

## COMPARATIVE EFFECTS OF MODEL ORGANIC COMPOUNDS ON GIBBSITE CRYSTALLIZATION

H.R. Watling, P.G. Smith and J. Loh

A.J. Parker Cooperative Research Centre for Hydrometallurgy,  
CSIRO Division of Minerals, P.O. Box 90, Bentley, Western Australia 6102

and

P. Crew and M. Shaw

c/- School of Applied Chemistry, Curtin University of Technology,  
P.O. Box U1987, Perth WA 6000

### ABSTRACT

Variations in the stereochemistry and functional groups of model organic compounds create some interesting differences in their abilities to affect gibbsite precipitation. Results indicate that in addition to the links between precipitation and adsorption, or precipitation and soda incorporation, there is a further link between poisoning strength and the ability to form complex anions with aluminium in alkaline solution. Other effects noted are increased induction periods, changed particle size distributions and morphologies. These comparative data are valuable tools in understanding mechanisms of crystallization poisoning.

#### 1.0 INTRODUCTION

As part of our on-going research on the mechanism(s) of gibbsite precipitation in the Bayer process, the effects of model organic compounds, chosen specifically for their functional groups and conformations, on gibbsite precipitation from seeded and unseeded synthetic Bayer liquors are being investigated. Previously reported links between poisoning and adsorption or soda incorporation (Coyne *et al.*, 1994; Armstrong, 1993) are corroborated. Data from spectroscopic studies provide evidence of a further link between the ability of a compound to complex aluminium in solution and the ability to inhibit crystallization.

#### 2.0 EXPERIMENTAL

Detailed descriptions of the preparation of synthetic liquors (C200, A/C 0.7) and other solutions, and of the crystallization experiments and solution complexation studies are given in Smith *et al.* (1996). Unseeded precipitation experiments were carried out under similar conditions. Induction periods for unseeded supersaturated solutions were estimated using a DAWN multi-angle laser light scattering instrument.

#### 3.0 RESULTS

The effects of more than 30 compounds have been investigated in one or more of these comparative tests. Results for a representative few are shown in Table 1. It is found, in general terms, that the poisoning strength of hydroxy-compounds increase as the number of hydroxyl groups increases, with some exceptions. For example, the poisoning abilities of the C5-polyols (ribitol, arabinitol and xylitol)

differ significantly, and the tartaric acids are unexpectedly strong poisons. In addition, meso-tartaric acid has almost twice the poisoning ability of its two isomers.

Table 1:  
Comparative effects of selected model organic compounds

Compound	Yield* rel. control (1.0)	Complex anion formed	Changed size distribution	Changed morphology	increased induction time	increased soda incorp.
2,3-butanediol	1.0	no	no	-	-	-
meso-erythritol	0.92	no	-	-	yes	-
l-tartaric	0.45	yes	yes	yes	yes	yes
meso-tartaric	0.12	yes	yes	-	yes	-
ribitol	0.85	no	-	-	yes	-
arabinitol	0.58	possibly	yes	yes	yes	yes
xylitol	0.11	yes	yes	yes	yes	-
mannitol	0.34	possibly	yes	yes	yes	-
gluconate	0.05	yes	yes	yes	yes	-

Raman and  $^{13}\text{C}$  NMR spectroscopic data indicate that hydroxyl and carboxylate groups may participate in the aluminate ion-ligand interaction for strong poisons. Analysis of the combined data for the C5-polyols indicates that the preferred interaction between these compounds and the aluminate ion in solution (or, by inference, the gibbsite surface) is via tridentate binding which is facilitated by a particular conformation of three hydroxyl groups, the so called M,P arrangement (Smith *et al.*, 1996). Polyhydroxy-carboxylates may bind in the same way, there is also strong evidence that the carboxylate group can also participate in complex anion formation. NMR spectra for the tartaric acids indicate that complexation is through both hydroxyl groups and one of the carboxylates.

The effects of organic poisons on seeded and/or unseeded precipitation were also investigated, specifically their effects on induction period and on particle size distributions and morphologies. In many cases, the presence of an organic poison greatly increased the time taken to form gibbsite particles in unseeded solutions, sometimes to several weeks; clearly the presence of these compounds affects the crystal growth mechanism. In addition, many of the compounds tested, including some which did not reduce precipitation yield, caused significant changes in particle size distributions and particle morphologies. Without exception, smaller particles were obtained when compared with the control for unseeded precipitation and different compounds were found to inhibit growth of different crystal faces.

#### 4.0 ACKNOWLEDGEMENTS

The financial support of the Australian Government, under its Cooperative Research Centres Program, for this research is gratefully acknowledged.

#### 5.0 REFERENCES

Armstrong, L. (1993) *Bound Soda Incorporation during Hydrate Precipitation*. Proc. Third International Alumina Quality Workshop (Hunter Valley, NSW), 282-292.

Coyne, J.F., Wainwright, M.S., Cant, N.W. and Grocott, S.C. (1994) Adsorption of Hydroxy Organic Compounds on Alumina Trihydrate. *Light Metals 1994*, 39-45.

Smith, P.G., Watling, H.R. and Crew, P. (1996) The Effects of Model Organic Compounds on Gibbsite Crystallization: Polyols. (*Colloids and Surfaces*, in press).