**Counterion competition in xanthan gum solutions**

Glen Redpath1, Tim W Overton1, Eddie Pelan1, Lisa Manus2, Paul Thomson2, Andrei Potanin2

1. *School of Chemical Engineering, University of Birmingham, Edgbaston, B15 2TT*
2. *Colgate-Palmolive Company, 909 River Road, Piscataway, NJ, 08854, USA*

Corresponding authors email: [GXR324@student.bham.ac.uk](mailto:GXR324@student.bham.ac.uk)

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

It has previously been reported that for polyelectrolyte solutions above their critical polyelectrolyte concentration (cD) the addition of counterions leads to an increase the solutions resistance to deformation and flow1,2. However, these effects have only been shown in simplified, single ‘salt’ systems in idealised processing environments, the effects on resistance to deformation and flow in the presence of multiple counterions are not readily available in the current literature surrounding these topics.

Two commercially supplied xanthan gums having different acetate/pyruvate ratios were studied. They were used as is to provide as relevant a system for industrial applications as possible. A relevant concentration was selected for study and prepared in a simple mixing vessel, this batch solution was used as a control and subsequent cationic salt-loaded solutions (1 M total) were prepared using this concentration. Storage time effects were also studied and measurements were taken immediately after preparation, and subsequently at 3, 7 and 14 days to mimic a FMCG storage schedule, at temperatures of 4 and 60oC.

The counterion valency, counterion concentration order of addition, storage time and storage temperature were all shown to affect viscoelastic moduli of both xanthan solutions.

Interestingly, the monovalent-only counterion systems exhibited greater viscoelastic moduli when compared to the divalent-only counterion system at 1 M concentration, which is somewhat contradictory to studies of similar systems. Solutions with tetravalent ions formed far stronger gels, which is consistent with earlier findings3. And finally, for the binary counterion containing systems the viscoelastic behaviour was influenced by whichever counterion was introduced first to the xanthan solution in the within 0-3 days of preparation, suggesting the nature of the competition in these formulations is ‘first come, first served’. However, given enough time and a high temperature storage environment, the behaviour of the solution would revert to that of the higher valency cation.

Findings from this study have interesting implications for the rheology of consumer products that contain multiple ions in their formulations.

1. Wyatt NB, Gunther CM, Liberatore MW. Increasing viscosity in entangled polyelectrolyte solutions by the addition of salt. *Polymer*. 2011;52(11):2437-2444. doi:10.1016/j.polymer.2011.03.053

2. Wyatt NB, Liberatore MW. The effect of counterion size and valency on the increase in viscosity in polyelectrolyte solutions. *Soft Matter*. 2010;6(14):3346-3352. doi:10.1039/c000423e

3. Jeanes A, Pittsley JE, Senti FR. Polysaccharide B‐1459: A new hydrocolloid polyelectrolyte produced from glucose by bacterial fermentation. *J Appl Polym Sci*. 1961;5(17):519-526. doi:10.1002/app.1961.070051704