

An investigation of synthetic resins for water softening

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Introduction

Synthetic resins are well established for the softening of water and used in a wide range of industrial processes. Typically, a weak acid cation resin is employed due to its inherently high capacity and relatively easy regenerability. In recent years, shallow shell technology (SST) resins have been introduced to the marketplace by Purolite. These resins are characterized by a densely functionalized outer core with an inert inner core [Figure 1]. According to Purolite these resins are easier to regenerate, more resistant to poisoning and still of high cation capacity. Consequently, in relation to the expanding use of softening stages to protect reverse osmosis membranes from fouling, it was of interest to examine the behaviour of the SST resins in comparison with conventional weak acid cation (WAC) resins such as DOW MAC-3 resin.

Aim

This research was undertaken in order to better understand the following:

- What properties effect the ability of a synthetic resin to uptake ions from solution.
 - Amount of resin
 - Concentration of solution
- How does a 'shallow-shell' resin compare to a standard Weak Acid Cation (WAC) resin in achieving equilibrium loading of calcium ions?
- What can we conclude from interpretation of ion exchange equilibria?

Method

The main focus of this study was the equilibrium ion exchange behaviour of various WAC resins involved in the exchange of calcium ions from solution with sodium ions on the resin sites. A bottle-point method was used to construct isotherms, wherein variable resin mass and variable normality solutions comprising of sodium and calcium chlorides were used. The fundamental experiments involved weighing appropriate masses of resin into Nalgene bottles and introducing the solution of interest. The samples were then agitated at a fixed temperature for a period sufficient to ensure equilibrium had occurred. All solutions were then analysed by either ICP-MS or AAS techniques, and equilibrium concentrations of ions in solution (C_e) calculated and loadings of ions on the resin surface inferred (q_e).

Acknowledgements

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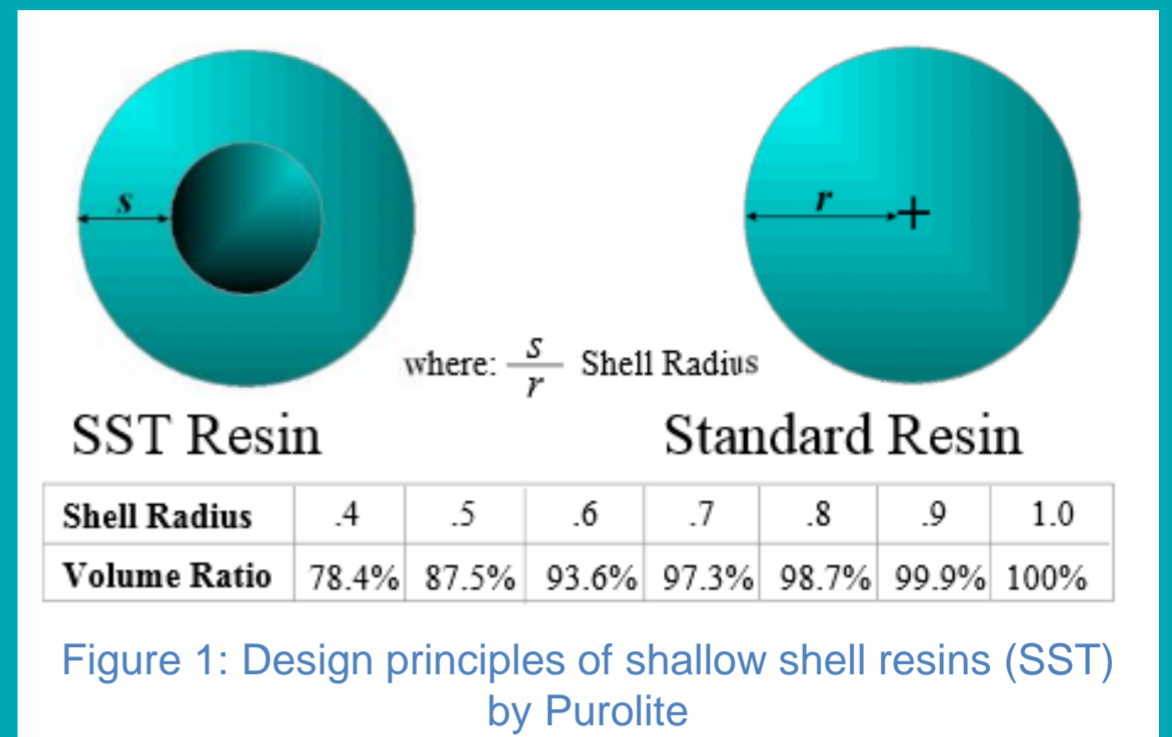


