



Propolis-Enhanced Pectin Hydrogels: A Multifunctional Platform for Skin Cancer Treatment

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INTRODUCTION & METHODS

Dialdehyde pectin (OP), prepared by sodium periodate oxidation of pectin—a fruit juice industry by-product—forms dynamic Schiff base linkages with gelatin and ADH, enabling injectability, self-healing, and cell adhesion. **Propolis** (PP), rich in flavonoids (e.g., apigenin, quercetin), offers antioxidant, anti-inflammatory, and anticancer effects, while reinforcing the hydrogel via secondary interactions and enhancing antitumor immunity[1].

Owing to the gelation ability of OP and the tissue-adhesive properties of gelatin, the resulting hydrogel provides a biocompatible matrix. Procaine (PC) was incorporated for local anesthesia and redox modulation in skin cancer treatment[2]. Commercial propolis was provided by Zadevital™ which is collected from six different sources in Italy. Hydrogels were coded based on their composition as α Gel β pp, where α indicates the gelatin concentration and β refers to the pp content.

AIM

This study aims to develop an **injectable, self-healing**, and **tissue-adhesive** hydrogel by crosslinking oxidized pectin with gelatin and ADH, incorporating PP for bioactivity and PC for localized anesthetic and **antioxidant** effects in skin cancer treatment.

