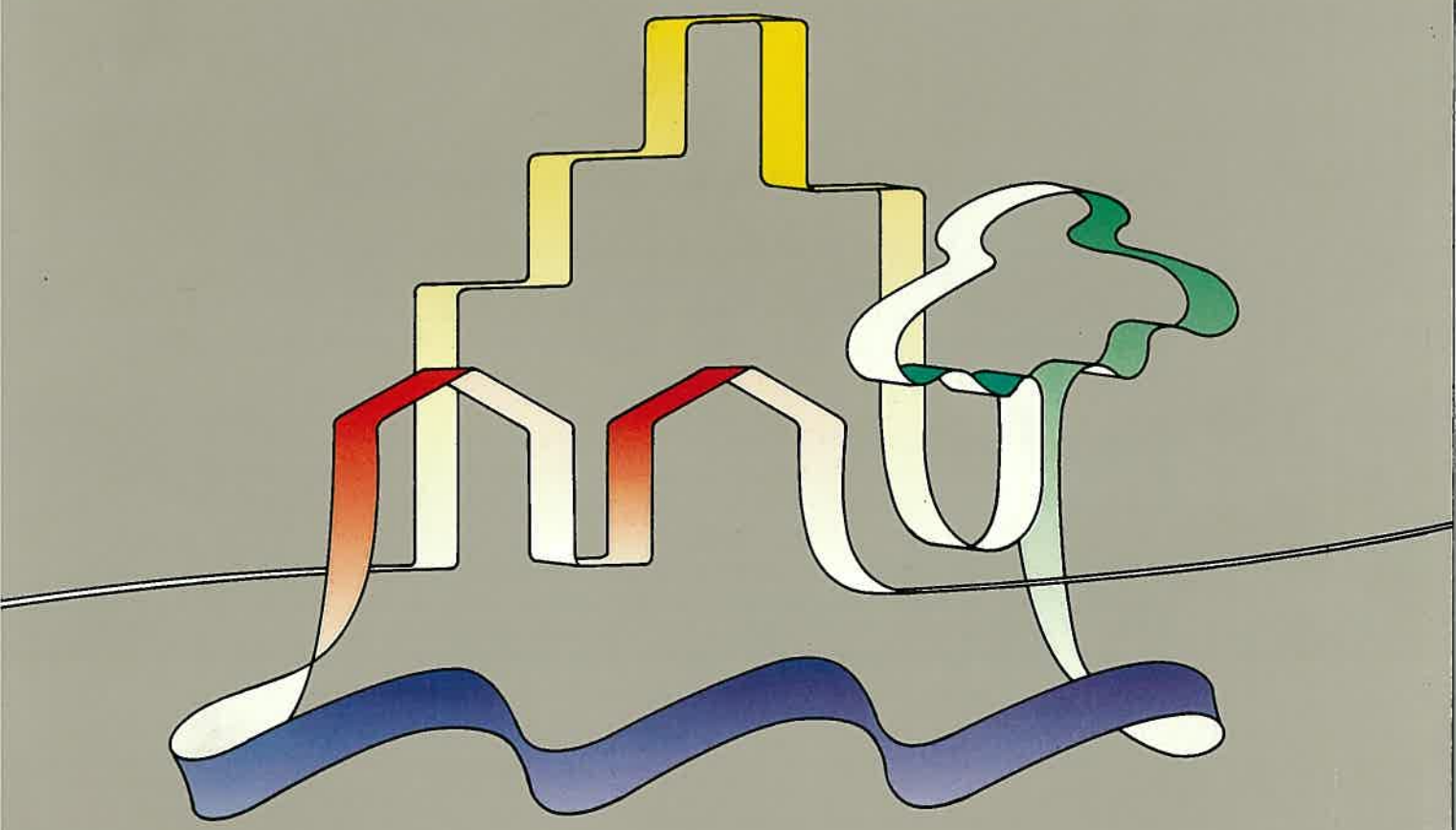
Urban Water Research Association of Australia

Coagulants for Water Treatment : A Generic Guide



Research Report No 42

URBAN WATER RESEARCH ASSOCIATION OF AUSTRALIA

The Association was formed in 1986 following initiatives by the Australian Water Research Advisory Council and the Major Urban Water Authorities of Australia. The Association's primary role is to foster and promote a comprehensive, co-ordinated and cost-effective approach to urban water research within Australia, for both metropolitan and non-metropolitan areas.

The Association invites proposals for research work through its member authorities and allocates funding to approved projects on an annual basis. The actual research is undertaken by water authorities, research organisations, universities, consultants and government agencies.

The UWRAA Research Report series presents information resulting from research projects supported by the Association and is published as a record of the work undertaken and as a means of disseminating the research findings. The Association also encourages the presentation of findings by the researchers in professional journals and at conferences. The Association's reports are indexed on STREAMLINE, the national water data base.

For further details contact:
Executive Officer
Urban Water Research Association of Australia
C/– Melbourne Water
GPO Box 4342 Telephone: (03) 615 5816
Melbourne 3001 Telex: AA34220
AUSTRALIA Fax: (03) 615 4408

Urban Water Research Association of Australia

Coagulants for Water Treatment

A Generic Guide to Coagulants, Coagulant Aids and Flocculant Aids available in Australia

Research Report No 42
May 1992

Published for the Urban Water Research Association of Australia by the Melbourne and Metropolitan Board of Works.

ISBN 1 875298 42 8

Cover design by Gregory R Smith

FOREWORD

This report is a summary of UWRAA Research Report No 41 : 'Assessment of Coagulants for Water Treatment' and has been prepared by the Australian Centre for Water Quality Research, Adelaide, South Australia. It contains a generic summary of coagulants, coagulant aids and flocculant aids available in Australia for the treatment of drinking waters and is intended as a handbook for personnel involved in treatment plant operations. It is proposed to update the summary every 1-2 years to include new products.

CONTENTS

1.0 INTRODUCTION. 1

2.0 TREATED WATER QUALITY CRITERIA. 3

2.1 General Treated Water Quality Objectives. 3
2.2 Limits for Inorganic Residuals. 4
2.3 Limits for Organic Residuals. 5

3.0 INORGANIC COAGULANTS. 7

3.1 Aluminium Products. 7
3.1.1 Alum. 7
3.1.2 Polyaluminium Chloride (PACl). 8
3.1.3 Aluminium Chloride. 9
3.1.4 Sodium Aluminate. 9
3.2 Iron Products. 10
3.2.1 Ferric Sulphate. 10
3.2.2 Ferric Chloride. 10
3.2.3 Ferrous Sulphate. 10
3.3 Recommendations for Inorganic Coagulants. 11

4.0 ORGANIC COAGULANTS. 12

4.1 Polydadmac Products. 15
4.2 Polyethyleneamine (Polyamine) Products. 15
4.3 Epi/Dma Products. 15
4.4 Polyacrylamide Products. 16
4.5 Inorganic Salts-Polydadmac Polymer Blends. 17
4.5.1 Polyaluminium Chloride (PACl)-Polydadmac Polymer Blends. 17
4.5.2 Alum-Polydadmac Polymer Blends. 17
4.5.3 Ferric Chloride-Polydadmac Polymer Blends. 17
4.6 Recommendations for Organic Coagulants. 18

5.0 COAGULANT AIDS. 19
5.1 Polydadmac Polymers (as Coagulant Aids). 20
5.2 Polyamine Polymers (as Coagulant Aids). 20
5.3 Epi/Dma Polymers (as Coagulant Aids). 20
5.4 Polyacrylamide Polymers (as Coagulant Aids). 21
5.4.1 Cationic Polyacrylamides. 21
5.4.2 Non-ionic Polyacrylamides. 21
5.4.3 Anionic Polyacrylamides. 21
5.5 Anionic Latex Emulsions (as Coagulant Aids). 22
5.6 Activated Silica (as a Coagulant Aid). 22
5.7 Recommendations for Coagulant Aids. 23

6.0 FLOCCULANT AIDS. 24

6.1 Recommendations for Flocculant Aids. 25

Figure 1. 'The Water Treatment Train' 2

Table 1. Specific Polymer Descriptions 13

Table 2. Description of Polymers by Application Type 14

Appendix 1. Inorganic Product Specifications. 27

Appendix 2. Organic Product Specifications. 35

1.0 INTRODUCTION.

This summary of coagulants, coagulant aids and flocculant aids available in Australia for the treatment of drinking waters has been prepared by the Australian Centre for Water Quality Research. It is derived from the results of a research project funded by the Urban Water Research Association of Australia (UWRAA). The information obtained from this project is presented in a generic manner as a guide to water authorities on the selection of water treatment chemicals.

