Aluminium chlorohydrate

(endorsed 2005)

Aluminium chlorohydrate is used as a primary coagulant in the treatment of drinking water. It is effective over a range of pH values and forms strong floc. It is particularly effective in some low alkalinity waters.

GENERAL DESCRIPTION

Aluminium chlorohydrate, $Al_2(OH)_5Cl$ (also known as ACH, polyaluminium chlorohydrate or aluminium chlorhydroxide), solution is a clear colourless, odourless liquid. It has a specific gravity of 1.32–1.35 at 25°C, a pH of 3.5–4.5, and is completely soluble in water.

ACH is of the polyaluminium chloride family, with a high aluminium oxide content and high basicity. It is supplied with an aluminium content of 12.2 to 12.7% (23–24% as equivalent alumina) and a basicity of 83–84%. The chemical coagulates over a wide pH range (pH 6–9) and does not usually require alkalinity adjustment.

The formula $Al_2(OH)_5Cl$ is simply a representation of the proportions of aluminium, hydroxide and chloride in the solution and it does not imply the predominant aluminium species is dimeric (see below). A generic formula for the ACH species may be given as $Al_n(OH)_mCl_{(3n-m)}$ where the m/n ration exceeds 1.05.

ACH can be stored in fibreglass-reinforced plastic, polyethylene, polypropylene or phenol formaldehyde, but can be corrosive to metals.

CHEMISTRY

ACH is manufactured from aluminium metal, which is reacted with either hydrochloric acid or aluminium chloride solution under controlled conditions.

ACH solution is a complex, dynamic mixture of positively charged polynuclear aluminium species, with no single species predominating and with molecular weights exceeding 1000. When applied to water, these species interact with and destabilises negatively charged colloidal matter, such as inorganic particles and the high molecular weight organic compounds that largely constitute natural organic matter. The polynuclear species also hydrolyse to form dense flocs of aluminium hydroxides that further act to entrap particles and remove some organic. An example of one of the many polynuclear species that may be present in ACH solution is the so called Al-13 ion that has the formula $[AlO_4.Al_{12}(OH)_{24}(H_2O)_{12}]^{13+}$.

The hydrolysis of ACH produces far less acid than the hydrolysis of aluminium sulfate owing to the very high degree of hydroxylation of the aluminium. As a result, ACH requires little of no pH correction with alkali when applied to water and results in only marginal increase in the concentration of dissolved salt.

The hydrolysis reaction proceeds as follows:

$$Al_2(OH)_5.Cl + H_2O \leftrightarrow 2Al(OH)_3 + H^+ + Cl^-$$

As the hydrolysis reactions proceed, mononuclear hydroxide products can form polynuclear species. The reactions are complex and the species formed are quite variable. Examples of the species formed are:

- mononuclear: Al OH^{2+}, $Al(OH)_2^+$, $Al(OH)_3$ (solid precipitate), $Al(OH)_4^-$
- polynuclear: $Al_8(OH)_{20}^{4+}$, $Al_{13}O_4(OH)_{24}^{7+}$.

NOTE: Important general information is contained in PART II, Chapter 8

TYPICAL USE IN AUSTRALIAN DRINKING WATER TREATMENT

In drinking water treatment, ACH is used as a primary coagulant. It is effective in cold temperatures and is particularly suited for use in low alkalinity raw water. It is commonly used for coagulation before membrane filtration, because this appears to reduce membrane fouling and prolong the life of the filter. The concentration of coagulant used depends on the properties of the raw water, including factors such as turbidity, dissolved organic carbon, temperature and alkalinity.

Typical ACH doses (with 23% Al_2O_3 content) are 3–100 mg/L. The actual concentration required should be determined by laboratory trials; higher doses may be required with particularly dirty water.

CONTAMINANTS

The contaminants that may be present in ACH are:

- antimony
- arsenic
- barium
- beryllium
- cadmium
- chromium
- copper
- fluoride
- iron
- lead
- manganese
- mercury
- nickel
- phosphorus
- selenium
- silver
- thallium
- zinc

RESIDUAL AND BY-PRODUCT FORMATION IN DRINKING WATER

When employed in drinking water treatment, ACH should be used in such a way that any contaminant or by-product formed by the use of the chemical does not exceed guideline values in the *Australian Drinking Water Guidelines*.

Most of the aluminium ions resulting from the use of ACH as a coagulant are removed by conventional water treatment processes. Residual chloride is usually at low levels that do not adversely affect drinking water quality.

STATUS

ACH was endorsed by the NHMRC for use as a drinking water treatment chemical in 2005.

REFERENCES

Clesceri LS, Greenberg AE and Eaton AD (eds) (1998). *Standard Methods for the Examination of Water and Wastewater*, 20th edition. American Public Health Association, Washington, DC.

Fitzgerald JJ and Rosenberg AH (1999). Chemistry of aluminium chlorohydrate and activated aluminium chlorohydrates. In *Cosmetic Science and Technology Series, 20. Antiperspirants and deodorants*, second edition, Laden K (ed). Marcel Dekker Inc, 83–136.

Rosenberg AH, Hodges RD and Harper TL (1995). *Chemical characterisation of polyaluminium chlorides and TOC removal*. American Water Works Association Water Quality Technology Conference.

Ruehl KE (1998). Effective coagulation for variable source water: a coagulant comparison by bench and full sale evaluations. American Water Works Association Water Quality Technology Conference.

NOTE: Important general information is contained in PART II, Chapter 8