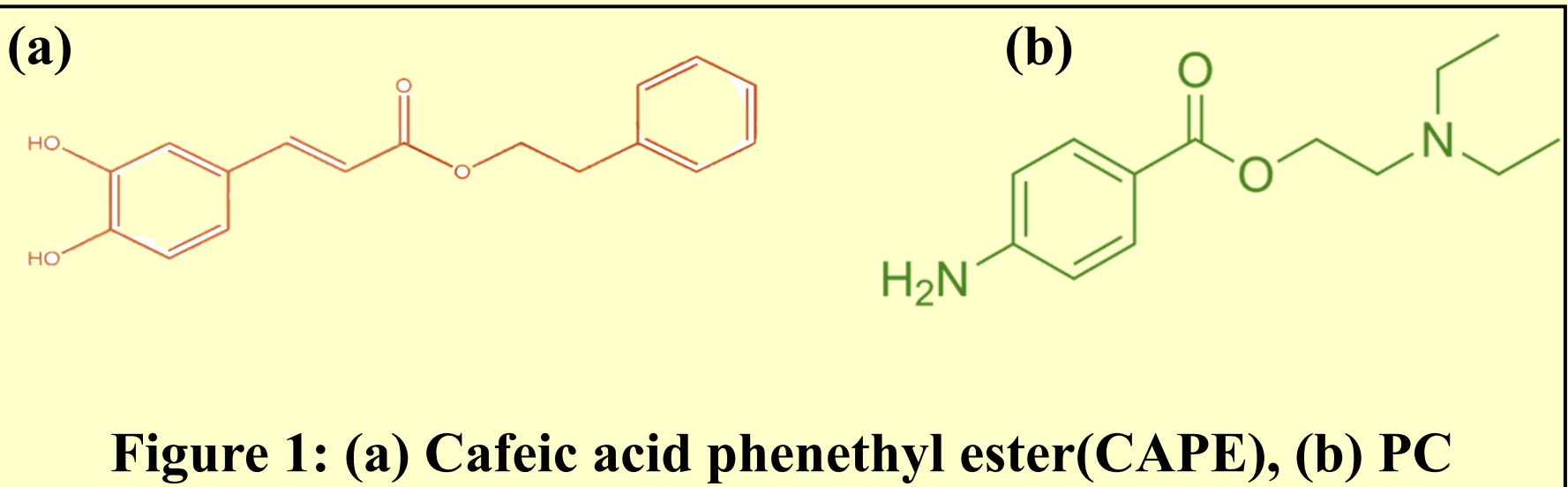


Figure 1: (a) Cafeic acid phenethyl ester(CAPE), (b) PC

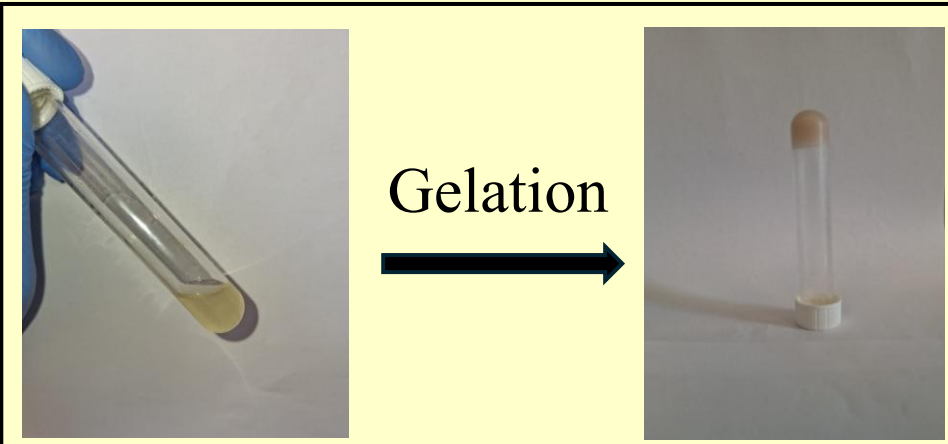


Figure 2: Gelation of the hydrogel