Suppliers of coagulation products participated in the project by supplying product samples for laboratory evaluation, together with relevant technical and operational information.

Each product has been categorised according to its chemical structure. The effectiveness of each product category is based on its performance in waters of different water quality as determined by its capacity to produce a filtered water of acceptable quality with respect to colour, turbidity, aluminium, iron and manganese. No recommendations on particular product brands are made.

A detailed report, which includes the results of laboratory testing, is available from the Urban Water Research Association of Australia.

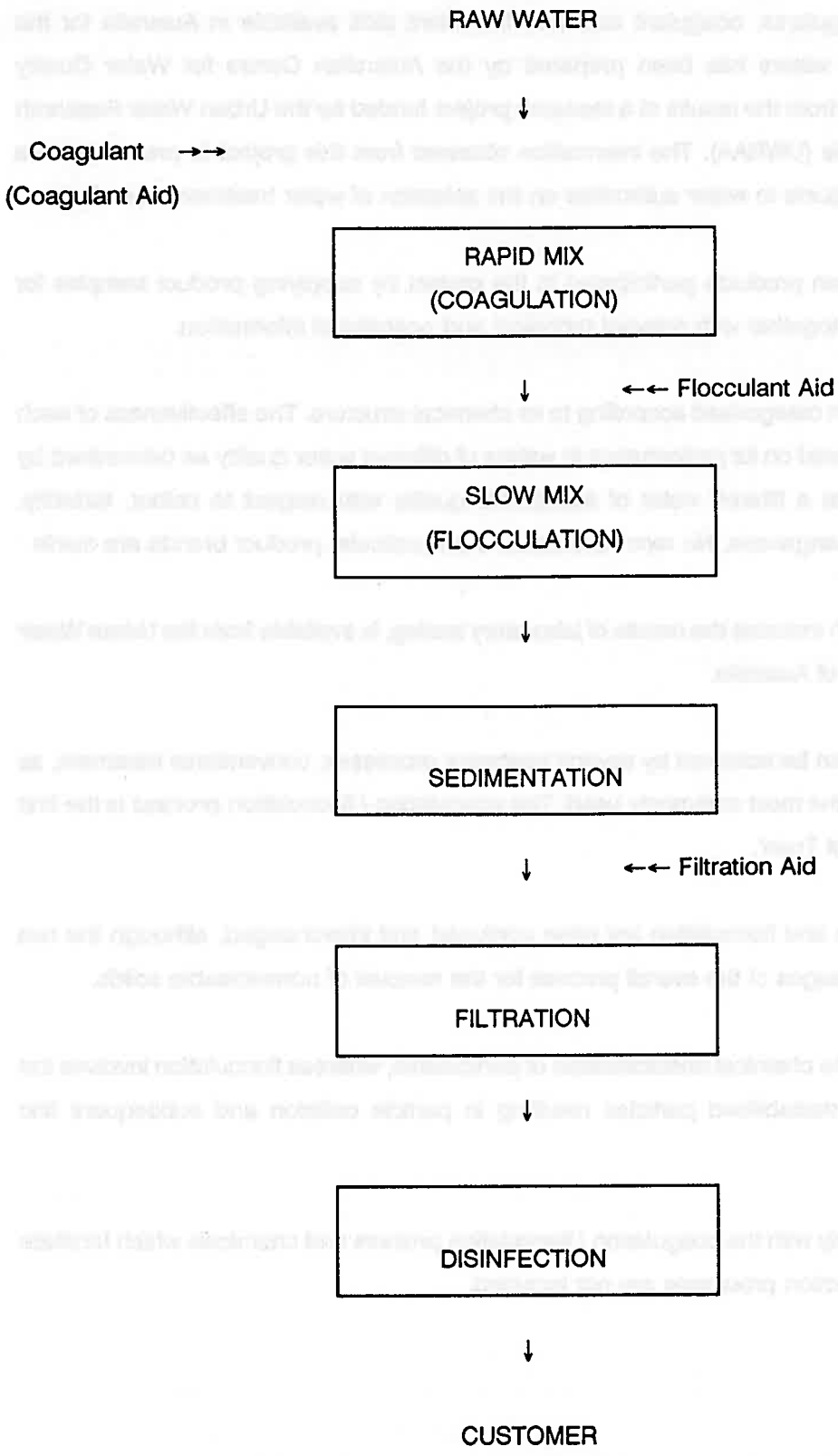
Clarification of water can be achieved by several treatment processes; conventional treatment, as outlined in figure 1, is the most commonly used. The coagulation / flocculation process is the first in the 'Water Treatment Train'.

The terms coagulation and flocculation are often confused and interchanged, although the two refer to quite distinct stages of the overall process for the removal of nonsettleable solids.

Coagulation involves the chemical destabilisation of particulates, whereas flocculation involves the physical transport of destabilised particles resulting in particle collision and subsequent floc formation.

This summary deals only with the coagulation / flocculation process and chemicals which facilitate it. Filtration and disinfection processes are not included.

Figure 1. 'The Water Treatment Train'



2.0 TREATED WATER QUALITY CRITERIA.

2.1 General Treated Water Quality Objectives.

To enable comparison of products it is necessary to define water quality objectives that water treated by all products must meet. Treated water colour and turbidity levels were based on the following operating guidelines currently in use in water treatment plants in South Australia.

Turbidity	:	<0.5 NTU (90% of the time)
		<1.0 NTU (always)
Colour	:	<10 HU (90% of the time)
		<15 HU (always)

For simplicity, the lower levels were chosen as the objectives for this study. Limits for inorganic residuals were also used and these were based on guidelines recommended by the National Health and Medical Research Council (NHMRC) / Australian Water Resources Council (AWRC).

The water quality objectives used in this study were:

Turbidity	:	<0.50 NTU
Colour	:	<10 HU
Aluminium	:	<0.2 mg/L
Iron	:	<0.3 mg/L
Manganese	:	<0.1 mg/L

For the purpose of this study the optimum dose of a particular coagulant is the minimum dose required for treated water samples to satisfy these objectives.

2.2 Limits for Inorganic Residuals.

The National Health and Medical Research Council (NHMRC) / Australian Water Resources Council (AWRC) guidelines for aluminium, iron and manganese residuals are <0.2, <0.3 and <0.1 mg/L respectively. These guideline values are consistent with those of the World Health Organisation (WHO).

Aluminium levels above 0.2 mg/L may cause post-flocculation in distribution systems resulting in increased turbidity.

Although water with levels of aluminium exceeding 0.2 mg/L is not suitable for use by renal dialysis patients and aluminium has also been implicated in the aetiology of Alzheimer's disease, there is no conclusive evidence of health effects on normal individuals from the oral ingestion of aluminium compounds. There has been no revision of aluminium levels based on health effects and recent information suggests that none are planned in the current review of WHO and NHMRC guidelines.

As the iron concentration in water supplies approaches 0.3 mg/L iron hydroxides may precipitate and cause staining of plumbing fixtures. The presence of iron may also result in undesirable growths of iron bacteria in distribution systems causing aesthetic problems.

High levels of manganese in water can also cause staining of plumbing fixtures as well as undesirable tastes.

The presence of these metals together at levels higher than the limits stated may result in the deposition of large quantities of metallic hydroxide complexes giving rise to consumer complaints.

It is important to note that these limits become particularly significant when dosing with aluminium and iron salts.

2.3 Limits for Organic Residuals.

The United States National Sanitation Foundation (NSF) has established the following guidelines for maximum organic polymer doses to be used for the treatment of potable water.

Polydadmac, Polyamine, Epi/Dma	:	10.0 mg active polymer / L
Polyacrylamide	:	1.0 mg active polymer / L

However, the NHMRC has only approved the use of polydadmac and polyacrylamide polymers for the treatment of potable waters in Australia, with dosing guidelines also of 10.0 and 1.0 mg active polymer/L respectively.

Although polyamines and epi/dma polymers are not yet approved for use in potable waters in Australia, these products are available and testing was undertaken as part of this study for completeness.

The above dosing guidelines were not exceeded at any stage of the testing program.

Although polydadmac and polyacrylamide polymers are not considered harmful, the formation of toxic organic by-products as the result of subsequent treatment processes, such as chlorination and ozonation is possible. There is evidence that even at low concentrations, residual organic polymers can be oxidised by chlorine and ozone to give toxic by-products.

Unreacted monomers, which are generally the major contaminants in polymer products, are known to be toxic. Consequently, in addition to the restrictions on polymer dosing in treated waters mentioned above, guidelines have also been developed for the levels of monomer.