Figure 1: Design principles of shallow shell resins (SST) by Purolite

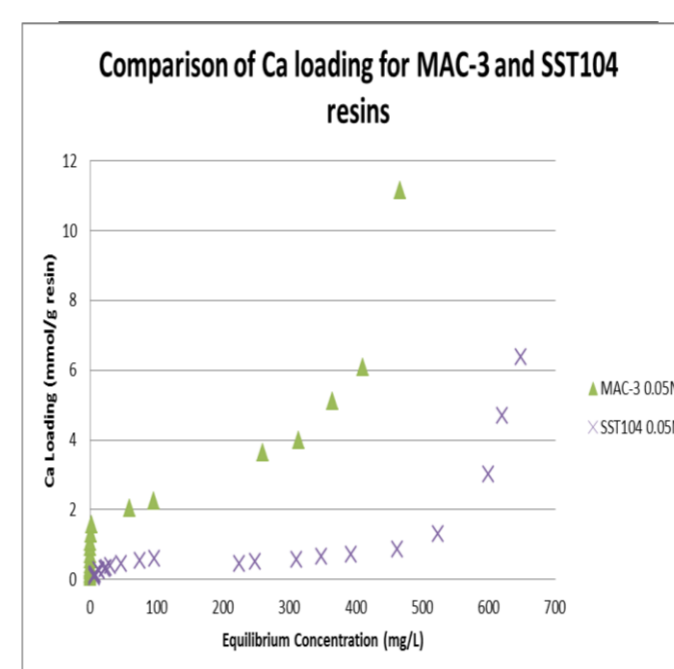
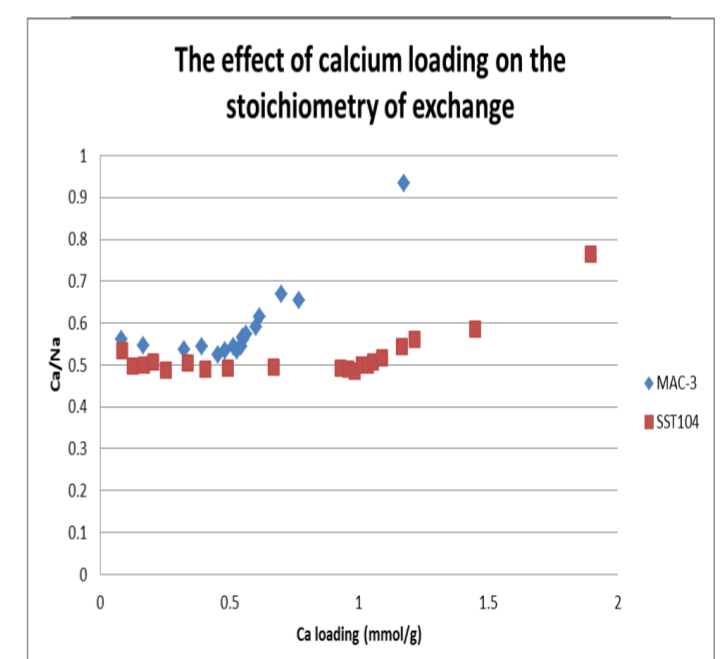


Figure 2: Equilibrium loading conditions for MAC-3 and SST104. MAC-3 is seen to have a higher capacity and greater adsorption characteristics.

Figure 3: Stoichiometry data for MAC-3 and SST104. Data shows a resistance by SST104 to begin adsorption when compared to MAC-3



Results

The data in the images above illustrates the 'beyond-stated capacity' abilities of synthetic resins, presumably by salt adsorption when the resin is placed in conditions of high driving force. This latter observation has not been clearly documented before, albeit the definitive ion exchange text by Helfferich emphasises that ion exchange is invariably accompanied by adsorption. Figure 2 indicates that MAC-3 loads more calcium through ion exchange and especially adsorption processes. Figure 3 shows that the exchange stoichiometry is similarly more complicated than previously described.

Conclusion

In terms of equilibrium loading conditions, MAC-3 resin has a greater ion exchange capacity and a superior adsorption capacity. SST104 resin although of lower capacity, may display different behaviour during column conditions where ease of regenerability becomes more important. The exchange process is complex and requires more in depth study to elucidate.