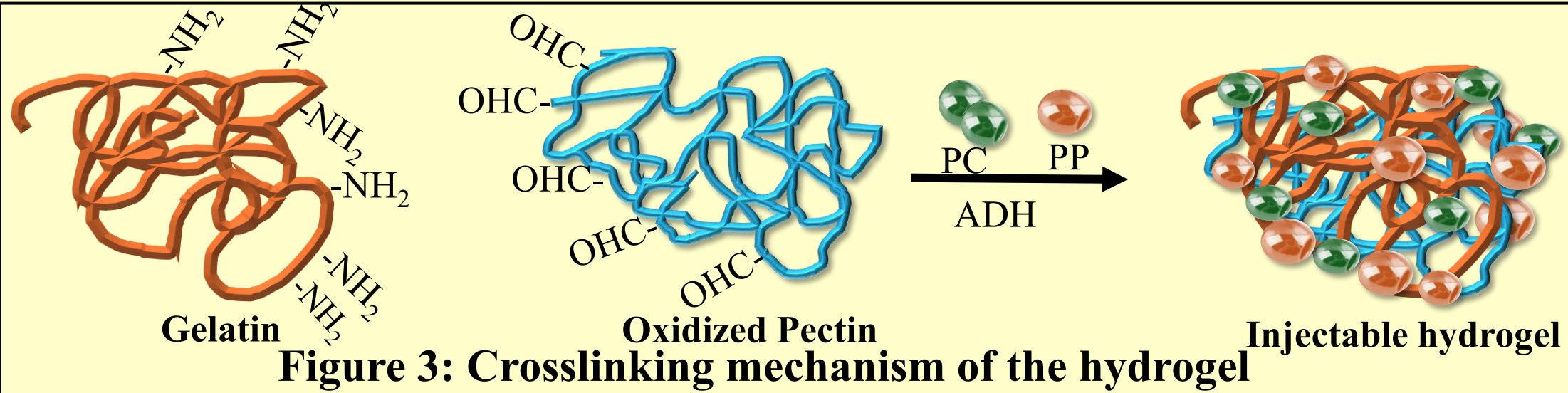


Figure 3: Crosslinking mechanism of the hydrogel

RESULTS

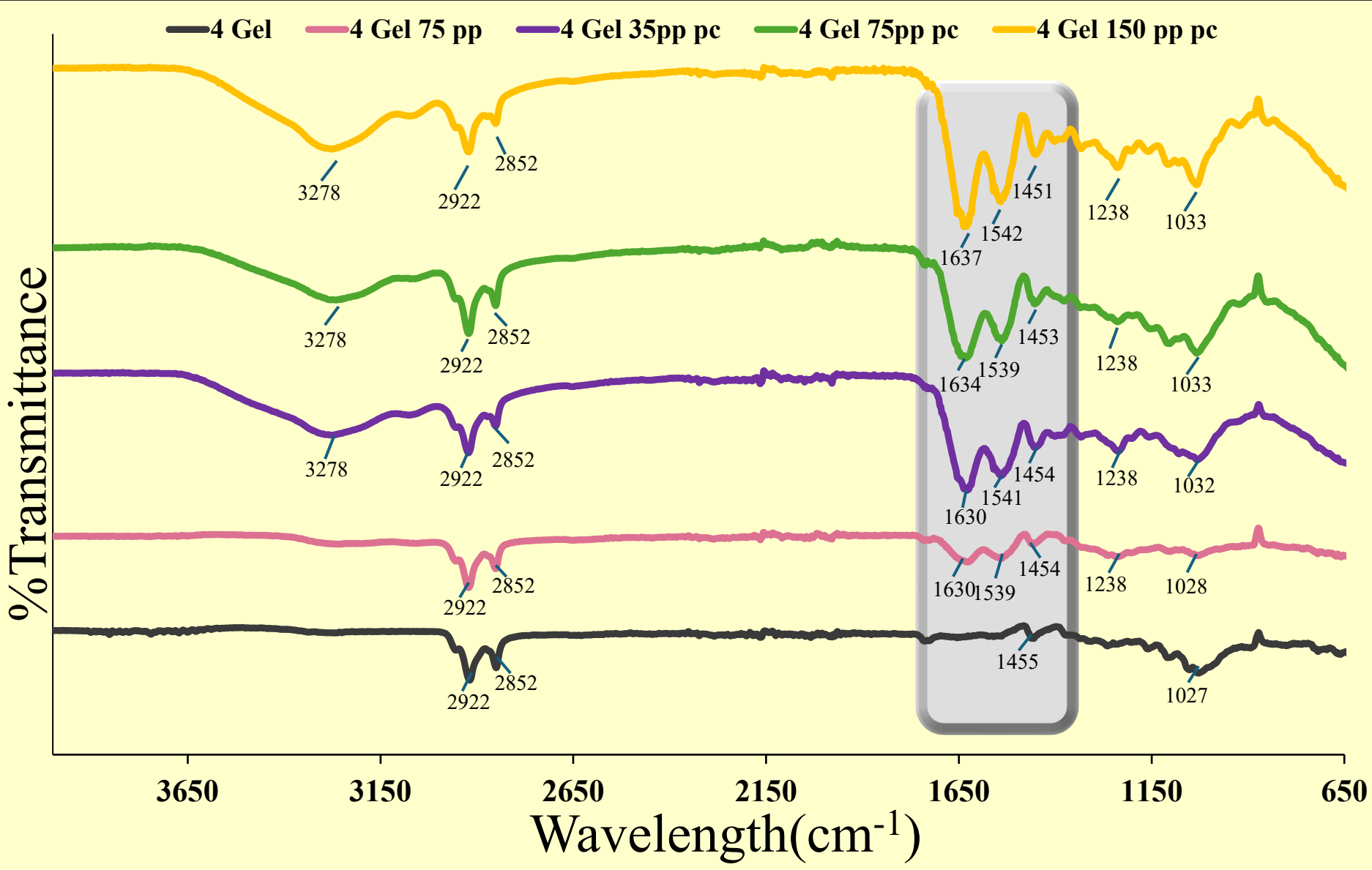


