Polyelectrolyte determination in drinking water

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Abstract

Chemical contaminants that occur in drinking water are not usually associated with acute health effects when compared to microbial contaminants and are usually given a lower priority. Those that are of concern have cumulative toxic properties such as metals and substances that are carcinogenic. Some of these potentially hazardous chemical contaminants are a consequence of the treatment chemicals themselves e.g. organic polyelectrolytes used as coagulant aids in water treatment. The presence of residues of the un-reacted monomer in these polyelectrolyte products is a cause for concern.

Historically, inorganic coagulants such as aluminium sulphate and ferric chloride have been used as coagulants/flocculants in the treatment of drinking water. The residual amounts of these chemicals were easy to detect and to control using readily available standard methods. The increasing use of polyelectrolytes has created a problem for the potable water industry as there are no readily available methods for the determination of residual polyelectrolyte concentration.

This study aims at extending existing analytical techniques and comparing them to determine results that are most accurate and reliable to the quantification of residual polyelectrolytes.

Keywords: polyelectrolytes, chemical contaminants, health effects, analytical techniques

Introduction

Polydiallylydimethyl ammonium chloride (polydadmac) and epichlorohydrin-dimethylamine (epi-dma) are established coagulants in the treatment of drinking water. Their efficiency can be seen in the fact that approximately 75% of waterworks in South Africa have adopted these polyelectrolytes as part of their water treatment process (Leopold, 2004).

Polyelectrolyte products used in the water supply industry may contain in addition to polyelectrolyte, measurable amounts of certain contaminants. These contaminants are essentially unreacted raw material from the polyelectrolyte manufacturing process, e.g. the monomers, un-reacted chemicals used to form the monomer units, initiators, quenchers, etc. A list of contaminants that may be found in polydadmac and epi-dma are highlighted in Table 1.

Different reactants and manufacturing processes can be used to prepare what is essentially the same polymer. Process monitoring and control is therefore an important consideration in polyelectrolyte manufacture if contaminant levels are to be managed. However, national standards and regulations governing the quality of the polyelectrolyte product is something South Africa lacks (Freese et al., 2002).

Letterman and Pero (1990) have suggested that certain of these contaminants could have an adverse effect on the health of water consumers. Polyelectrolytes and their contaminants may also react with treatment chemicals added from other water treatment processes like ozonation and chlorination to form undesirable by-products (Mallevialle et al., 1984).

This is highlighted by the fact that low concentrations of polyelectrolyte remains in the water after the filtration stage and continued exposure to low concentrations of contaminants such as epichlorohydrin is an important concern as it is an animal carcinogen (WHO, 1996). The techniques available for measuring residual organic polyelectrolytes in potable water are inadequate, making the need to quantify them more critical (Fielding, 1999).

TABLE 1
List of contaminants found in polyelectrolyte products

Contaminant	Polyelectrolyte
Diallyldimetylammonium chloride	Polydadmac
Dimethylamine	Polydadmac/epi-dma
Allylchloride	Polydadmac
Diallylether	Polydadmac
5-Hexanal	Polydadmac
Epichlorohydrin	Epi-dma
Glycidol	Epi-dma
1, 3-dichloro-2-propanol	Epi-dma
2, 3-dichloro-1-propanol	Epi-dma
3 chloro-1,2-propanediol	Epi-dma
2-hydroxy-3-dimethylaminopropyl chloride	Epi-dma
1,3-Bis(dimethylamino)-2-propanol	Epi-dma

(Source: Letterman and Pero, 1990)

Review and investigation of existing analytical methodologies

A number of methods have been devised for the quantitative determination of polyelectrolytes in water. Some of these include: colloidal titration, extraction-spectrophotometry, chromatography, fluorometry and potentiometry.

Methods that are simple to perform and that allow waterworks operators to achieve precise results are desirable as quick

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