The American Water Works Association (AWWA) standard for polydadmac requires that the monomer content of a polydadmac product be less than 5.0% of total active polymer content. However, the NHMRC limit for monomer content is somewhat stricter, requiring monomer levels to be below 2.0% of total active polymer content and the residual monomer in treated water to be below 0.2 mg/L.

All polydadmac polymers assessed in this study were analysed for unreacted dadmac monomer using ion chromatography. All contained less than 5.0% monomer and the majority actually contained less than 2.0% monomer. Although treated water samples were not analysed for residual

monomer levels polymer dosing was controlled so that the maximum monomer level of 0.2 mg/L was not exceeded.

The NHMRC also recommends that the level of acrylamide monomer in polyacrylamide polymers should not exceed 0.05 mg/L.

3.0 INORGANIC COAGULANTS.

Salts of aluminium (Al[III]) and iron (Fe[III]) have been used extensively for many years as coagulants. The aluminium based coagulants included in this summary are alum, polyaluminium chloride (PACl), aluminium chloride and sodium aluminate. The iron based products are ferric sulphate, ferric chloride and ferrous sulphate. Product specifications for these inorganic products are listed in Appendix 1.

3.1 Aluminium Products.

3.1.1 Alum.

Aluminium sulphate or alum is an acidic coagulant consisting of trivalent aluminium ions. It is a very effective, cost efficient coagulant which is applicable to a wide range of water quality. As it is an acidic coagulant, pH correction may be necessary, particularly in poorly buffered waters.

3.1.2 Polyaluminium Chloride (PACl).

PACl is a polynuclear complex of polymerised aquo-aluminium ions having the general formula $Al_n(OH)_mCl_{(3n-m)}$. It is a widely used acidic coagulant prepared by controlled alkaline hydrolysis of aluminium chloride.

PACl products do not perform identically and each should be considered separately.

The extent of alkaline hydrolysis (polymerisation) of aluminium chloride and thus the type and level of polymerised aluminium species is variable. This is the likely cause of differences in product performance.

Based on testing undertaken within the UWRAA project:

- PACl is an effective coagulant in all waters.
- PACl products vary between manufacturers and each product should be tested on the water supply in question.
- PACl is a very effective coagulant in medium-high turbidity water (10-75 NTU) with optimum aluminium doses equivalent to or lower than alum.
- In high colour/low turbidity water, the optimum aluminium dose for PACl is generally higher than for alum.

3.1.3 Aluminium Chloride.

Aluminium chloride is an acidic product consisting of trivalent aluminium ions. It is not a commonly used coagulant.

Generally, aluminium chloride is not as effective as alum or PACl. pH correction is required at high doses.

3.1.4 Sodium Aluminate.

Sodium aluminate requires considerably higher aluminium doses than alum and pH correction is required for satisfactory coagulation. It is therefore, not considered an effective coagulant.

However, there is evidence to suggest that sodium aluminate can be successfully used as a coagulant aid.

In the United States sodium aluminate is used widely as a partial replacement of alum. The basicity of the sodium aluminate results in higher treated water pH than when alum is used alone. This eliminates the need for post-treatment pH correction.

3.2 Iron Products.

When assessing the performance of iron salts compared with aluminium salts it is important to allow for the molecular weight of iron being 2.07 times greater than that of aluminium. Therefore, to directly compare optimum levels, the iron level must be halved to give an aluminium equivalent.

3.2.1 Ferric Sulphate.

Ferric sulphate is a readily available, acidic trivalent iron salt. It is an effective coagulant for all waters. However, in terms of equivalent cation concentration, the required doses for ferric sulphate are higher than those for alum.

3.2.2 Ferric Chloride.

Ferric chloride is also acidic and consists of trivalent iron species. It is an effective coagulant for all water types.

3.2.3 Ferrous Sulphate.

Divalent ferrous sulphate is less effective than the trivalent aluminium and iron ions. Consequently, much higher doses are required for coagulation. In addition, pH correction is required to facilitate the process.

3.3 Recommendations for Inorganic Coagulants.

Aluminium chloride, sodium aluminate and ferrous sulphate are generally not recommended as alternative coagulants to alum because of the high level of metal ion required to satisfy treated water guidelines. They also require pH correction in order to perform effectively.

However, polyaluminium chloride (PACl), ferric sulphate and ferric chloride are possible alternatives to alum. Doses of metal ion required to treat water compare with that for alum.

In order for these products to be viable alternatives to alum on a large scale they must also be cost competitive. To make effective cost comparisons between these products and alum, several factors should be considered. For example, as PACls generally require lower doses than alum with a consequent smaller decrease in pH of treated waters, the amount of post-treatment pH correction required is reduced. These savings, together with the possibility of not requiring any coagulant aids or flocculant aids need to be evaluated before considering these inorganic salts as alternatives to alum.

4.0 ORGANIC COAGULANTS.

Synthetic organic polymers are being used increasingly in water treatment as partial or total replacements for inorganic coagulants. They generally form stronger, more settleable floc than inorganic coagulants and reduce the overall amount of coagulant required, thus reducing the amount of sludge produced.

Organic polymers or polyelectrolytes are chains of individual monomer units, linked together in linear or branched configurations, with functional groups attached periodically along the chain. These functional groups may possess a negative charge (anionic polymers), positive charge (cationic polymers) or an overall neutral charge (non-ionic polymers).

Tables 1 & 2 provide information regarding the types of polymers used in water treatment.

The chemical names and structures of the relevant polymers are listed in Table 1. Table 2 groups the polymers by their application. Although there is only a small number of polymer types, a multitude of products are available because characteristics such as molecular weight and product activity are variable.

The products listed can be grouped into two distinct categories, as indicated in Table 2;

1. Low molecular weight / cationic (coagulants, coagulant aids)

2. High-very high molecular weight / regardless of charge (flocculant aids)

Products from the first category, which are designed to perform as total replacements for traditional inorganic coagulants were assessed in this section. Polymers from this category generally have relatively low molecular weights (less than 10^5) but relatively high cationic charge densities. These cationic polymers facilitate coagulation by charge neutralisation, in a similar way to inorganic coagulants.

Products from the second category, which are designed as coagulant aids and/or flocculant aids (ie. effective when used in conjunction with a coagulant) are discussed in sections 5 and 6.

However, selected cationic samples from the second category were also assessed as coagulants for two reasons. Firstly, because some manufacturers stated they were suitable coagulants and secondly in order to emphasise differences between categories.

Organic product specifications are listed in Appendix 2.

Table 1. Specific Polymer Descriptions

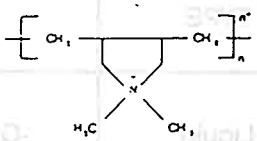
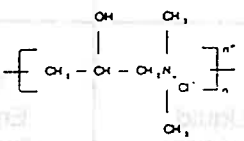
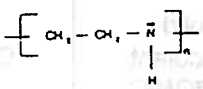
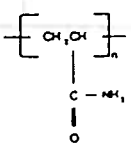
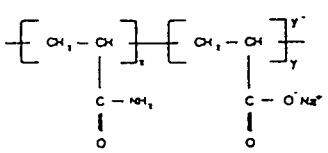
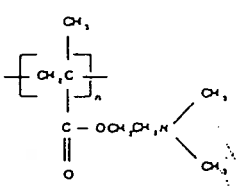
CHEMICAL NAME	SYNONYMS	POLYMERIC STRUCTURE
Poly(diallyl-dimethylammonium Chloride)	- Polydadmac - Quaternary amine	
Poly(2-hydroxy-propyl-1,N,N-dimethylammonium Chloride)	-Epi/DMA (epichloro-hydrin / dimethylamine) -Quaternary amine	
Poly(ethyleneamine)	- PEA -Polyamine	
Poly(acrylamide)	- PAM	
Poly(acrylamide/ acrylic acid) copolymer	- PAM/PAA -poly(acryl-amide/acrylate salt)copolymer -Hydrolysed PAM	
Poly(N,N-dimethyl-aminoethyl-methacrylate)	-Quaternary polyamine	

Table 2. Description of Polymers by Application Type

POLYMER TYPE	SYNONYMS	POLYMER NAME	RELATIVE MOLECULAR WEIGHT	CATEGORY
Liquid Solution Coagulant **CATIONIC**	-Organic Coagulant -Coagulant Aid	-PDADMAC -Epi/DMA -PEA -Mel/Form	1-500 $x10^3$ (low)	1
Liquid Emulsion **ANIONIC**	Latex Emulsion Coagulant Aid	-PAM/PAA	> 30 $x10^6$ (very high)	2
Solid Flocculant **CATIONIC ANIONIC NONIONIC**	Coagulant Aid	-PAM -PAM/PAA Quaternary polyamine	> 30 $x10^6$ (very high)	2

4.1 Polydadmac Products.

Polydadmac polymers are the most common organic coagulant available.

