MONITORING HYDRATION OF DENTURE FIXATIVES:
PREDICTING PERFORMANCE AND SENSORY ATTRIBUTES

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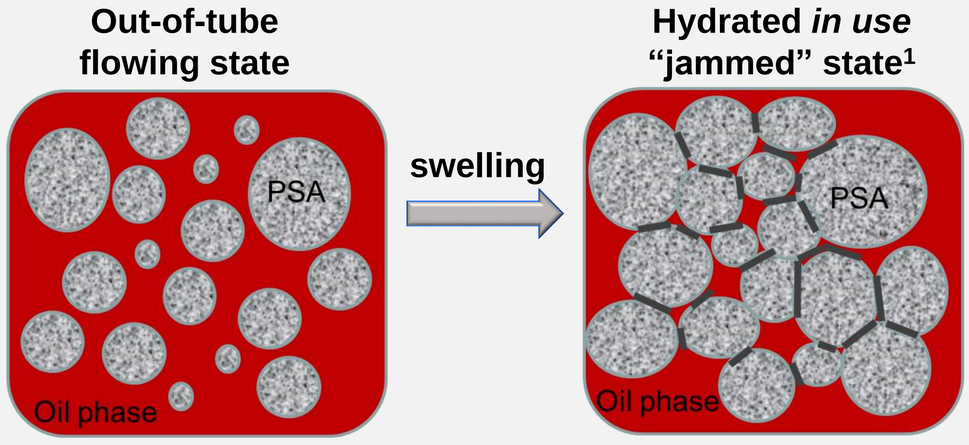
Introduction

Activation of Denture Fixatives (DF) by saliva involves ***hydration*** and ***swelling*** of DF components that leads to the formation of a consolidated adhesive material.

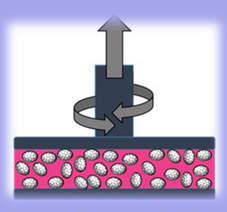


Objectives

1. **Map dynamics and spatial distribution of water upon ingress into the denture fixative.**
2. **Determine the impact of hydration boundary on the adhesive properties of DF measured in vitro.**
3. **Assess the impact of material dissolution on the cohesiveness of the DF film**
4. **Correlate instrumental measure with sensory attributes**

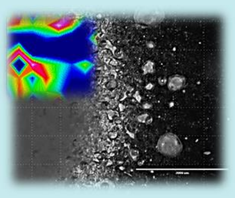
Methodology

Rheometer-based Tack adhesion



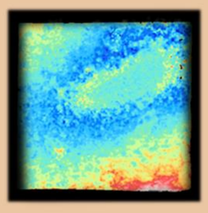
Mechanical (shear, extension, fracture) and adhesion Information as a function of hydration

Optical & FTIR Imaging



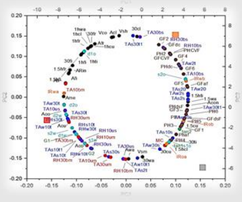
Hydration dynamics, composition and phase behaviour under swelling conditions

NMR Imaging and Relaxometry



Dynamics of chemical components: bound / free water distinction and distribution mapping

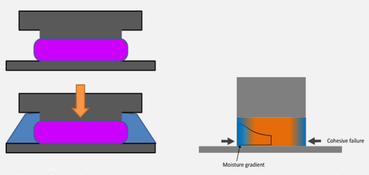
Statistical Modelling



Principle Component Analysis (PCA) and Principal Component Regression (PCR)

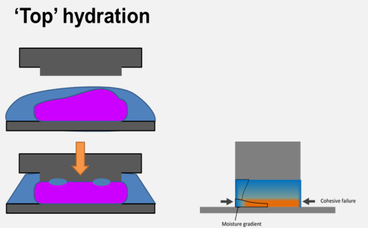
Tack test methodology.
(*Anton Paar MCR302 Rheometer*) Probing adhesion using parallel plate configuration equipped with exchangeable surface fixture.

'Side' hydration



- Well-defined area: controlled hydration dynamics
- Small contact area inhibits hydration.

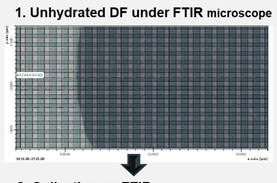
'Top' hydration



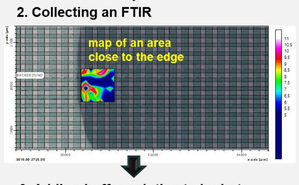
- Large area of contact b/w DF and fluid
- A more 'realistic' (biomimetic) behaviour: it captures the fact that the hard palate is a moist oral mucosal tissue.
- Precise amount of fluid trapped between the DA and the top plate is hart to control.

