Macromolecule uptake and characterisation of hydrogels designed for gingival crevicular fluid sampling for periodontal disease diagnostics.

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Introduction

Periodontal disease affect more than 3.5 million people globally[1]. Sampling of fluids for rapid diagnostics remain challenging. Current sampling techniques is limited in both quality and volume of biomarkers[2].

A range of advanced biocompatible hydrogels have been designed and characterised to demonstrate their potential in uptaking macromolecules, standardising biofluid sampling technique, eliminate variability in biofluid volumes and concentrations of biomarkers.

The aim of this work is to assess the uptake of a macromolecule (FITC-dextran) by Gantrez S97,and Polyvinyl alcohol (Mw 31,000-50,000) based hydrogel devices and evaluate their physicochemical characteristics. This serves as preliminary data for further work in using these hydrogels for gingival crevicular fluid sampling and analysis in PD diagnostics. ***Fig.1.*** gives the general aim of the study.

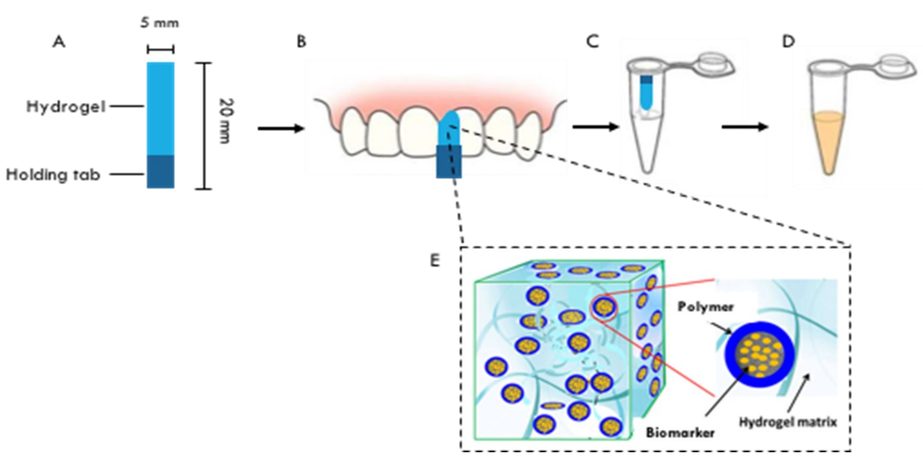

Fig. 1 *Schematic representation of the A) proposed gingival crevicular fluid sampling device B) device in situ in periodontal pocket, C) removed fully intact and placed in elution buffer, D) eluted GCF sample for testing. E) schematic diagram of devices hydrogel matrix swollen having adsorbed GCF from the periodontal pocket.*

Materials and Methods

Hydrogels were formulated from aqueous blends of Gantrez S97, Polyvinyl alcohol (Mw 31,000-50,000), plasticizers and salts. Formulations were cast in silicone moulds, dried at 25, and thermally crosslinked at 80°C.

Dried hydrogel samples (0.09 -0.026 g) were each incubated on a cell strainer (70 µm) in 10 mL of FITC-dextran (150 KDa) solution 0.1 mg/mL at room temperature under light protected conditions for a total incubation period of 10 minutes. Samples were extracted from the absorption medium, and the fluorescence intensity of the retained solution was analysed.

The percentage concentration of FITC-dextran uptake was then calculated. In addition to uptake studies, formulations were further characterised by shear modulus. Characteristics of their swelling capacity in phosphate-buffered saline at 5 s to 24 h were analysed to further characterise hydrogels.