Levels of monomer in Profloc 5YB and 5YC exceed the NHMRC limit of 2.0%, but dosing can be controlled so that a maximum level of 0.2 mg/L in treated water is not exceeded.

Polydadmac polymers are most effective as coagulants in low coloured waters. At low doses, turbidity removal is adequate (even for highly turbid waters) and provided the raw water colour is low, the filtered water colour guideline is satisfied. In high coloured waters the high polymer doses required to adequately remove colour generally cause unacceptably high filtered water turbidity.

4.2 Polyethyleneamine (Polyamine) Products.

The performance of polyamine products is similar to those of polydadmac polymers. They are most effective for treating low colour/high turbidity waters. However, as stated previously these products are not yet approved for use in potable water treatment in Australia.

4.3 Epi/Dma Products.

Epi/Dma polymers perform similarly to polydadmacs and polyamines. They are most effective for treating low colour/high turbidity waters.

However, as for polyamine polymers, epi/dma polymers have not been approved for potable water treatment in Australia.

4.4 Polyacrylamide Products.

Several suppliers claim that cationic polyacrylamides are effective as coagulants. Generally, cationic polyacrylamides have higher molecular weights but lower charge densities than polymers designed as coagulants.

Colour removal is negligible with cationic polyacrylamides. However, turbidity removal is more effective than for other cationic polymers. These polymers are most effective in low coloured waters of varying turbidity.

4.5 Inorganic Salts-Polydadmac Polymer Blends.

This group of coagulants belong to a group of commercially available inorganic salts, each blended with small amounts of polydadmac polymer. Several types of blend are available; namely polyaluminium chloride (PACl)-polydadmac, alum-polydadmac and ferric chloride-polydadmac blends.

4.5.1 Polyaluminium Chloride (PACl)-Polydadmac Polymer Blends.

These products are effective coagulants in all waters.

4.5.2 Alum-Polydadmac Polymer Blends.

These blends perform very well in all waters.

4.5.3 Ferric Chloride-Polydadmac Polymer Blends.

These blends are effective coagulants in all waters.

4.6 Recommendations for Organic Coagulants.

The four types of polymer perform best in highly turbid/low coloured waters. They show a very limited ability to remove colour but are very effective for removing turbidity, particularly in highly turbid samples. Unless the water requiring treatment is low in colour, the four polymer types are not viable alternatives to alum in conventional water treatment.

However, the inorganic salt-polydadmac polymer blends are possible alternatives to alum.

While cost analyses for various products have not been undertaken, it is reasonable to expect these inorganic salt-polydadmac products to be more expensive per milligram of metal ion than alum. However, in order to make meaningful cost comparisons between these products and alum, several factors, as described in section 3.3, should be considered before determining whether the blended products are cost effective alternatives to alum.

5.0 COAGULANT AIDS.

Coagulant aids (or co-coagulants) are designed to partially replace coagulants, in particular inorganic coagulants. This means they are expected to assist in the coagulation process, as described in section 1.0. Polydadmac, polyamine and epi/dma polymers (Table 2, category 1) are suitable for this purpose.

Polymers with high molecular weight (greater than $3x10^6$) but relatively low charge density (Table 2, category 2) are also designed for this purpose. Such polymers (anionic, cationic or non-ionic in charge) however, operate by a different mechanism. They adsorb to one or more sites on a particle surface. The long chains of such polymers enable them to attach to other particles.

Partial replacement of inorganic coagulants is a possible means of reducing undesirable residual coagulant levels (eg. aluminium) and improving floc characteristics both of which are very important when considering the large scale operations within treatment plants. (section 6.0)

5.1 Polydadmac Polymers (as Coagulant Aids).

Although the level of dadmac monomer in Profloc 5YB and 5YC exceed the 2.0% limit, levels of polymer dosing are sufficiently low to prevent the 0.2 mg/L residual limit in treated waters being approached.

Doses of 0.25-0.50 mg active polymer/L decrease the required alum to 60% of the optimum dose in medium colour/medium turbidity and high colour/low turbidity waters. A similar decrease in the required alum dose (60-70%) is obtained with 0.50-1.0 mg active polymer in low colour/high turbidity waters.

Polydadmac polymers perform well in all water types.

5.2 Polyamine Polymers (as Coagulant Aids).

In medium colour/medium turbidity water, polyamines reduce the required alum to 60% of the optimum dose with doses of 0.25-0.50 mg active polymer/L. The same level of reduction in alum dose is achieved by doses of 0.50-1.0 mg active polymer/L in high colour/low turbidity water. In low colour/high turbidity water these products satisfy all treated water criteria except that for filtered water turbidity when alum is dosed at 70% of the optimum. An increase in alum and/or polymer dose would lead to improved turbidity removal.

Although not yet approved for use in potable waters in Australia, the polyamines perform well in all waters, especially in those with low-medium turbidity.

5.3 Epi/Dma Polymers (as Coagulant Aids).

A 0.50 mg active polymer/L dose of epi/dma is sufficient to decrease the required alum dose in medium colour/medium turbidity water and low colour/high turbidity water to 60 and 70% of the optimum level respectively. A 60% decrease in the required alum dose in high colour/low turbidity water is achieved with a polymer dose of 1.0 mg active polymer/L.

Although not yet approved for use in potable waters in Australia, epi/dma polymers are effective in all water types, particularly in medium and high turbidity waters.

5.4 Polyacrylamide Polymers (as Coagulant Aids).

Three types of polyacrylamide polymer are available. Positively charged (cationic), negatively charged (anionic) and neutral (non-ionic) polymers were assessed as coagulant aids.

5.4.1 Cationic Polyacrylamides.

Cationic polyacrylamides are effective in low colour/high turbidity waters, reducing the required alum dose to 70% of the optimum with polymer doses ranging from 0.25-1.0 mg active polymer/L. In medium colour/medium turbidity and high colour/low turbidity waters, ICI's Profloc 2XC and Allied Colloids' Magnafloc LT22 reduce the required alum dose to 85% of the optimum with doses ranging from 0.50-1.0 mg active polymer/L. The remainder of products do not satisfy colour removal guidelines.

These products are effective in low coloured waters. However, in medium-high coloured waters colour removal is minimal.

5.4.2 Non-ionic Polyacrylamides.

With insufficient colour removal from all waters and lack of turbidity removal from low colour/high turbidity waters, these polymers do not perform well as coagulant aids.

5.4.3 Anionic Polyacrylamides.

With a lack of sufficient colour removal from all waters, insufficient turbidity removal from low colour/high turbidity waters and unacceptable aluminium residuals in low and medium turbidity waters, anionic polyacrylamides do not perform well as coagulant aids.

5.5 Anionic Latex Emulsions (as Coagulant Aids).

The exact composition of these polymer types has not been supplied by the manufacturers.

The anionic emulsions perform similarly to the anionic polyacrylamides. Colour removal is inadequate in all waters, filtered turbidity is unacceptable in high turbidity waters and in low and medium turbidity waters aluminium residuals exceed filtered water criteria. These anionic latex emulsions do not perform well as coagulant aids.

5.6 Activated Silica (as a Coagulant Aid).

Activated silica is produced on site by reacting or activating sodium silicate with chlorine according to water filtration plant procedures.

Activated silica effectively removes turbidity but not colour. It is not an effective coagulant aid.

5.7 Recommendations for Coagulant Aids.

Liquid, cationic polymers, namely polydadmacs, polyamines and epi/dmas, perform well as partial replacements for alum in all water types. Their use at doses of up to 1.0 mg active polymer/L enables the required alum dose to be reduced to as low as 60% of the optimum level. However, only polydadmac polymers are recommended as coagulant aids as polyamines and epi/dmas are not approved for use in Australia.

Cationic polyacrylamides are effective coagulant aids in low coloured waters. However, at less than optimum alum dose non-ionic and anionic polyacrylamides, anionic latex emulsions and activated silica did not satisfy treated water parameters and are not recommended as coagulant aids.

6.0 FLOCCULANT AIDS.

There is a distinct difference between coagulant aids and flocculant aids. Coagulant aids assist in particle destabilisation by charge neutralisation and therefore assist in colour and turbidity removal. Highly positively charged, low molecular weight polymers, such as polydadmac, polyamine and epi/dma polymers were shown in sections 5.1 - 5.3 to be effective as coagulant aids when used as partial replacements for alum.