Figure 4: FTIR results

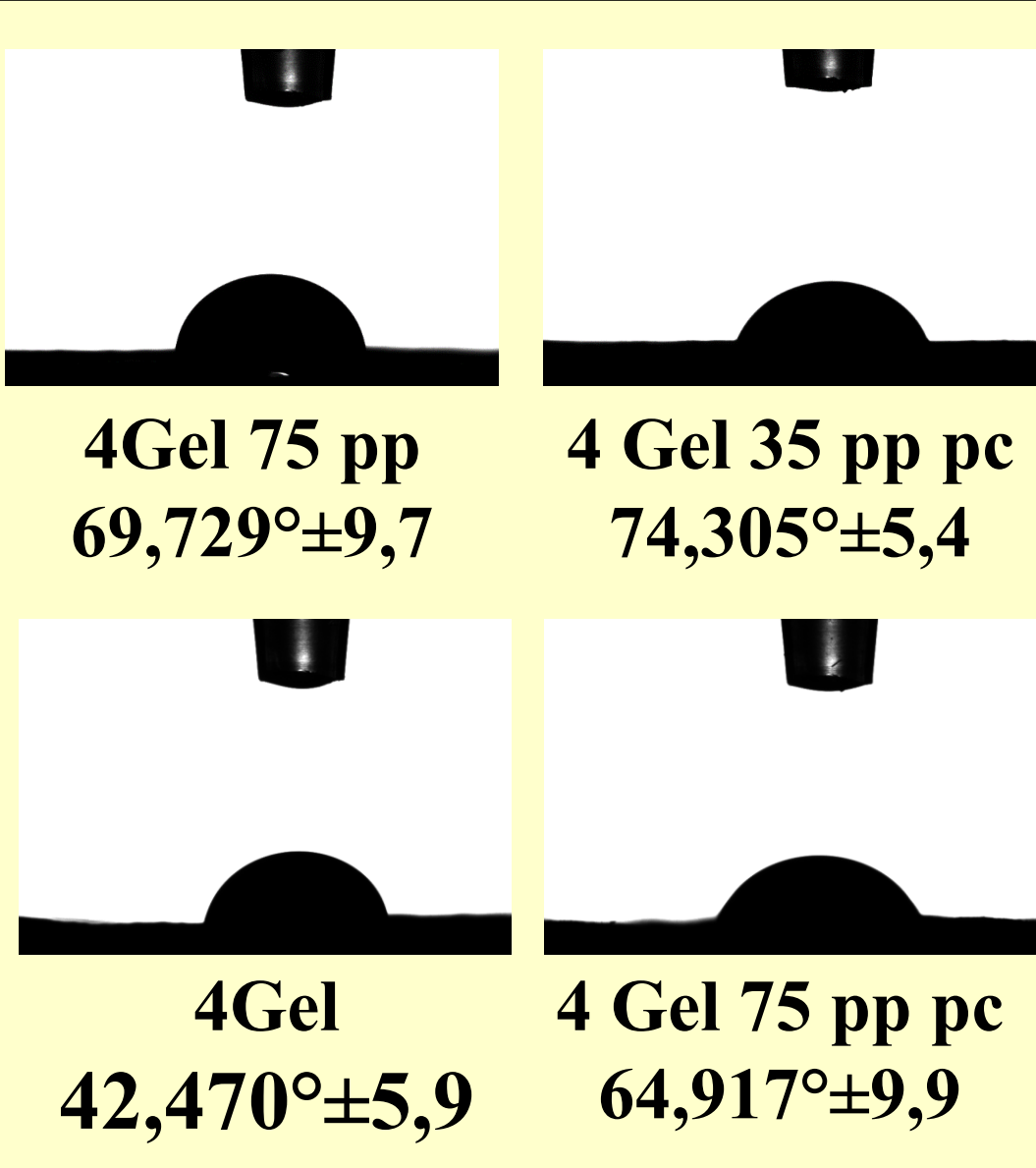


Figure 5: Contact angle measurement

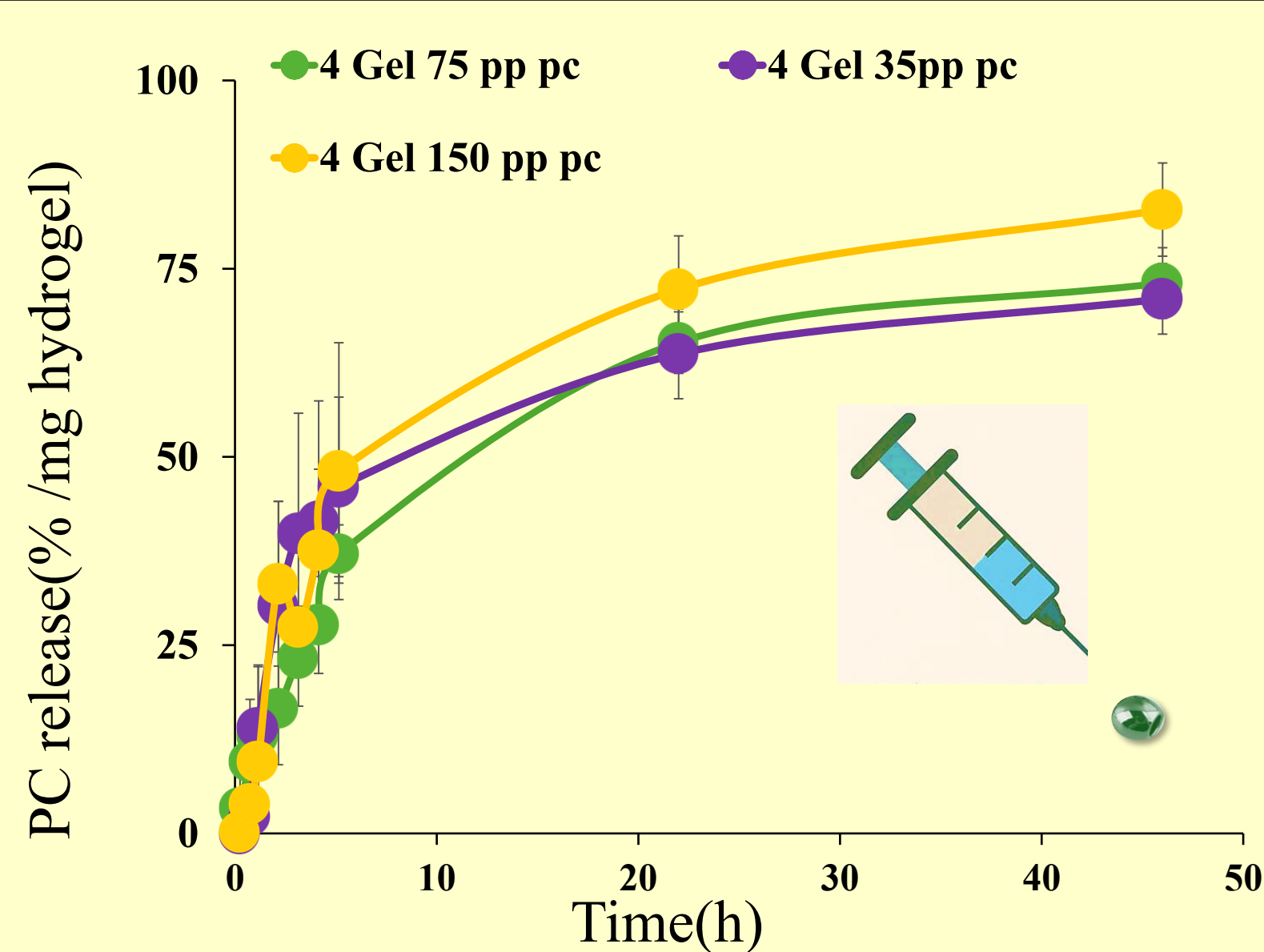


Figure 6: Drug release experiment

