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The effect of additives on gibbsite auto-precipitation and bauxite residue flocculation when processing goethitic bauxites

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Introduction

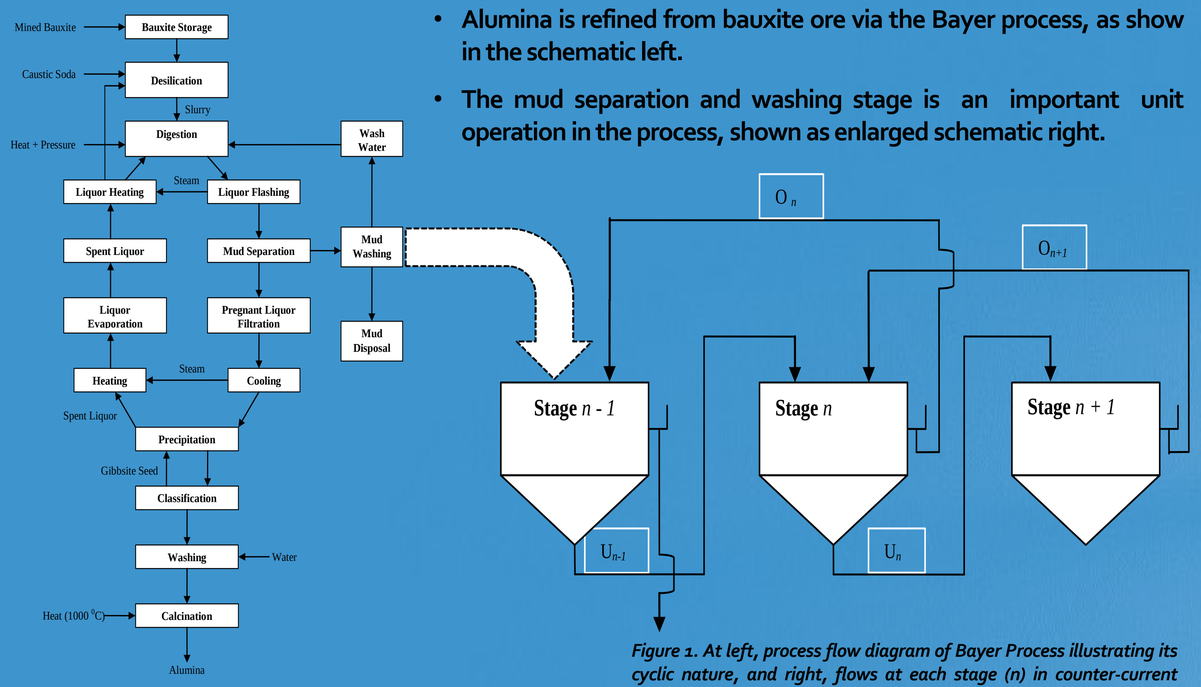


Figure 1. At left, process flow diagram of Bayer Process illustrating its cyclic nature, and right, flows at each stage (n) in counter-current decantation (O = overflow; U = underflow).

- Alumina is refined from bauxite ore via the Bayer process, as show in the schematic left.
- The mud separation and washing stage is an important unit operation in the process, shown as enlarged schematic right.

Motivation

- Alumina producers often experience premature alumina crystallisation (gibbsite auto-precipitation) in the mud separation and washing stage: $Al(OH)_4^- \leftrightarrows Al(OH)_3 + OH^-$
- Recent changes to bauxite ore quality at a Jamaican Bayer refinery saw major losses of alumina and caustic from the process, attributable to certain mineral phases in the bauxite.

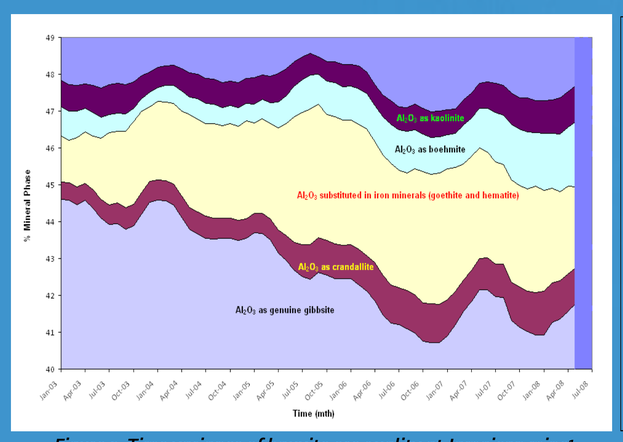


Figure 2. Time variance of bauxite ore quality at Jamaican mine[1].