However, low charge, high molecular weight polymers such as polyacrylamides and latex emulsions, as well as activated silica, were shown in sections 5.4 - 5.6 to be ineffective coagulant aids because although they can effectively reduce turbidity by inter-particle bridging they do not assist the removal of colour.

Although the above mentioned polymers are generally not suitable as coagulant aids (ie. partial replacements for inorganic coagulants), they are very useful when used in addition to inorganic coagulants (ie. flocculant aids).

Dosing these polymers at levels of up to 1.0 mg active polymer/L in conjunction with alum significantly increases floc size in all water types and reduces settled water turbidity by as much as 90%, with consequent improved filtered water turbidity.

The use of polymers as flocculant aids also offer a number of benefits which are not apparent in small scale laboratory testing. For example, these polymers increase the rate of flocculation, produce larger, denser floc that settle faster and strengthen the floc which helps improve filtration. This enables increased filtration rates and longer filter runs. In addition, the amount of floc passing through the filters is reduced.

The use of flocculant aids enables a greater volume of water to be treated in a given plant size. Their use is also important during periods of time when flocculation becomes difficult because of water quality changes or because of the effect of low temperatures. Flocculant aids can provide operational improvements and possible cost savings within a treatment plant and are therefore important water treatment chemicals.

Of the products identified only as flocculant aids, namely polyacrylamides, latex emulsions and activated silica, cationic polyacrylamides and activated silica are most effective at reducing settled water turbidity in all water types.

Anionic and non-ionic polyacrylamides and anionic latex emulsions perform well in high turbidity water but do not significantly reduce settled water turbidity in low or medium turbidity waters.

6.1 Recommendations for Flocculant Aids.

If turbidity removal is the major criterion by which flocculant aids are judged, then cationic polyacrylamides and activated silica are more effective than non-ionic and anionic polyacrylamides and anionic latex emulsions in all water types.

However, as their true benefits are measured in filtration plant performance, no product should be discounted without full scale assessment.

APPENDIX 1.

INORGANIC PRODUCT SPECIFICATIONS

ALUM

Product	:	Aluminium Sulphate, Alum.
Supplier	:	Top Australia.
Appearance	:	Pale yellow solution.
Description	:	≈50% w/w, $Al_2(SO_4)_3.18H_2O$.
Solubility	:	Completely water soluble.
Active Solid	:	≈25%
Al_2O_3	:	7.5 $\pm$0.1% (w/w)
Fe_2O_3 (max)	:	0.35% (w/w)
Spec. Grav. (25°)	:	≈1.3
pH	:	Highly acidic.
Molecular Weight	:	666.42

Product	:	Aluminium Sulphate (solid) (Cat 881).
Supplier	:	Ajax Chemicals.
Appearance	:	White granular solid.
Description	:	Granulated solid aluminium sulphate. $(Al_2(SO_4)_3.18H_2O)$
Solubility	:	Completely water soluble.
Al_2O_3	:	16.0 $\pm$0.5%
Fe_2O_3 (max)	:	0.005%
pH (1% solution)	:	3.0 - 3.5

Product	:	Aluminium Sulphate, Hydrate $(Al_2[SO_4]_3.14.3H_2O)$
Supplier	:	AKZO Chemicals.
Appearance	:	White, ground crystalline solid.
Solubility	:	Completely water soluble.
Al_2O_3 (min)	:	17.0%
$Al_2(SO_4)_3$ (min)	:	57.0%
Fe_2O_3 (max)	:	0.01%
pH (1% solution)	:	3.5

Product	:	Liquid Aluminium Sulphate T.I.F.
Supplier	:	Omega Chemicals.
Appearance	:	Pale yellow liquid.
Description	:	≈50% w/w, $Al_2(SO_4)_3.18H_2O$
Solubility	:	Completely water soluble.
Al_2O_3	:	8.0 $\pm$0.1% (w/w)
Fe_2O_3 (max)	:	0.1%
Spec. Grav. (20°)	:	1.30 - 1.31
pH	:	2.4 - 3.0

Product	:	Aluminium Sulphate T.I.F. (filtration grade).
Supplier	:	Omega Chemicals.
Appearance	:	White-off white powder.
Solubility	:	Completely water soluble.
Al_2O_3	:	17-18% (w/w)
Fe_2O_3 (max)	:	0.01% (w/w)
pH (1% solution)	:	3.7

Product	:	Aluminium Sulphate.
Supplier	:	ICI Australia.
Appearance	:	White powder.
Solubility	:	Completely water soluble.
Al_2O_3	:	17.3%
Fe_2O_3	:	0.1%
pH (15 g/L)	:	2.95

POLYALUMINIUM CHLORIDE

Product	:	Nupac 250A, Polyaluminium Chloride.
Supplier	:	Nufarm Industrial Chemicals.
Appearance	:	Clear, pale amber liquid.
Description	:	Poly-nuclear complex of polymerised aquo-aluminium ions. Type of inorganic polymer with general formula $Al_n(OH)_mCl_{3n-m}$
Solubility	:	Completely water soluble.
Active Solid	:	35% (w/w)
Al_2O_3	:	10.3 $\pm$0.3% (w/w)
Viscosity (25°)	:	4.0 ± 0.5 cp
Spec. Grav. (25°)	:	1.204 + 0.004
Fe (max)	:	0.006% (w/w)
Mn (max)	:	0.01% (w/w)
pH	:	2.6 $\pm$0.3

Product	:	Nupac 250AD, Polyaluminium Chloride.
Supplier	:	Nufarm Industrial Chemicals.
Appearance	:	Hydroscopic powder.
Solubility:	:	Completely water soluble.
Al_2O_3 (min)	:	30.0% (w/w)
Fe (max)	:	0.03% (w/w)
Spec. Grav. (25°)	:	0.85 $\pm$0.05
pH (solution)	:	Highly acidic.

Product	:	PAC 30PW, Polyaluminium Chloride.
Supplier	:	Hardman Australia.
Appearance	:	Clear, colourless liquid.
Description	:	A poly-nuclear complex of polymerised aquo-aluminium ions having general formula: $Al_n(OH)_mCl_{3n-m}$
Solubility	:	Completely water soluble.
Active Solid	:	30% (w/w)
Al_2O_3	:	10.0 $\pm$0.1% (w/w)
Fe (max)	:	0.05% (w/w)
Mn (max)	:	0.025% (w/w)
Spec. Grav.(25°)	:	1.18 (min)
pH	:	Highly acidic.
Molecular weight	:	High.

Product	:	PAC, Polyaluminium Chloride.
Supplier	:	Aquapac International Pty.Ltd.
Appearance	:	Pale yellow, faintly cloudy liquid.
Solubility	:	Completely water soluble.
Al_2O_3	:	10.0 $\pm$0.2% (w/w)
Spec. Grav.(25°)	:	1.15 - 1.18
pH	:	2.7 - 2.9
Molecular Weight	:	High.

POLYALUMINIUM CHLORIDE (cont.)

Product	:	'Sludgex EA/L', Polyaluminium Chloride.
Supplier	:	Maxwell Chemicals.
Appearance	:	Pale yellow, viscous liquid.
Solubility	:	Completely water soluble.
Al_2O_3	:	10-11% (w/w)
Spec. Grav.(20°)	:	1.18
pH	:	Highly acidic.

Product	:	Profloc A-10, Polyaluminium Chloride.
Supplier	:	ICI Industrial Chemicals.
Appearance	:	Clear, colourless liquid.
Description	:	Inorganic, polymeric cationic coagulant.
Solubility	:	Completely water soluble.
Al_2O_3	:	10.0% (w/w)
Spec. Grav.(25°)	:	1.18
pH	:	Acidic

Product	:	Profloc A-10S, Polyaluminium Chloride.
Supplier	:	ICI Industrial Chemicals.
Appearance	:	Clear, colourless liquid.
Description	:	Inorganic, polymeric cationic coagulant.
Solubility	:	Completely water soluble.
Al_2O_3	:	10.0% (w/w)
Spec. Grav.(25°)	:	1.18
pH	:	Acidic

Product	:	Redifloc 130P, Polyaluminium Chloride.
Supplier	:	AKZO Chemicals.
Appearance	:	Free flowing, pale yellow powder.
Description	:	Inorganic, polymeric cationic coagulant.
Solubility	:	Completely water soluble.
Al_2O_3	:	30.0% (w/w)
Density(kg/l 25°)	:	0.77 (bulk)
pH	:	Acidic (in solution)

POLYALUMINIUM CHLORIDE (cont.)