FTIR Imaging methodology.
Obtaining integrated signals from water ('W') and mineral oil ('O') recorded in the reflectance mode at 1h and 2h hydration.

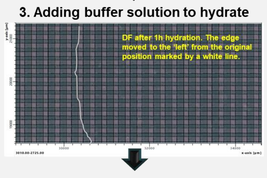
1. Unhydrated DF under FTIR microscope



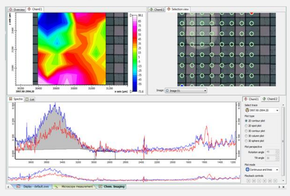
2. Collecting an FTIR



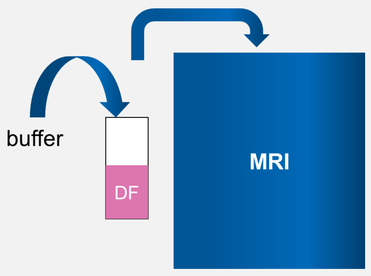
3. Adding buffer solution to hydrate

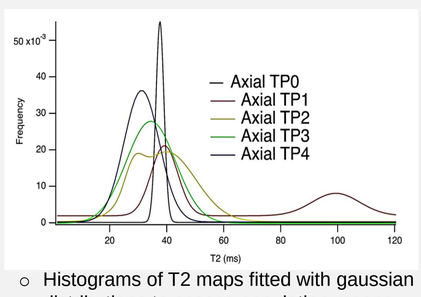


4. Recording FTIR spectra as a function of time



NMR Imaging methodology[2].
(*Bruker 9.4T Ultra-high field microimaging system*) Obtaining total spin as well T2 spin relaxation signals.



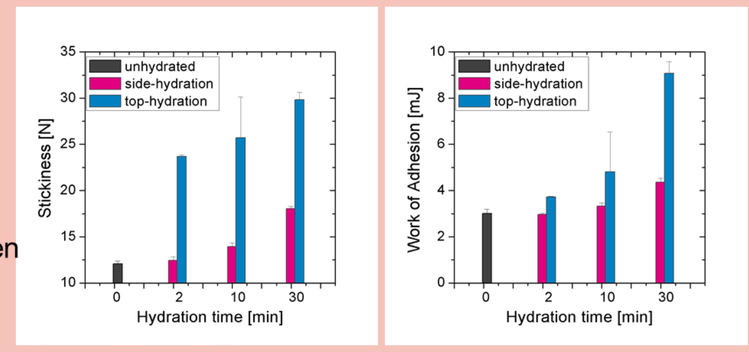


- Histograms of T2 maps fitted with gaussian distributions to assess population means, FWHM and area
- Narrow initial peak at 37.8ms
- Addition of water created 2 peaks
- Gradual shortening of T2 to 31.2ms at TP4
- FWHM remains elevated indicating increased heterogeneity in the sample

Results

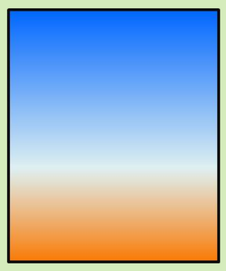
1. Adhesive and cohesive behaviour as a function of hydration time

- Hydration plays the key role in the formation of the adhesive cushion.
- The hydration is proportional to the contact area between the adhesive and buffer/saliva.

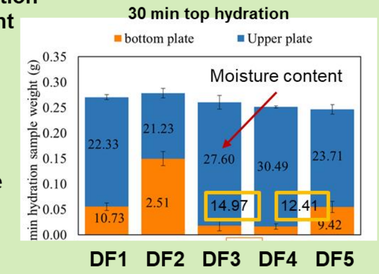


2. Hydration front and formation of water/oil boundary

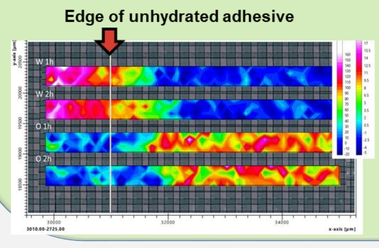
- The hydration front creates an interfacial zone between the hydrated and unhydrated layers within the adhesive.
- This interfacial zone is associated with the cohesive failure during the pull-off tests.