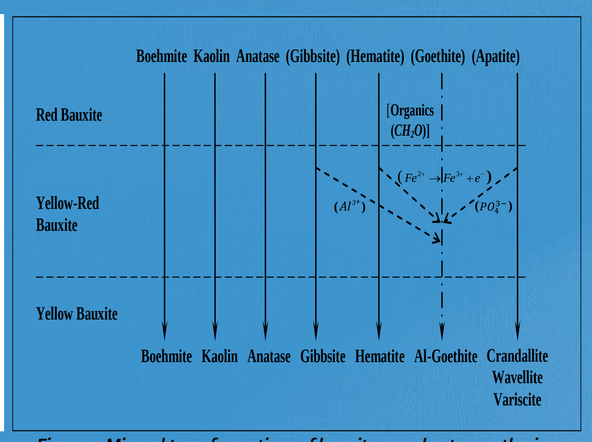


Figure 3. Mineral transformations of bauxite ores due to weathering

Experimental

Table 1. Bayer process terminologies and concentrations, and their molar equivalents.

Bayer Process Terminology	Bayer Process Concentration (gL^{-1})	Molar Equivalent Terminology	Molar Equivalent Concentration ($mol\ L^{-1}$)
A as Al_2O_3	156	$NaAl(OH)_4$	3.06
C as Na_2CO_3	240	NaOH	1.47
		$NaAl(OH)_4$	3.06
TTS as Na_2CO_3	300	Na_2CO_3	5.66
Carbonate as Na_2CO_3	60	Na_2CO_3	0.57

- Bauxite ores were digested at 150 °C for 30 minutes (A/C ≈ 0.65) to give bauxite residue seeds used in the study.
- The effect of additives on gibbsite auto-precipitation was monitored at 75 °C.
- Gibbsite crystallisation and bauxite residue flocculation were monitored by FBRM.

Figure 4. Baskerville pilot autoclave used to digest bauxite ores.

Figure 5. Baskerville Eurotherm process control unit.

Figure 6. Parr 4560 benchtop autoclave used for digestion.

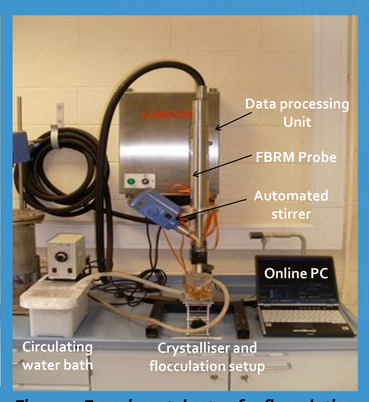


Figure 7. Experimental setup for flocculation and gibbsite crystallisation studies.

Results & Discussion

Gibbsite auto-precipitation experiments

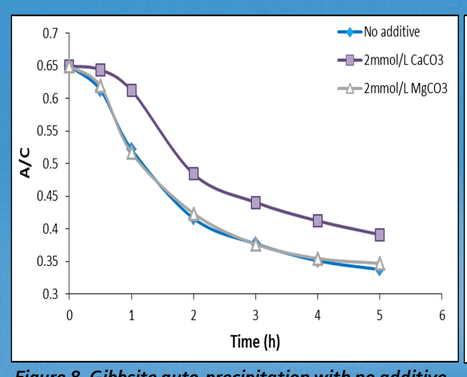


Figure 8. Gibbsite auto-precipitation with no additive and 100 ppm HX800.

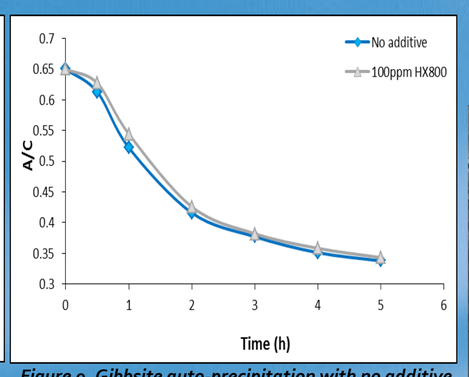


Figure 9. Gibbsite auto-precipitation with no additive, 2 mmol L^{-1} $CaCO_3$ and $MgCO_3$.

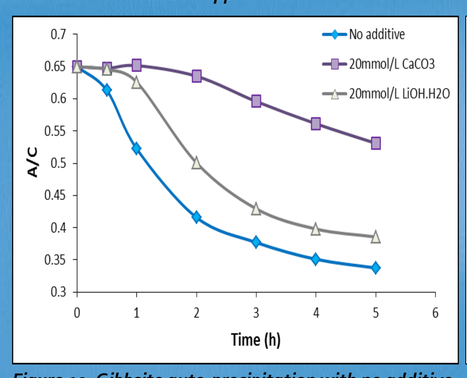


Figure 10. Gibbsite auto-precipitation with no additive, 20 mmol L^{-1} $CaCO_3$ and $LiOH.H_2O$.

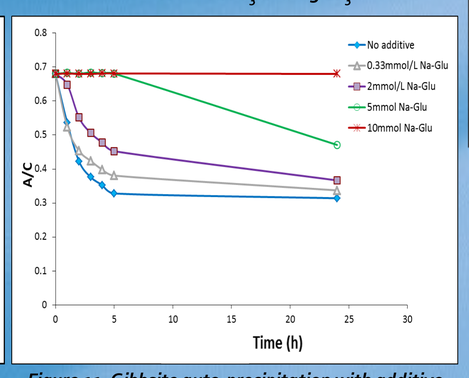
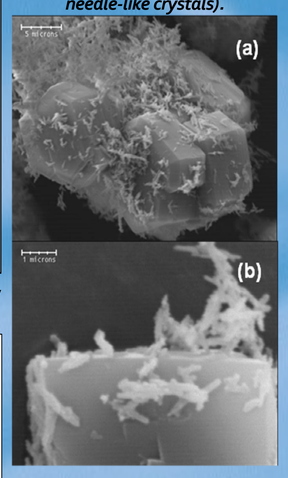


Figure 11. Gibbsite auto-precipitation with additive and a range of gluconate doses.