Product	:	Hydroxy Aluminium Chloride Polymer (HAP)
Supplier	:	AKZO Chemicals.
Appearance	:	Free flowing, white powder.
Description	:	Inorganic, polymeric cationic coagulant.
Solubility	:	Completely water soluble.
Al_2O_3	:	47%
Density	:	-
pH	:	Acidic

Product	:	Polyaluminium Chloride.
Supplier	:	Groningen Pty. Ltd.
Appearance	:	Colourless, transparent liquid.
Description	:	Inorganic, polymeric cationic coagulant.
Solubility	:	Completely water soluble.
Al_2O_3	:	10.0% (w/w)
Spec. Grav.(20°)	:	1.19
pH	:	2.0-3.0

ALUMINIUM CHLORIDE

Product	:	Aluminium Chloride Hexahydrate (Cat 4746).
Supplier	:	Ajax Chemicals.
Appearance	:	Clear, colourless solution.
Description	:	50% aqueous solution ($AlCl_3.6H_2O$).
Solubility	:	Completely water soluble.
Active Solid	:	27.5 - 28.0% (w/w)
Al_2O_3	:	10.25 - 10.7% (w/w)
Fe (max)	:	0.005% (w/w)
Heavy Metals (max)	:	0.010% (w/w)
Spec. Grav. (25°)	:	1.27
pH	:	2.3

Product	:	Aluminium Chloride (anhydrous) (Cat 5018).
Supplier	:	Ajax Chemicals.
Appearance	:	Crystalline aggregates.
Solubility	:	Completely water soluble.
Assay (min)	:	99%
Iron (max)	:	0.05%
Bulk Density	:	0.9 - 1.2 kg/L.
Molecular Weight	:	133.35
pH (solution)	:	Highly acidic.

SODIUM ALUMINATE

Product	:	'Alfloc' Sodium Aluminate, $AlNaO_2$.
Supplier	:	Ajax Chemicals.
Appearance	:	White, crystalline powder.
Solubility	:	Very water soluble.
Al_2O_3	:	52.7% (w/w)
Na_2O_4	:	41.4% (w/w)
Fe_2O_3	:	0.02% (w/w)
pH (solution)	:	Strongly alkaline in aqueous solution.
Molecular Weight	:	81.97

FERRIC SULPHATE

Product	:	'Ferriclear', Ferric Sulphate Solution, $Fe_2(SO_4)_3$
Supplier	:	Iron Chemicals Australia Pty.Ltd.
Appearance	:	Red-brown, viscous liquid.
Solubility	:	Completely water soluble.
Active Solid	:	44.5 - 45.5% (w/w)
Fe^{3+}	:	12.5 - 12.7% (w/w)
Fe^{2+}	:	0.2% (w/w)
pH	:	<1
Molecular Weight	:	399.88

Product	:	Ferric Sulphate.
Supplier	:	Deltrex Chemicals Pty.Ltd.
Appearance	:	Red-brown liquid.
Solubility	:	Completely water soluble.
Active Solid	:	44.5 - 45.5% (w/w)
Fe^{3+}	:	12.5 - 12.6% (w/w)
Fe^{2+} (max)	:	0.2% (w/w)
pH	:	<1

FERROUS SULPHATE

Product	:	Ferrous Sulphate Heptahydrate, $FeSO_4.7H_2O$
Supplier	:	Deltrex Chemicals Pty.Ltd.,
Appearance	:	Light blue crystalline solid.
Solubility	:	Completely water soluble.
Assay	:	95% (min).
Fe^{2+}	:	19 $\pm$1% (w/w).
Mn (max)	:	0.2% (w/w).
pH (5% solution)	:	<2.5
Molecular Weight	:	278.02

Product	:	Ferrous Sulphate Heptahydrate (Cat 5406).
Supplier	:	Ajax Chemicals.
Appearance	:	Green crystals.
Solubility	:	Completely water soluble.
Total Iron	:	20.0% w/w.
Fe^{3+}	:	0.01% w/w.
pH (solution)	:	Highly acidic.

FERRIC CHLORIDE

Product	:	Ferric Chloride Solution, $FeCl_3$
Supplier	:	Deltrex Chemicals Pty.Ltd.
Appearance	:	Dark red liquid.
Solubility	:	Completely water soluble.
$FeCl_3$	:	42.0 - 43.0% (w/w).
Fe	:	12.3 - 12.6% (w/w).
Density	:	14.5 lb/gal.
pH	:	Highly acidic.
Molecular Weight	:	162.35

Product	:	Ferric Chloride (Cat 5390).
Supplier	:	Ajax Chemicals.
Appearance	:	Greenish to black crystalline powder.
Solubility	:	Completely water soluble.
$FeCl_3$ (min)	:	98% (w/w).
Fe^{2+}	:	0.1% (w/w).
Spec. Grav. (25°)	:	2.804
pH (solution)	:	Highly acidic.
Molecular Weight	:	162.22

Product	:	Ferric Chloride Hexahydrate (Cat 5391).
Supplier	:	Ajax Chemicals.
Appearance	:	Yellowish brown pieces (10 mm thick).
Appearance (soln.)	:	Dark brown liquid.
Solubility	:	Completely water soluble.
$FeCl_3.6H_2O$ (min)	:	98%
$FeCl_3$	:	0.006%
Fe^{2+} (max)	:	0.05%
pH (solution)	:	Highly acidic.

Product	:	'Profloc F', Ferric Chloride Solution.
Supplier	:	ICI Australia.
Appearance	:	Reddish liquid.
Solubility	:	Completely water soluble.
$FeCl_3$	:	42% (w/w).
Fe^{3+}	:	13% (w/w).
Fe^{2+}	:	0.2% (w/w).
Spec. Grav. (25°)	:	1.45
pH	:	Highly acidic.

APPENDIX 2.

ORGANIC PRODUCT SPECIFICATIONS

POLYDADMAC POLYMERS

Product	:	Magnafloc LT35.
Supplier	:	Allied Colloids.
Appearance	:	Amber coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	40% ± 1%
Spec. Grav.	:	1.09 ± 0.02
pH (as supplied)	:	6.5 ± 0.5
Charge	:	High Positive
Molecular Weight	:	Low-Medium

Product	:	Profloc 5YA.
Supplier	:	ICI.
Appearance	:	Straw coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	40%
Spec. Grav. (25°)	:	1.08 - 1.09
pH (as supplied)	:	5.0 - 7.0
Charge	:	Positive
Molecular Weight	:	Low

Product	:	Profloc 5YB.
Supplier	:	ICI.
Appearance	:	Straw coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	40%
Spec. Grav. (25°)	:	1.08 - 1.09
pH (as supplied)	:	5.0 - 7.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Profloc 5YC.
Supplier	:	ICI.
Appearance	:	Straw coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	20%
Spec. Grav. (25°)	:	1.03 - 1.05
pH (as supplied)	:	5.0 - 7.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Profloc 4YC.
Supplier	:	ICI.
Appearance	:	Straw coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	20%
Spec. Grav. (25°)	:	1.03 - 1.05
pH (as supplied)	:	5.0 - 7.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Profloc 4YA.
Supplier	:	ICI.
Appearance	:	Amber coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	35%
Spec. Grav.	:	-
pH (as supplied)	:	5.0 - 7.0
Charge	:	Positive
Molecular Weight	:	Low

Product	:	Profloc 6YA.
Supplier	:	ICI.
Appearance	:	Straw coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	50%
Spec. Grav. (25°)	:	-
pH (as supplied)	:	5.0 - 7.0
Charge	:	Positive
Molecular Weight	:	Very Low

Product	:	Maxfloc 754.
Supplier	:	Maxwell Chemicals.
Appearance	:	Straw coloured liquid.
Solubility	:	Completely water soluble.
Active Content	:	40%
Spec. Grav. (25°)	:	-
pH (as supplied)	:	5.0 - 6.0
Charge	:	Positive
Molecular Weight	:	-

Product	:	Catfloc CL.
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	40%
Density (25°)	:	8.88 lbs./gal.
pH (as supplied)	:	3.0 - 4.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Catfloc T-2.
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	33%
Density (25°)	:	8.72 lbs./gal.
pH (as supplied)	:	3.5 ± 0.2
Charge	:	Positive
Molecular Weight	:	Low

