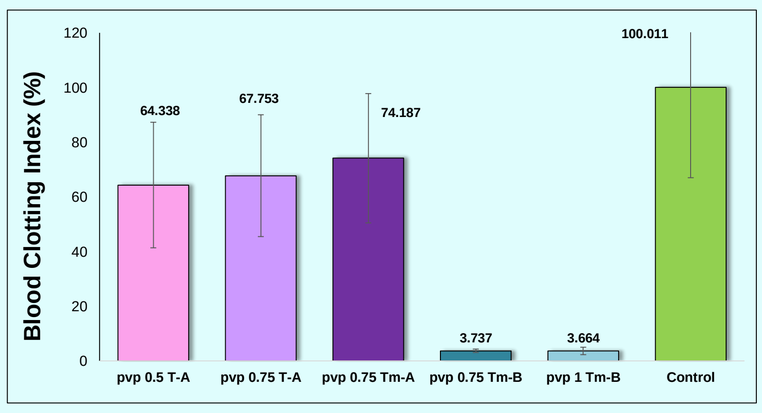

Figure 11. Hemostatic activity of the hydrogels measured by blood clotting index (%).

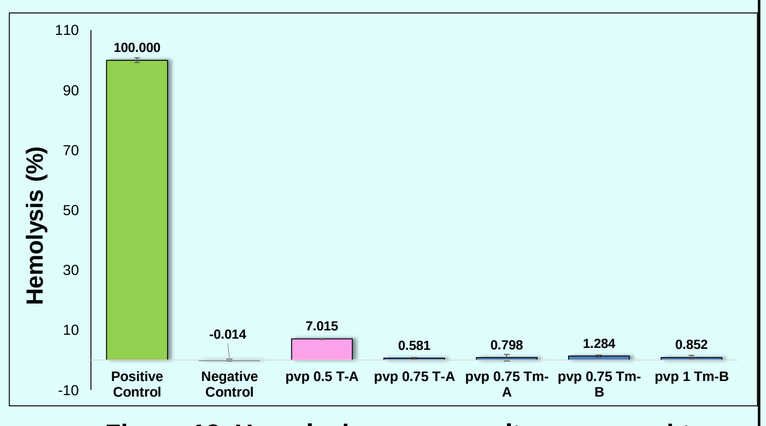

Figure 12. Hemolysis assay results, compared to positive and negative controls.

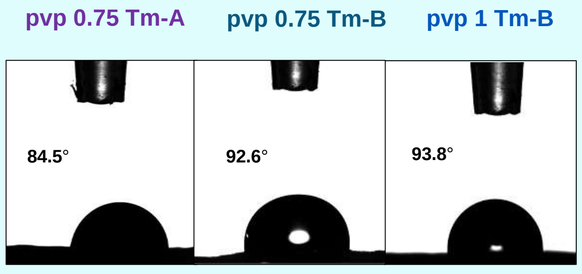

Figure 13. Contact angle images of water droplets on the tissue adhesive surface, indicating hydrophobicity.

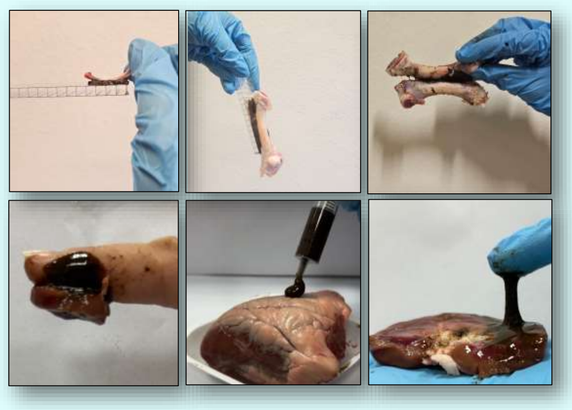

Figure 14. Ex vivo demonstration of the hydrogel's tissue adhesion and mechanical stability on biological surfaces including chicken bone and lamb kidney, heart, and liver.

REFERENCES

ACKNOWLEDGEMENT

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