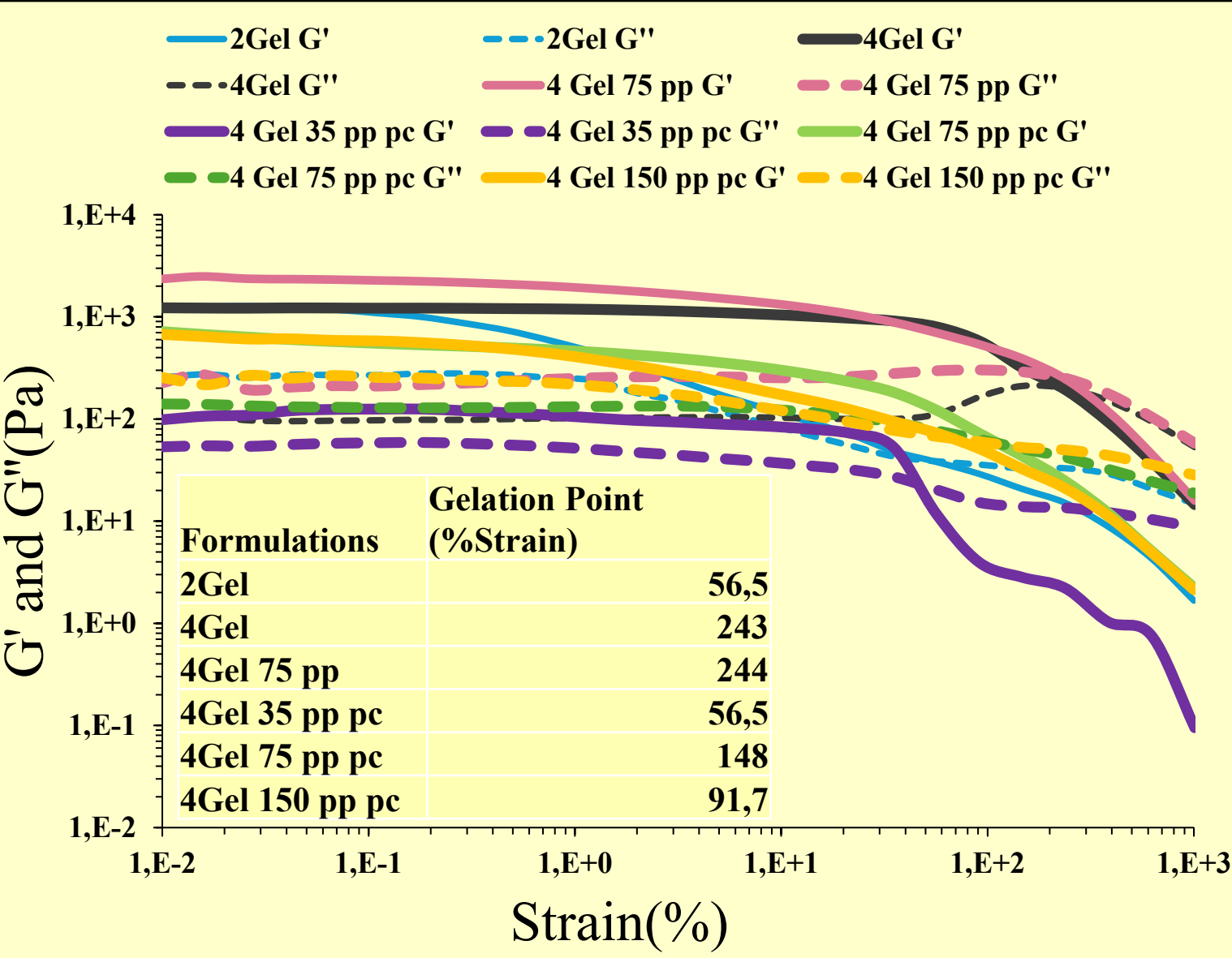


Figure 7: Amplitude sweep

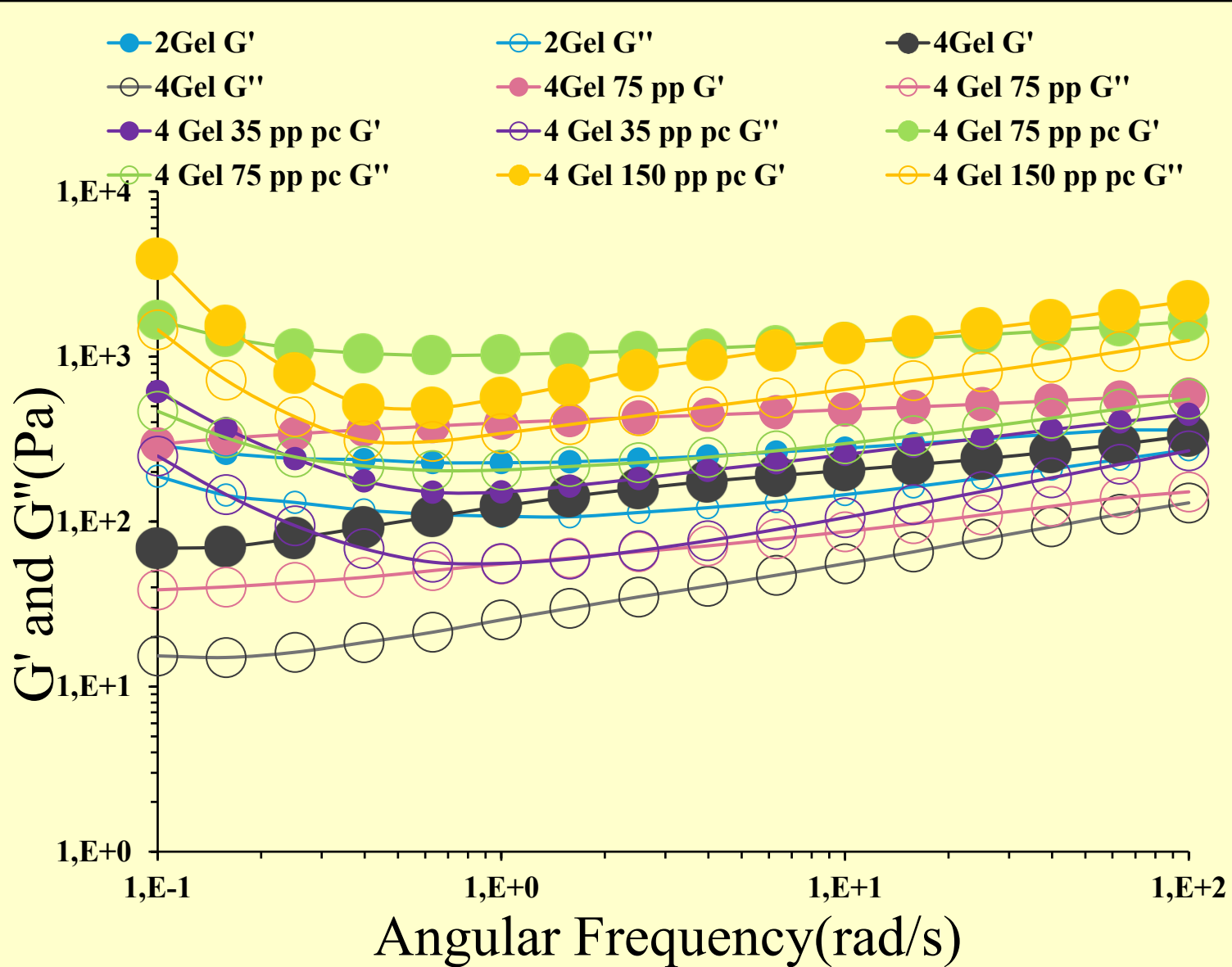


Figure 8: Frequency sweep