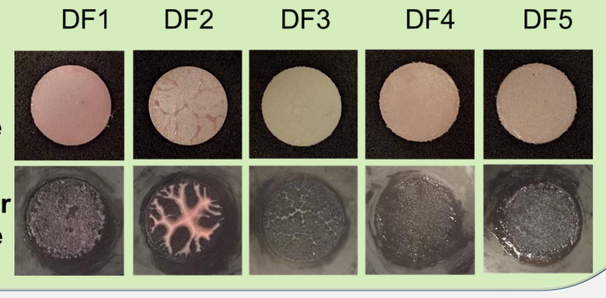


- Mass distribution between the top and bottom plates after failure

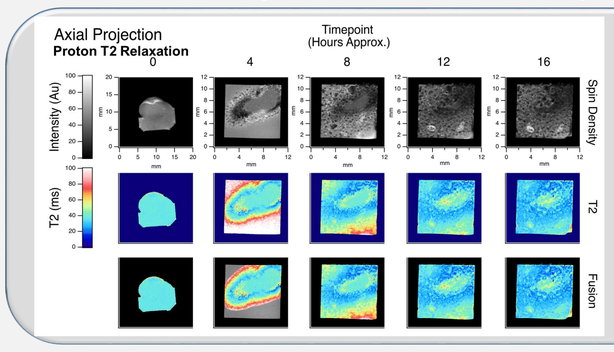


- FTIR cross-section of the hydration front: water signal (top bars), oil signal (bottom bars)





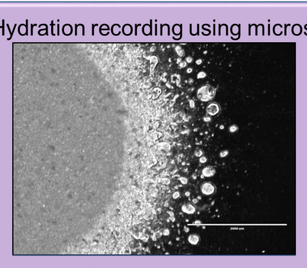
3. Effect of hydration on water dynamics



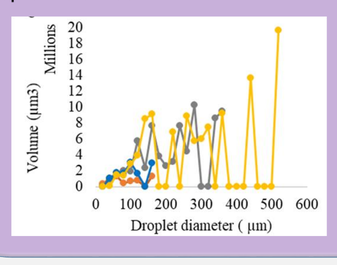
- Baseline of unhydrated adhesive is around 35ms
- Addition of water creates a halo (red to yellow) around the edge of adhesive
- T2 in cured adhesive is lower than baseline without water added
- As time progresses, T2 shortens as water is absorbed & the adhesive hardens

4. Effect of hydration on the outer edge of DF

1) Hydration recording using microscopy



2) Analysis of droplet numbers and droplet volumes



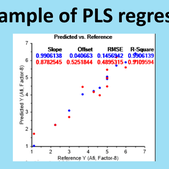
5. Principle component analysis of instrumental measures

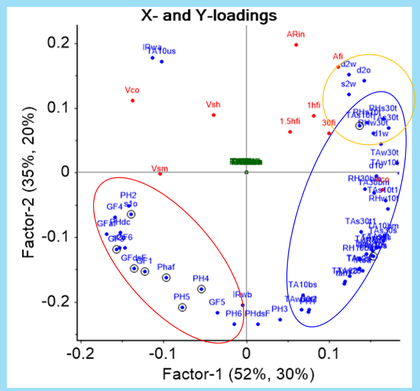
CLUSTER 1
- All stickiness measurements
- Rheology
- Samples weights
- Moistrure content

CLUSTER 2
- FTIR imaging

CLUSTER 3
- Image analysis

Example of PLS regression





PLS can be used to understand the correlations between different attributes and a quick quality evaluation.

Future perspectives

- Characterise the water/continuous phase (oil, polymer matrix) boundary and determine its effect on cohesive failure of DF.
- Determine the effect of inter-polymer adhesion on the cohesiveness of the DF upon hydration.
- Develop biomimetic substrates to simulate oral surfaces.
- Develop a toolbox for the analysis of sensory attributes to enable rational product design.

References

1. **H.M. Shewan, G.E. Yakubov, M.R. Bonilla, J.R. Stokes. (2021)**
Viscoelasticity of non-colloidal hydrogel particle suspensions at the liquid–solid transition. ***Soft Matter*, 17 (19), 5073-5083**
2. **S.J. Keppie, C.J. Philip, A. Wall, G.E. Pavlovskaya, T.L. Vincent. (2020)**
Growth factor release upon cartilage injury is due to aggrecan-dependent sodium flux that is lost in osteoarthritis. ***Osteoarthritis and Cartilage, 28, S180*.**

Financial Interest Disclosure

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