Figure 12. (a) Far view; (b) close view. Gibbsite auto-precipitation with goethite seed present (fine needle-like crystals).



- Order of effect: HX800 ≈ $MgCO_3$ < $LiOH.H_2O$ < $CaCO_3$ < Gluconate.
- Gluconate is effective in the concentration range 2 - 10 mmol L^{-1}.

Bauxite residue flocculation experiments

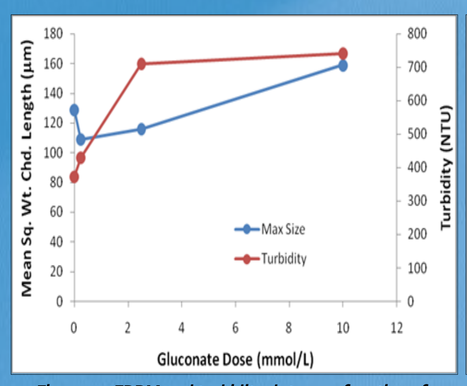


Figure 13. FBRM and turbidity data as a function of gluconate dose for the flocculation of bauxite residue with 202 g/t 9779 flocculant.

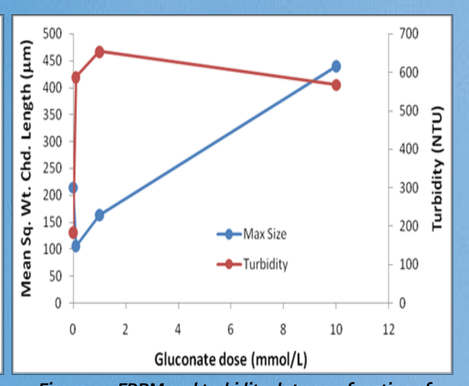


Figure 14. FBRM and turbidity data as a function of gluconate dose for the flocculation of bauxite residue with 702 g/t HX300 flocculant.

- Gluconate behaviour is complex.
- Flocculation negatively affected at low doses, but positive affected at high doses.
- The effect may involve surface adsorption or complexation of the residue/flocculant.

Gibbsite crystallisation experiments

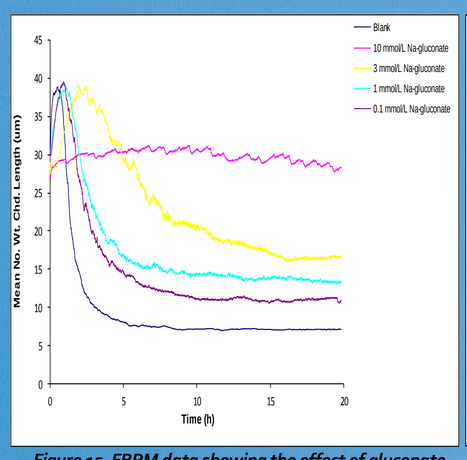


Figure 15. FBRM data showing the effect of gluconate additive on gibbsite crystallisation.

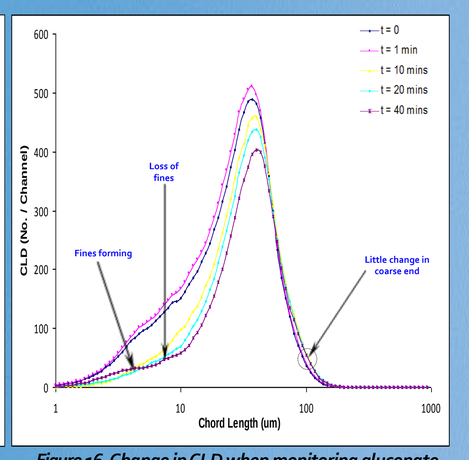


Figure 16. Change in CLD when monitoring gluconate effect on gibbsite crystallisation.

- Gibbsite crystallisation deteriorates markedly as the gluconate dose increases.
- Gluconate suppression mechanism is likely due to adsorption onto gibbsite seed surfaces.

Conclusions

- Goethite is an active seed in the premature crystallisation (auto-precipitation) of gibbsite in the mud circuit.
- Sodium gluconate is an effective additive for mitigating against premature crystallisation of gibbsite.
- Sodium gluconate negatively affects bauxite residue flocculation and gibbsite crystallisation, this warrants further investigation, due to the potential impact it may have on these unit operations.

Acknowledgements

This work was funded by West Indies Alumina Company (Windalco). Technical and logistical assistance were received from the UC RUSAL group and Aughinish Alumina Limited. [1]Mr. Desmond Lawson is credited with the production of Figure 2.