Product	:	Catfloc L.
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	20%
Density (25°)	:	8.60 lbs./gal.
pH (as supplied)	:	7.0 ± 1.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Catfloc DL.
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	17%
Density (25°)	:	8.50 lbs./gal.
pH (as supplied)	:	3.0 - 4.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Catfloc LS.
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	10%
Density (25°)	:	8.45 lbs./gal.
pH (as supplied)	:	7.0 ± 0.5
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Catfloc TL.
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	20%
Density (25°)	:	8.60 lbs./gal.
pH (as supplied)	:	3.5 ± 0.2
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Alfloc 8103
Supplier	:	Catoleum
Appearance	:	Pale amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	40%
Spec. Grav. (20°)	:	1.09
pH (as supplied)	:	4.5
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Floctreat 77-75
Supplier	:	Houseman
Appearance	:	Yellow-brown liquid.
Solubility	:	Completely water soluble.
Active Content	:	40%
Spec. Grav. (25°)	:	1.2
pH (as supplied)	:	6.5
Charge	:	Positive, medium
Molecular Weight	:	Low

Product	:	Polymer 1192
Supplier	:	Betz
Appearance	:	Clear yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	-
Spec. Grav. (20°)	:	1.032
Density (20°)	:	8.60 lbs./gal.
pH (as supplied)	:	6.4 ± 0.5
Charge	:	Positive
Molecular Weight	:	Medium

POLYAMINE POLYMERS

Product	:	Superfloc C521.
Supplier	:	Cyanamid
Appearance	:	Amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	-
Spec. Grav. (25°)	:	1.14
pH (as supplied)	:	5.0-7.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Superfloc C573
Supplier	:	Cyanamid
Appearance	:	Amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	-
Spec. Grav. (25°)	:	-
pH (as supplied)	:	-
Charge	:	Positive
Molecular Weight	:	Low

Product	:	Superfloc C577.
Supplier	:	Cyanamid
Appearance	:	Amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	-
Spec. Grav. (25°)	:	1.14-1.18
pH (as supplied)	:	5.0-7.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Superfloc C581
Supplier	:	Cyanamid
Appearance	:	Amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	-
Spec. Grav. (25°)	:	1.14-1.18
pH (as supplied)	:	4.0-6.0
Charge	:	Positive
Molecular Weight	:	Medium

Product	:	Maxfloc 45
Supplier	:	Maxwell Chemicals
Appearance	:	Pale amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	20%
Spec. Grav. (25°)	:	-
pH (as supplied)	:	Acidic
Charge	:	Positive
Molecular Weight	:	-

Product	:	Maxfloc 753
Supplier	:	Maxwell Chemicals
Appearance	:	Pale amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	40%
Spec. Grav. (25°)	:	-
pH (as supplied)	:	Acidic
Charge	:	Positive
Molecular Weight	:	-

EPI/DMA POLYMERS

Product	:	Bubond 65
Supplier	:	Buckman Laboratories.
Appearance	:	Pale amber liquid.
Solubility	:	Completely water soluble.
Active Content	:	-
Density (25°)	:	1.09 g/ml
pH (as supplied)	:	4-6
Charge	:	Positive
Molecular Weight	:	-

POLYALUMINIUM CHLORIDE / POLYDADMAC POLYMER BLENDS

Product	:	Catfloc 2963
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	29% (PACl+Polymer)
Spec. Grav. (25°)	:	1.25
Density	:	10.4 lbs./gal
pH (as supplied)	:	2.2 ± 0.3
Charge	:	Positive
Molecular Weight	:	-

Product	:	Catfloc 2973
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	29% (PACl+Polymer)
Spec. Grav. (25°)	:	1.26
pH (as supplied)	:	2.2 ± 0.3
Charge	:	Positive
Molecular Weight	:	-

Product	:	Ultrion 8109
Supplier	:	Catoleum
Appearance	:	Pale green to amber liquid.
Solubility	:	Completely water soluble.
Al_2O_3	:	≈10.0%
Active Polymer	:	-
Spec. Grav. (25°)	:	1.25
Density	:	10.4 lbs./gal.
pH (as supplied)	:	2.2
Charge	:	Positive
Molecular Weight	:	Low

Product	:	Floctreat 76-36
Supplier	:	Houseman
Appearance	:	Pale yellow clear liquid.
Solubility	:	Completely water soluble.
Al_2O_3	:	≈11.0%
Active Polymer	:	-
Spec. Grav. (25°)	:	≈1.2
pH (as supplied)	:	≈2.5
Charge	:	Positive
Molecular Weight	:	Low

ALUM / POLYDADMAC POLYMER BLENDS

Product	:	Catfloc K-5
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	≈50% (Alum+Polymer)
Spec. Grav. (25°)	:	1.25
Density	:	10.8 lbs./gal.
pH (as supplied)	:	1.2-3.2
Charge	:	Positive
Molecular Weight	:	Low

Product	:	Catfloc K-10
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Clear to pale yellow liquid.
Solubility	:	Completely water soluble.
Active Content	:	≈50% (Alum+Polymer)
Spec. Grav. (25°)	:	1.25-1.37
Density	:	10.9 lbs./gal.
pH (as supplied)	:	1.0-2.8
Charge	:	Positive
Molecular Weight	:	Low

FERRIC CHLORIDE / POLYDADMAC POLYMER BLENDS

Product	:	Catfloc 8964
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	Dark brown liquid.
Solubility	:	Completely water soluble.
Active Content	:	≈40% (Ferric Chloride+Polymer)
Spec. Grav. (25°)	:	1.40
Density	:	11.7 lbs./gal.
pH (as supplied)	:	1.0
Charge	:	Positive
Molecular Weight	:	Low

CATIONIC POLYACRYLAMIDES

Product	:	Magnafloc LT22
Supplier	:	Allied Colloids
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Bulk Density	:	0.55-0.75
pH (soln.)	:	-
Charge	:	Medium/Low Positive
Molecular Weight	:	High

Product	:	Profloc 1XC, Profloc 2XC
Supplier	:	ICI
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (1% soln.)	:	5000, 3000 cps
pH (soln.)	:	-
Charge	:	Low, Medium Positive
Molecular Weight	:	Very High, High

Product	:	FO 4107 SH, FO 4115 SH, FO 4140 SH
Supplier	:	Floerger (Nufarm)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (5g/l soln.)	:	300, 250, 400 cps
Bulk Density	:	≈0.80
pH (soln.)	:	-
Charge	:	Low Positive
Molecular Weight	:	High; $14x10^6$, $14x10^6$, $13x10^6$

Product	:	Praestol 311 TR, Praestol 321 TR
Supplier	:	Stockhausen (Henkel)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (1.0% soln.)	:	100-300 mPa.s, -
Bulk Density	:	670±50, 620±50 kg/m^3
pH (10g/l)	:	3.5-5
Charge	:	Low, Medium Positive
Molecular Weight	:	High;

Product	:	Durafloc 2271, Durafloc 2272 PWG
Supplier	:	Floerger (AKZO)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Bulk Density	:	0.80-0.85
pH (soln.)	:	-
Charge	:	Positive
Molecular Weight	:	High

Product	:	Floctreat 79-80
Supplier	:	Houseman
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
pH (1% soln.)	:	≈7
Charge	:	Low Positive
Molecular Weight	:	Medium

NON-IONIC POLYACYLAMIDES

Product	:	Magnafloc LT20
Supplier	:	Allied Colloids
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Bulk Density	:	0.55-0.75
pH (soln.)	:	-
Charge	:	Neutral
Molecular Weight	:	High

Product	:	Profloc 1XF, Profloc 1XF PW, Profloc 3XF
Supplier	:	ICI
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (1% soln.)	:	2500 cps
pH (soln.)	:	-
Charge	:	Neutral
Molecular Weight	:	High, High, Very High

Product	:	FA 920 SEP/PWG
Supplier	:	Floerger (Nufarm)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (5g/l soln.)	:	70 cps
Bulk Density	:	0.75
pH (soln.)	:	-
Charge	:	Neutral
Molecular Weight	:	High; $15x10^6$

Product	:	CA 233
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (0.8% soln.)	:	75 cps
Bulk Density	:	42-49 lbs./cu.ft.
pH (0.1% soln.)	:	7.0
Charge	:	Neutral
Molecular Weight	:	High

Product	:	Maxfloc 301 PWG
Supplier	:	Maxwell Chemicals
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Bulk Density	:	0.8 gm/cc
pH (1% soln.)	:	5.5-6.5
Charge	:	Neutral
Molecular Weight	:	High

Product	:	Floctreat 78-10
Supplier	:	Houseman
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (soln.)	:	-
Bulk Density	:	-
pH (0.1% soln.)	:	7.0
Charge	:	Neutral
Molecular Weight	:	High

ANIONIC POLYACRYLAMIDES

Product	:	Magnafloc LT25
Supplier	:	Allied Colloids
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Bulk Density	:	0.55-0.75
pH (soln.)	:	-
Charge	:	Negative
Molecular Weight	:	High

Product	:	Profloc 1XI, Profloc 1XI PW, Profloc 2XI
Supplier	:	ICI
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (1% soln.)	:	3500, 3500, 7500 cps
pH (soln.)	:	-
Charge	:	Low, Low, Medium Negative
Molecular Weight	:	High, Very High, Very High

Product	:	AN 905, 910, 912, 913, 923, 934, 945, 956 SEP/PWG
Supplier	:	Floerger (Nufarm)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (5g/l soln.)	:	600, 900, 100, 1200, 1500, 1800, 2200, 2000
Bulk Density	:	0.80
pH (soln.)	:	-
Anionicity (moles %)	:	5, 10, 3, 15, 20, 30, 40, 50
Molecular Weight	:	High; $15x10^6$

Product	:	CA 243, CA 253
Supplier	:	Calgon (Hall Laboratories)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (0.5% soln.)	:	5000, 1800 cps
Bulk Density	:	30-40 lbs./cu.ft.
pH (0.1% soln.)	:	7.0-8.5
Charge	:	High, Medium Negative
Molecular Weight	:	High

ANIONIC POLYACRYLAMIDES (cont.)