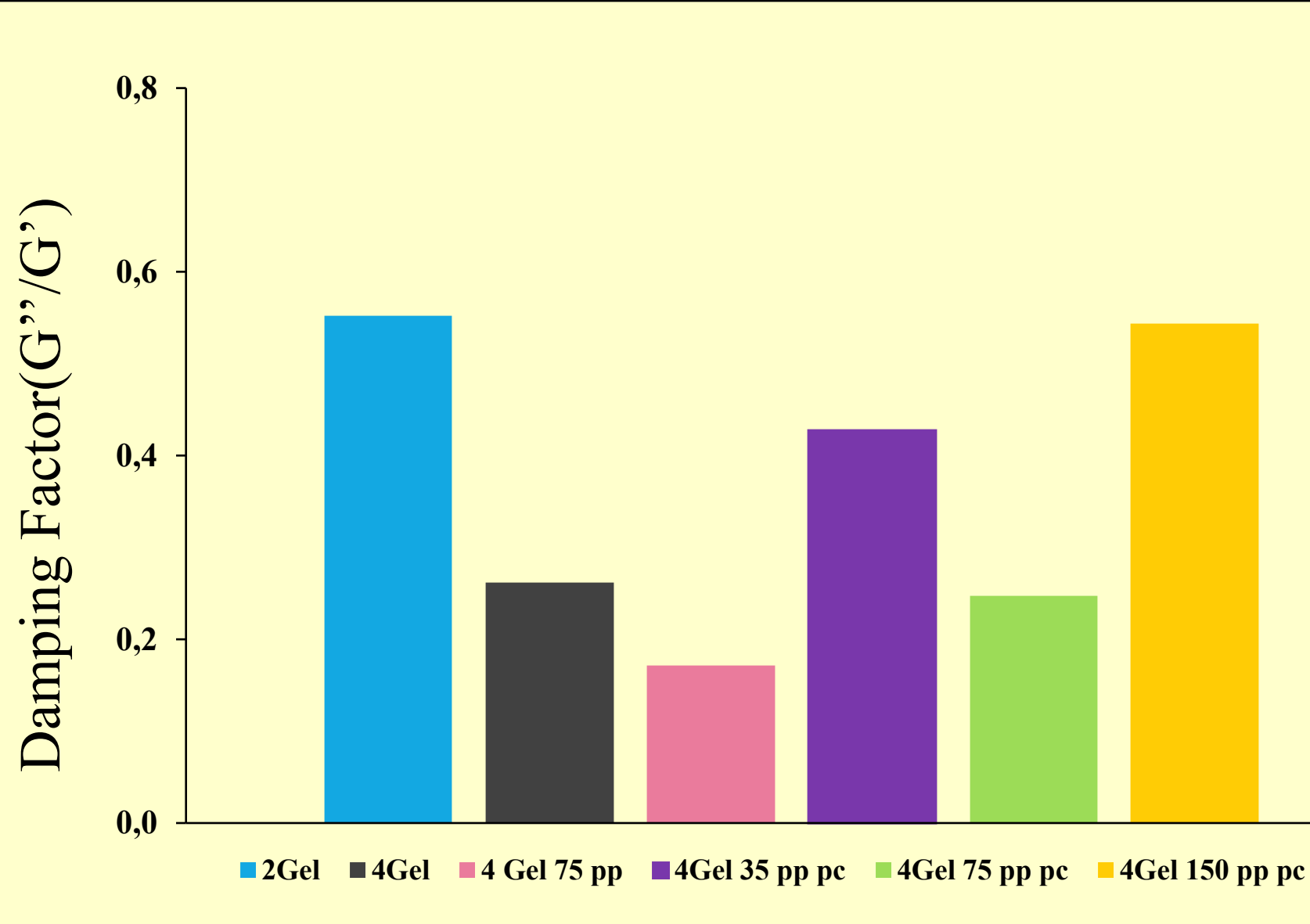


Figure 9: Mean damping factors of the hydrogels

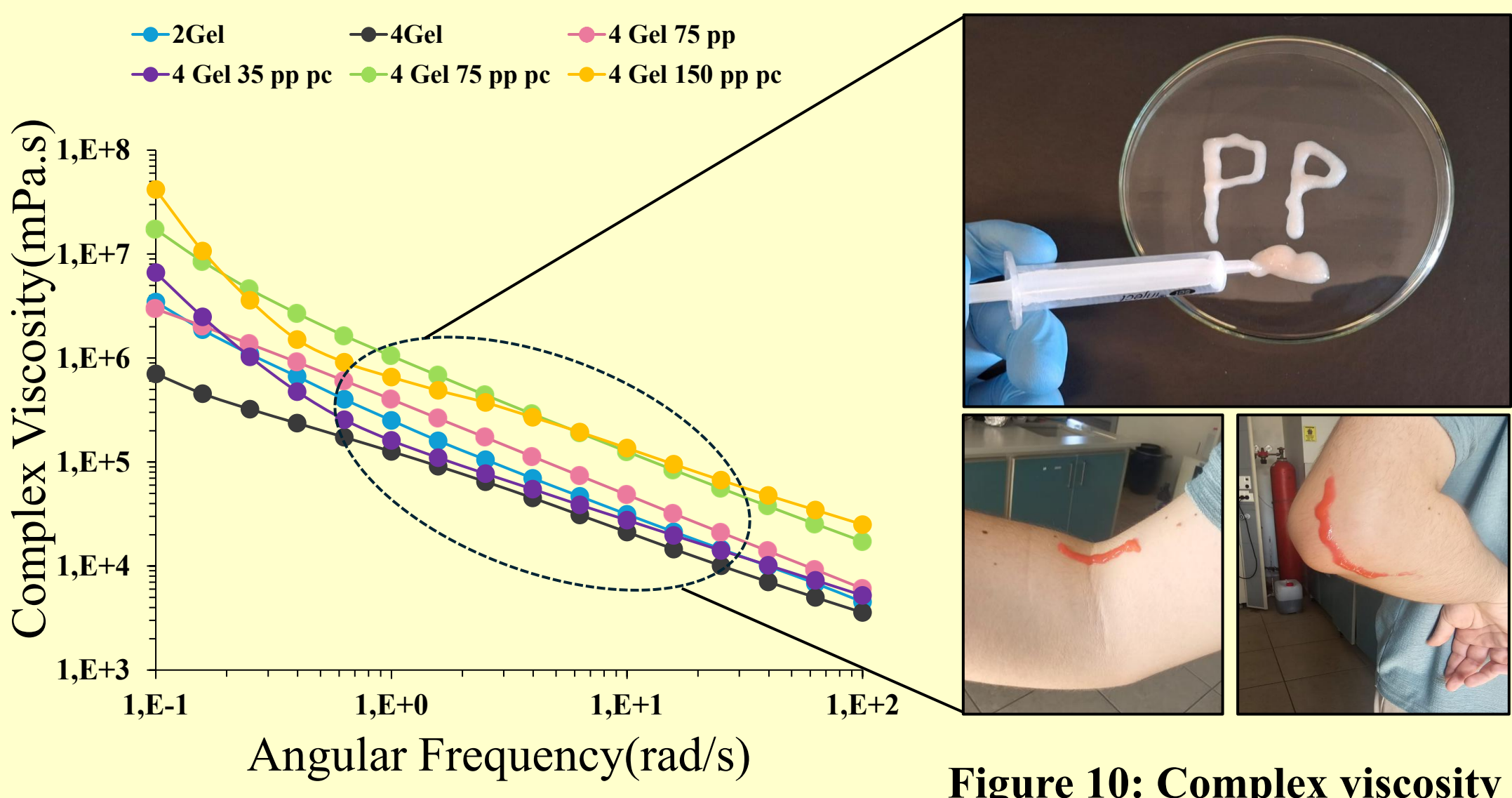


Figure 10: Complex viscosity

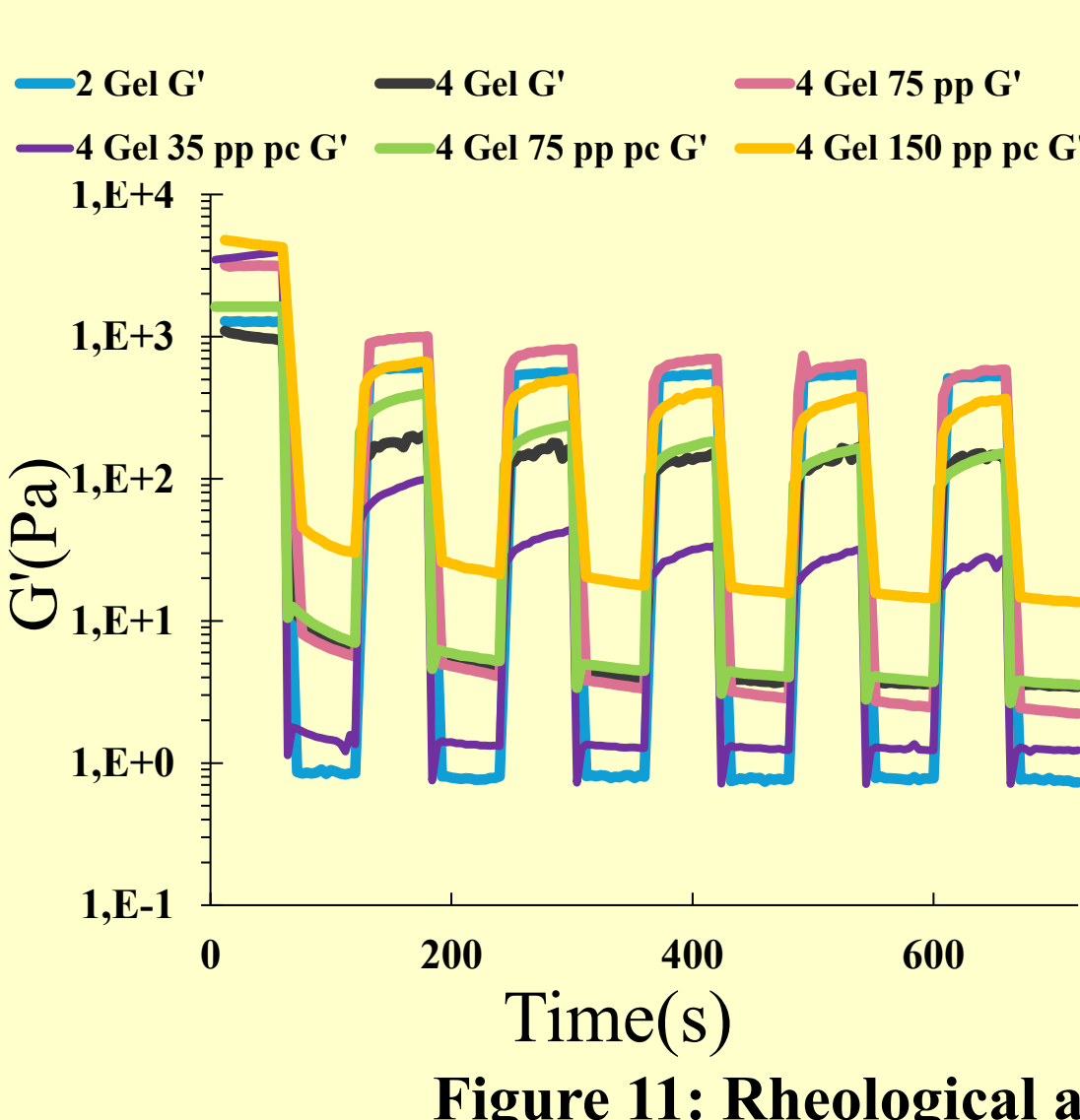