Results

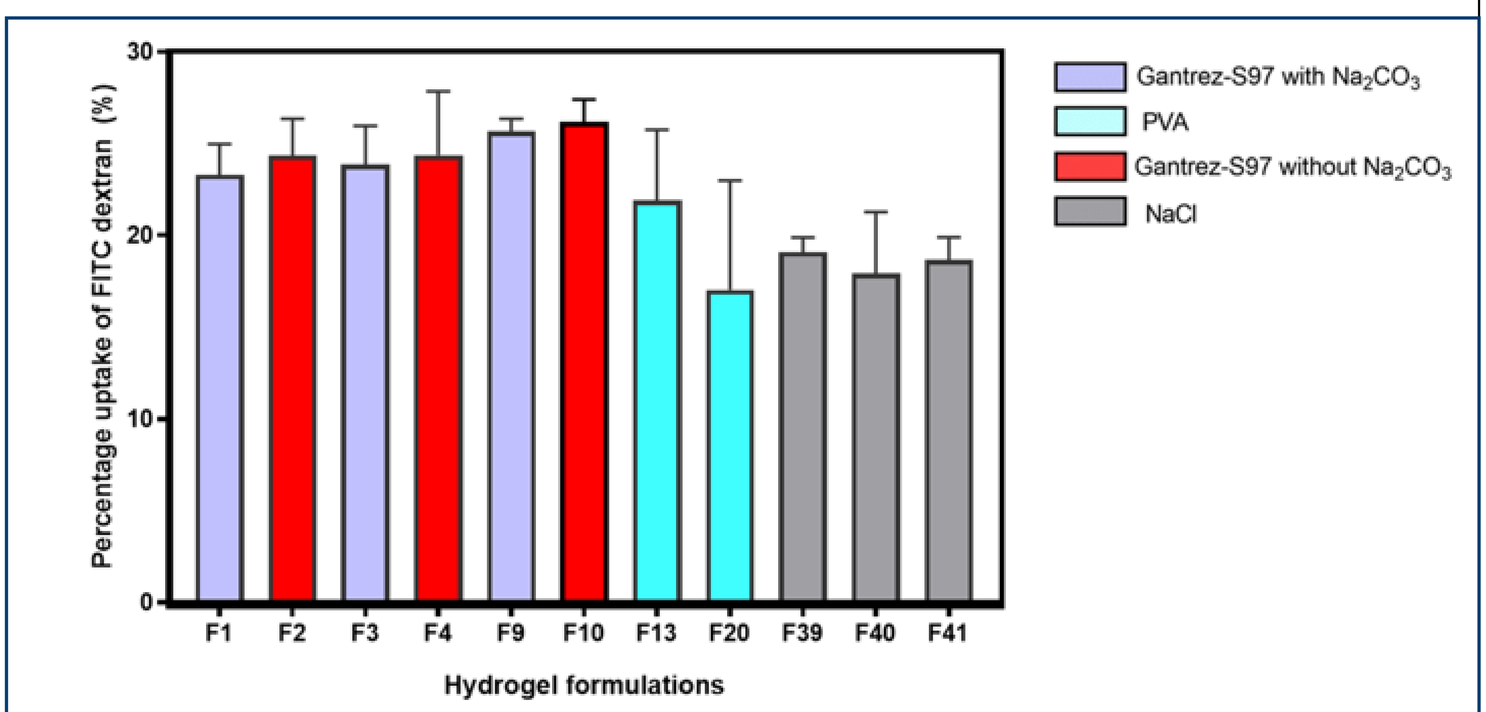

Fig. 2. *A graph of percentage concentration of FITC-dextran uptake by hydrogel formulations at an incubation time of 10 min at 25°C (n = 4 ± SD).*

