

# Correlation between rheological behavior and adhesion properties of denture adhesives

Nima Roohpour and Shirin Ghaderi  
GSK Consumer Healthcare, Weybridge, UK

**Statement of Purpose:** Denture adhesives improve quality of life for denture wearers by increasing denture retention and stability, preventing trapping of food particles and improving taste discrimination and perception even in well fitting dentures<sup>1,2</sup>. In general, denture adhesives are formulated with hydrophilic polymers as active ingredients, that swell and transform to a viscous sticky product in the presence of water or saliva creating a hydrogel based adhesive. The increased volume fills the voids between the denture base material and the oral mucosa creating retentive adhesive forces. The performance of the adhesive as well as its sensory properties is highly dependent on its composition<sup>1</sup>. There has been some evidence suggesting that the viscoelastic properties of the hydrogel based bio-adhesives affect their adhesion properties<sup>3</sup>. This *in-vitro* study was carried out to understand the correlation between viscoelastic behaviour and adhesion properties of denture adhesive formulations with alternative cations such as,  $\text{Na}^+$ ,  $\text{Ca}^{2+}$  and  $\text{Mg}^{2+}$ . It was the objective of this current study to identify if adhesion assessed in the tensile and shear test is dependent on the viscoelastic properties of the adhesive. In this experimental study, a wide range of rheological behaviours from viscoelastic solutions to stiff hydrogels involving various cationic sources was investigated.

**Methods:** Typical formulations of powder denture adhesive with variable ionic contents were developed using Sodium carboxymethyl cellulose (CMC, (CMC7H3SXF, Ashland, USA) and Poly(ethylene oxide) ((WSR301, Dow Chemical, USA). Rheological experiments (Oscillation frequency sweeps at 37°C) were performed on an AR2000EX Rheometer (TA Instruments, UK) fitted with a 20 mm steel parallel plate. The shear strength measurements were performed using Instron 5943 (Instron, UK) with PMMA slides. The same set up was used to measure adhesive strength according to ISO 10873<sup>4</sup>.

**Results:** In this model, there is a correlation between the rheological behavior and physical property of the denture adhesive. Figures a, b and c indicate that an increase in elastic behaviour resulted in reduced shear and adhesion strength. Presence of cation sources (e.g.  $\text{Ca}^{2+}$ ,  $\text{Na}^+$  and Chlorhexidine ) in the formulation has shown a significant effect on both the loss and storage modulus of the hydrogel, as well as the shear strength by increasing the elasticity behaviour. However, there were no significant differences between the groups. Chlorhexidine in a 1% (v/v) (from 8% (v/v)Chlorhexidine digluconate solution) exhibited the best adhesive properties and highest shear strength.

Figure a:

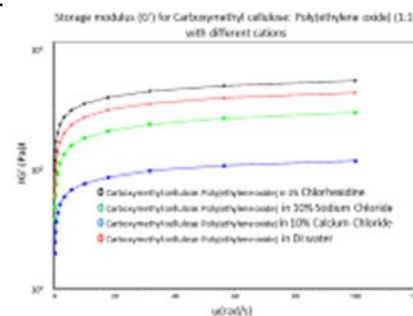


Figure b:

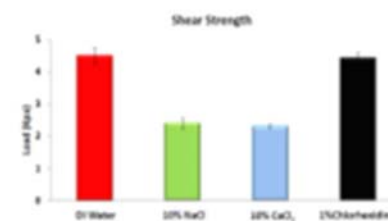
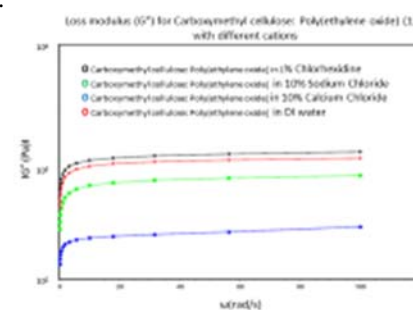


Figure c:

Figures a, b and c reveal storage modulus with viscoelastic behavior, the loss modulus which shows stiffer structure with elastic behavior and finally, variations in shear strength for different cations formulation.

**Conclusions:** This study suggests that the presence of cationic sources in the hydrogel formulation improves the adhesive properties and changes their rheological behaviour. Although adhesion strength in the tensile testing is independent of cation types and concentration, the shear strength is affected. In addition, rheological measurements can be an efficient way to determine optimal properties for adhesion and sensory characteristics of denture adhesives despite having variable physiochemical parameters.

## References:

1. Panagiotouni E.J Prosthet Dent 1995;73:578-585.
2. Han J. Dent Mater J 2014;33(1):98-103.
3. Serrero A. Biomacromolecules 2011;12:1556-1566.
4. ISO 10873:2010