Figure 11: Rheological and macroscopic self healing analysis

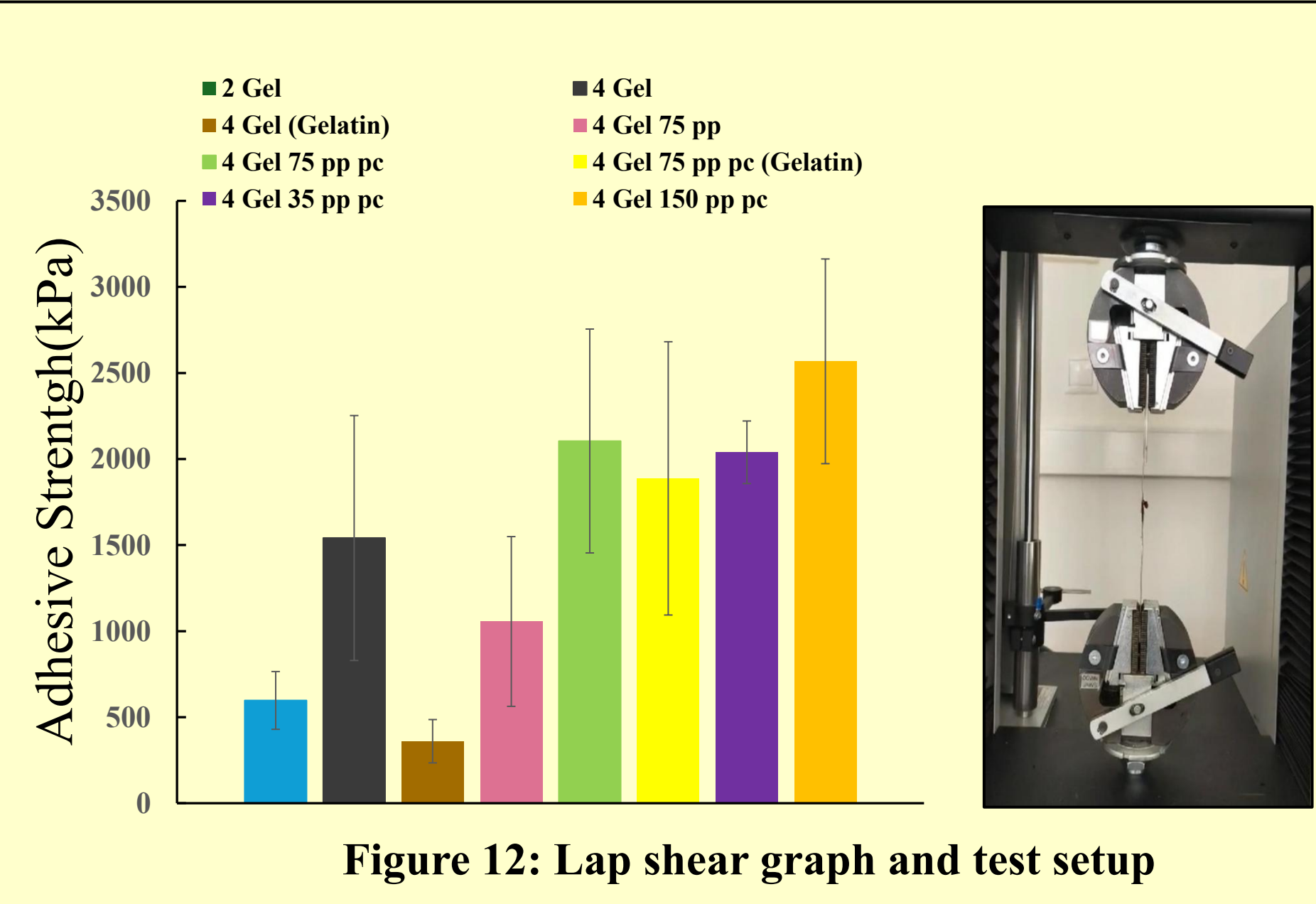
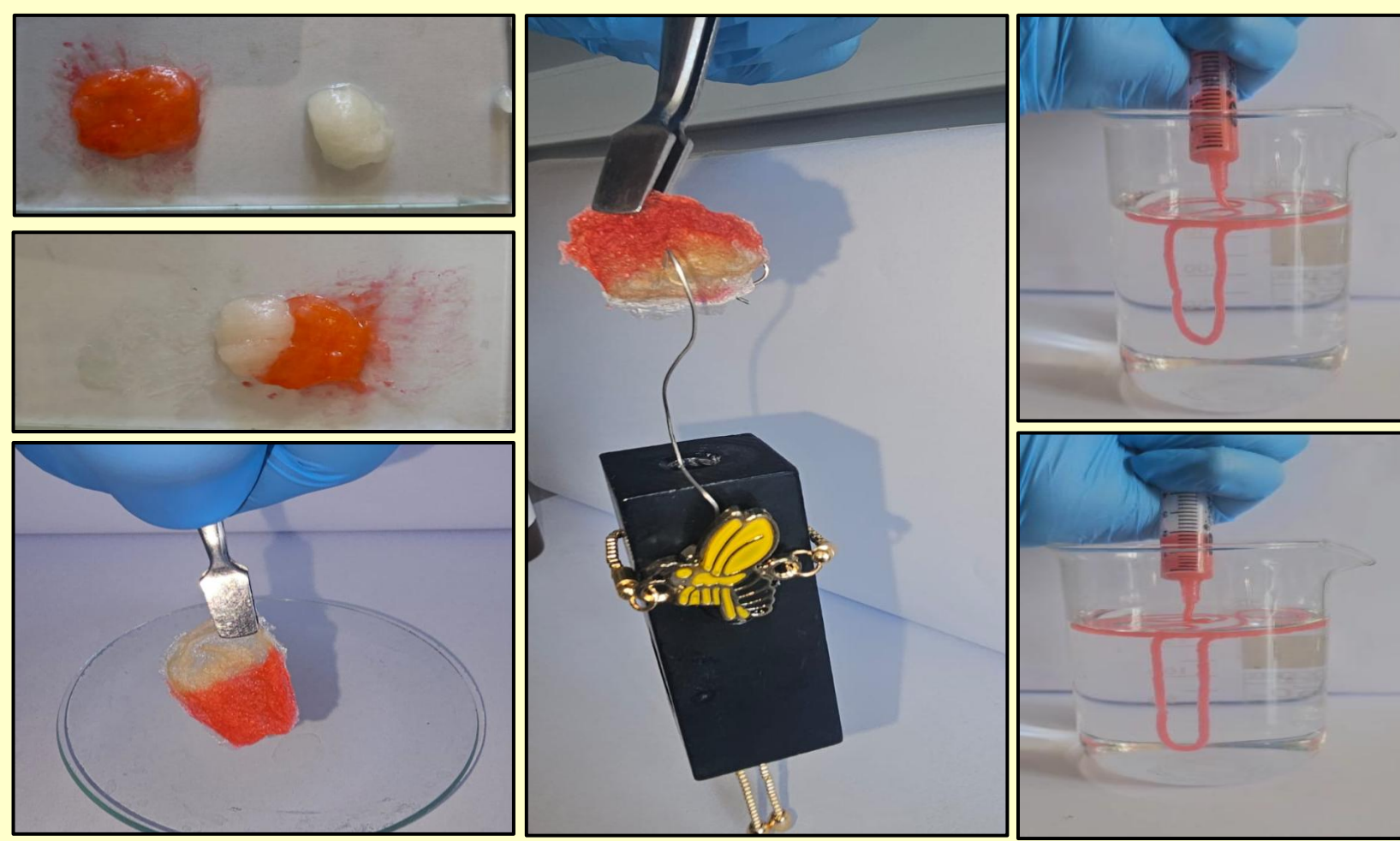