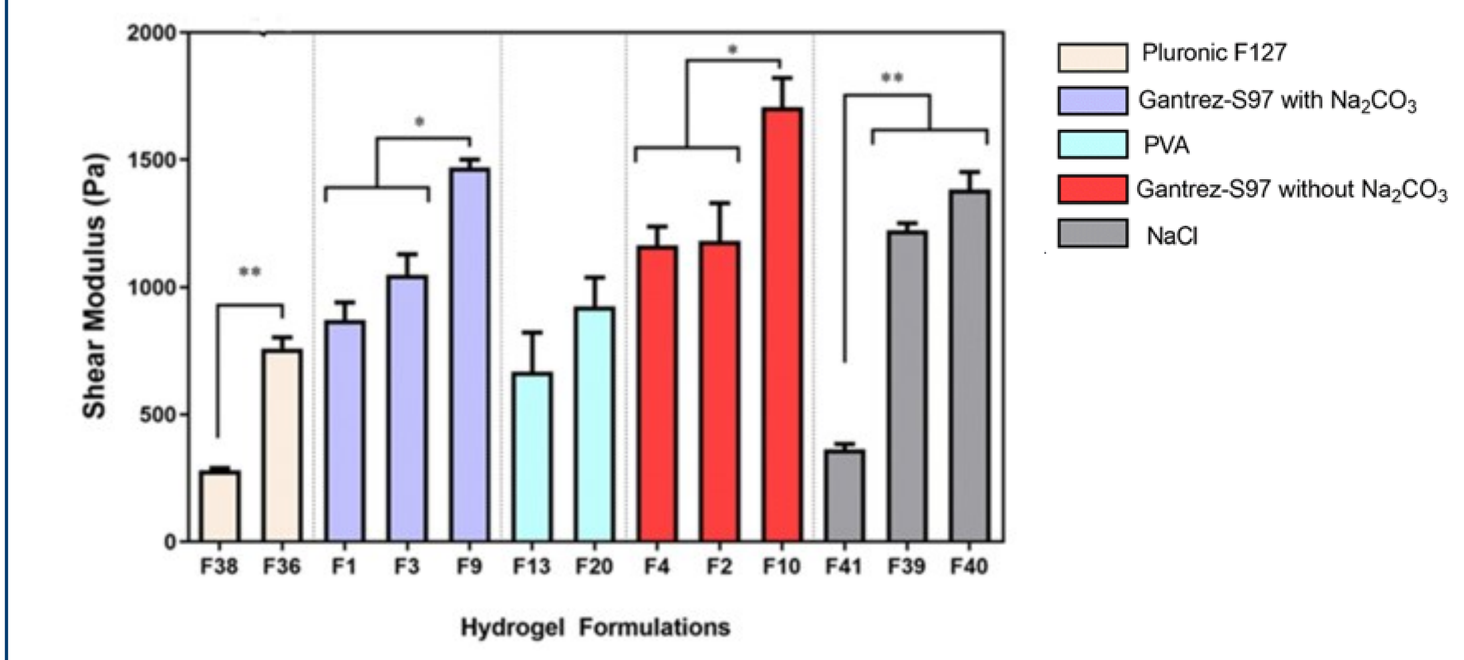

Fig. 3. *A graph of shear modulus (Pa) of hydrogel formulations at 25°C. (n = 5 ± SD). Data are analysed separately as groups with either Welch's t-test (for two in a group) or one-way ANOVA followed by a Tukey post hoc test. Formulations are significantly different from each member of its group if P < 0.05.(*P < 0.05,**P < 0.01)*

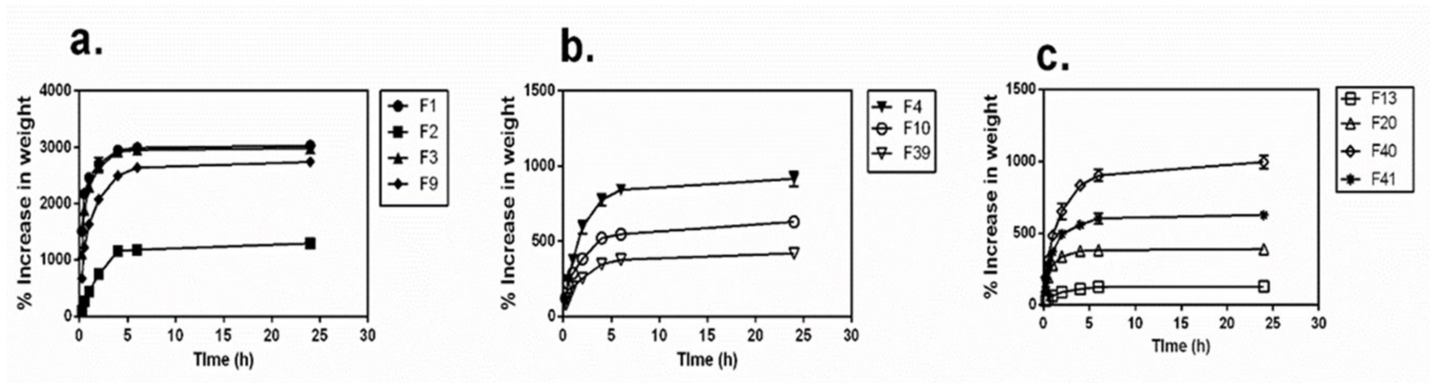

Fig. 4. *Line graph A, B, C indicating percentage increase in weight of dried hydrogel films in PBS (pH=7.4) solution at specific time points (0.25, 0.5, 1, 2, 4, 6 and 24 h) for each formulation. (n=6 ± SD)*

Discussion

FITC-dextran molecules were taken up efficiently (***Fig. 2***) by all formulations with the highest uptake observed in formulation F10.

The shear modulus of the aqueous blend of candidate hydrogels were between 300 to 1700 Pa as illustrated by ***Fig. 3***. F10 had the highest shear modulus, meaning that, among the formulations, it has the highest ability to resist deformation and can return to its original configuration after exposure to small deformations. This is a desirable quality in the handling, storage, and packaging of a prototype device.

The swelling behaviour of the formulations was grouped into three categories based on their percentage increase in weight after 24 hours in PBS pH 7.4 (moderate swelling 100 to 1000 %, intermediate swelling 250 to 1000 %, and super swelling 1000 to 3000 %) as seen in ***Fig 4***.

Conclusion

Hydrogels formulated exhibited desirable macromolecule uptake and characteristics for sampling oral biofluids potential to uptake specific volumes of biofluid.

Target product profile is currently under co-design with dental clinicians to identify key characteristics.

References

1. Dental, S., 2014. Prevention and Treatment of Periodontal Diseases in Primary Care Dental Clinical Guidance. Scottish Dental Clinical Effectiveness Programme.

2. Patel, J., et al., 2021. Oral health for healthy ageing. *The Lancet Healthy Longevity*, *2*(8),e521-e527.

Acknowledgement

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