Product	:	Superfloc A2100, A2110, A2115, A2120, A2125, A2130, A2150
Supplier	:	Cyanamid
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (0.5% soln.)	:	500, 700, -, 800, -, 850, 900 cps
Bulk Density	:	750, 800, -, 800, -, 825, 850 ± 50 g/l
pH (1% soln.)	:	-
Charge	:	Increasing Negative
Molecular Weight	:	High

Product	:	Praestol 2515, 2530, 2540 TR
Supplier	:	Stockhausen (Henkel)
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (0.5% soln.)	:	1000, 1300, 1600 mPa.s
Bulk Density	:	620-720, 650-750, 680-780 g/l
pH (0.1% soln.)	:	7.0-8.0
Charge	:	Low, Medium, Medium Negative
Molecular Weight	:	High

Product	:	Polymer 1100, 1110, 1120
Supplier	:	Betz
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (0.5% soln.)	:	1500, 2300, 2000-3000 centipoises
Bulk Density	:	42-48, 44-51, 42-50 lbs./cu.ft.
pH (0.1% soln.)	:	-
Charge	:	Low, Medium, High Negative
Molecular Weight	:	High

Product	:	Maxfloc 304
Supplier	:	Maxwell Chemicals
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (0.5% soln.)	:	-
Bulk Density	:	0.8 gm/cc
pH (0.1% soln.)	:	5.5-6.5
Charge	:	Negative
Molecular Weight	:	High

Product	:	Floctreat 78-70
Supplier	:	Houseman
Appearance	:	White Powder
Solubility	:	Completely water soluble.
Active Content	:	≈90%
Viscosity (0.5% soln.)	:	-
Density	:	-
pH (1% soln.)	:	≈7.0
Charge	:	Low Negative
Molecular Weight	:	High

LATEX EMULSIONS

Product	:	POL-E-Z 652, 675, 692
Supplier	:	Hall Laboratories
Appearance	:	Opaque, white liquid
Solubility	:	Completely water soluble.
Active Content	:	≈50%, ≈50%, ≈40%
Viscosity (1% soln.)	:	-, 75-100, 200-400 cps
Density	:	8.7, 8.7, 8.82 lbs./gal.
Spec. Grav. (25°)	:	1.02-1.08, 1.01-1.07, 1.03-1.09
pH (1% soln.)	:	-, 5.7, 5.7
Charge	:	Non-ionic, Negative, Negative
Molecular Weight	:	High

Product	:	Polymer 1115L
Supplier	:	Betz
Appearance	:	Opaque white liquid
Solubility	:	Completely water soluble.
Active Content	:	-
Viscosity (1% soln.)	:	180-270 cps
Spec. Grav.(25°)	:	1.008
pH (1% soln.)	:	-
Charge	:	Low Negative
Molecular Weight	:	High

ACTIVATED SILICA

Product	:	Activated Silica (Chlorine Activated)
Supplier	:	Crompton & Sons
Appearance	:	Clear liquid
Solubility	:	Completely water soluble.
Active Content	:	≈1.4 g SiO_2/l
Viscosity (1% soln.)	:	-
Spec. Grav.(25°)	:	-
pH (1% soln.)	:	-
Charge	:	-
Molecular Weight	:	High

UWRAA RESEARCH REPORTS

Report No.	Title	Author
1	Trickling filter - solids contact process: Pilot plant studies.	M. Laginestra
2	A model of water pricing for Melbourne, Sydney and Perth	P.B. Dixon P.M. Norman
3	Taste generation associated with chloramination	M. Kerslake
4	Bacterial regrowth in water supplies	K. Power L.A. Nagy
5	Leakage management: Assessing the effect of pressure reduction on losses from water distribution systems	B. Horvath
6	Improving communication with the public on water industry policy issues	B.E. Nancarrow G.J. Syme
7	Water use efficiency of domestic appliances	I.J. Beith D.J. Horton
8	Pilot plant study of fermentation units to increase degradable COD fraction in sewage.	P.J. Bliss D. Barnes P.R. Evans I. Law
9	Artificial destratification of water storages in Australia.	T.F. McAuliffe R.S. Rosich
10	Taste thresholds of monochloramine and chlorine in water	R. O'Halloran C. Veres
11	Chromatographic analysis of chloramines using electro-chemical detection	R. O'Halloran Hai Lin Ge P. Spizziri
12	Glass reinforced plastic bore casing for large diameter and deep bores	R. Bowyer
13	A guide to improving communication with the public on water industry policy issues	B.E. Nancarrow G.J. Syme
14	Fouling and cleaning of fine bubble ceramic dome diffusers	K.J. Hartley
15	Chloramination of Water Supplies	P.M. Thomas (ed)
16	The 1988 Australian Winter Storms Experiment: Report on aircraft observations	J.B. Jensen
17	Pipeline assets: Life cycle management and economic life	R. Vass M. Anderson R. Lewis D. Samson
18	Development of empirical model for tradewaste discharges to small treatment plants	Camp Scott Furphy
19	PRELIM users guide (Amended): Australian Version	Camp Scott Furphy
20	Chemical regeneration of activated carbon: Preliminary studies	G. Newcombe
21	Management and display of dam surveillance data	D.M. Stirling G.L. Benwell A.B. Murnane
22	Evaluation and demonstration facilities for primary sensors	J.A. Lanaway M. Cavey
23	Modelling and design of reservoir aeration destratification systems	D.P. Lewis J.C. Patterson J. Imberger R.P. Wright S.G. Schadlow
24	Modelling optimum conditions for reservoir destratification using mechanical mixers	R.M.A. Velzeboer J.A. Cugley J.C. Patterson
25	Methods for detection of *Giardia* and *Cryptosporidium* in water: A preliminary assessment	C.A. Bee P.E. Christy B.E. Robinson
26	Toxic cyanobacteria in water supplies: Analytical techniques	D.J. Flett B.C. Nicholson
27	Tracing toxic discharges to sewers by analysis of biofilms	D. Oliver T. Watson
28	Electronic meter reading: Link between water meter and house	P.J. Reid J.S. Renwick M.F. Prior
29	Identification of common noxious cyanobacteria: Part 1 – Nostocales	P. Baker
30	Forecasting water demand using weather data	M.N. Viswanathan
31	Effects of controls on water consumption	M.N. Viswanathan
32	Biological removal of iron from groundwater: Preliminary studies	M.N. Viswanathan
33	Statistical modelling of water main failures	E. Tsui G. Judd
34	Stratification, mixing and water quality in Darwin water supply reservoirs	R. Lukatelich D. Robertson K. Boland J. Imberger J. Patterson
35	Performance auditing in the Australian urban water industry	S. O'Kane I. Parry D. Blunden D. Herring
36	Microbiological studies on enhanced removal of phosphates from sewage	R.C. Bayly J.W. May G. Vasiliadis G.N. Rees
37	Magnetite and microwaves in sewage effluent treatment	D.R. Dixon A.J. Ware
38	Polymer based electrode for the selective detection of dichloramine	Y. Lin G.G. Wallace
39	Current cost asset valuation: Methodology	J. Dyke
40	Community analysis of household water pressure satisfaction	G.J.Syme B.E.Nancarrow B.J.Bishop P.VanderWal

UWRAA RESEARCH REPORTS

Report No.	Title	Author
41	Assessment of coagulants for water treatment	C. Donati
42	Coagulants for water treatment: A generic guide	ACWQR
43	Optional prices for urban water: A general equilibrium model applied to Melbourne	P.B. Dixon D.J. Baker

Report No.	Title	Author