Figure 12: Lap shear graph and test setup

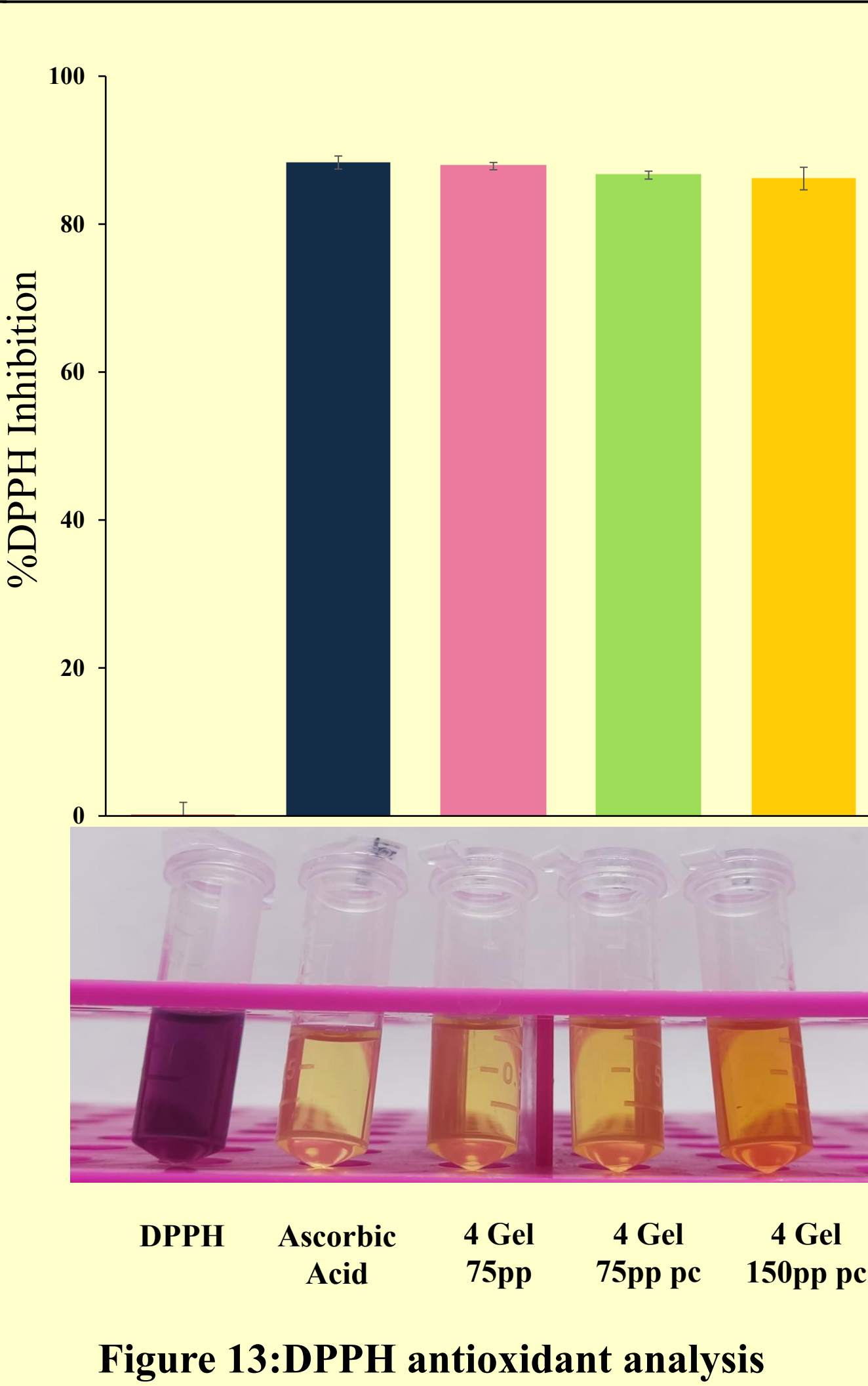


Figure 13:DPPH antioxidant analysis

DISCUSSION & CONCLUSION

- FTIR results confirmed complete crosslinking between gelatin, ADH, and OP.
- Drug release analyses indicated sustained and controlled PC delivery.
- PP and PC improved rheological and adhesive performance through hydrogen bonding and π - π interactions.
- Lap shear data revealed enhanced adhesion to moist tissue surfaces.
- DPPH assays showed strong antioxidant activity in PP-loaded hydrogels.
- These findings support the potential of the hydrogel as an injectable, multifunctional platform for localized skin cancer therapy.

REFERENCES

