Emerging trends in Water Clarification

Using

Efficient & Eco-Friendly Coagulants

By

D. K. Jain

President – Marketing

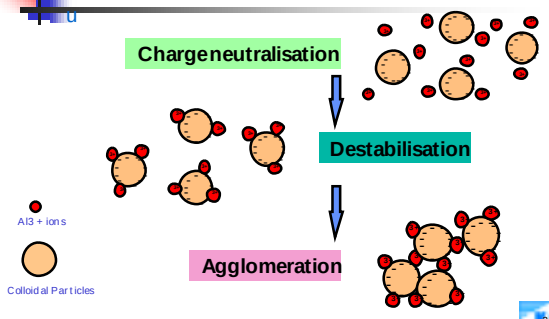
Kanoria Chemicals & industries Ltd.

Delhi

Process of Water Clarification

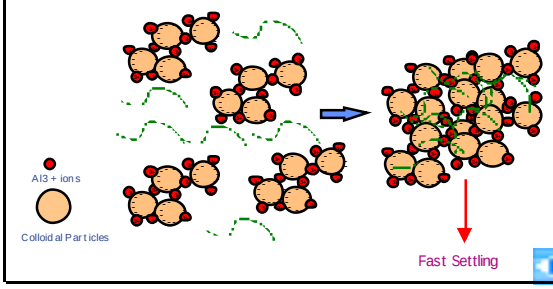
- **Removal of Suspended/Colloidal particles by:**
  - **Coagulation** – Charge Neutralization/ Destabilization of colloidal species
  - **Flocculation** – Adsorption of destabilised particles onto intentionally formed flocs
  - **Sedimentation** – Settling of flocs
  - **Filtration**

Mechanism of Coagulation



Mechanism of Flocculation

(Adsorption of Neutralized Colloidal particles on flocs)



Requirements of Ideal Coagulant

- Effective over wide pH range of water
- Efficient over broad temprature range
- Effective on low to high turbidity range

To meet following objectives:

- Decrease of turbidity
- Limited pH change
- Limited increase of TDS
- Higher stability of flocs
- Less sludge

Options available

Conventional Coagulants

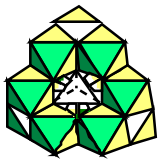
- Alum - Huge infra..for storage & soln prep.
- Ferrous Sulphate – Tremendous sludge
- Ferric Chloride – Inefficient, additional Chloride & sludge

New Coagulants

- Polyaluminium Chloride(PAC)
- (presently produced in India)
- Polyaluminium Chloride Sulphate (PACS)
- (presently produced in India)
- Polyaluminium Sulphate (Not yet produced in India)
- Polyaluminium Chloride Silicate (Not yet produced in India)

Structures of Al Ions

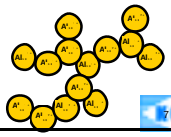
Monomeric Al^{3+}



$[Al_{13}O_4(OH)_{24}(H_2O)_{12}]^{7+}$

Oligomeric:

Al_2^{4+}, Al_3^{5+}, Al_4^{6+}, Al_{13}^{7+}



Polymeric :

Al_{13}-Cluster ,

Charged Species of Al

Monomer	Oligomer	Polymers
Al^{+3}	$Al_2(OH)_2^{+4}$	$[Al_{13}O_4(OH)_{24}]_n^{+7}$
		Where n =2,3,4,...n
$Al\,OH^{+2}$	$Al_3(OH)_4^{+5}$	
$Al(OH)_2^{+1}$	$Al_6(OH)_{12}^{+6}$	
$Al(OH)_3$	$Al_{10}(OH)_{22}^{+8}$	
$Al(OH)_4^{-1}$	$Al_{13}O_4(OH)_{24}^{+7}$	
$Al(OH)_5^{2-}$		

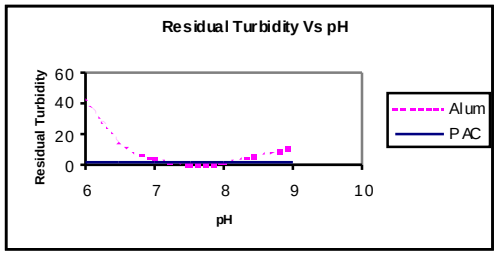
Comparative Constituents

More Polymeric Constituents → More effective Coagulation

Coagulant	Monomer	Oligomer	Polymer
Alum Soln.	~ 23 %	~ 73 %	~ 4 %
PAC-10 (high bacisity)	~ 13 %	~ 25 %	~ 62 %

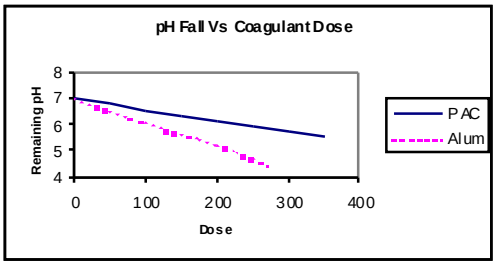
9

pH Vs Residual Turbidity



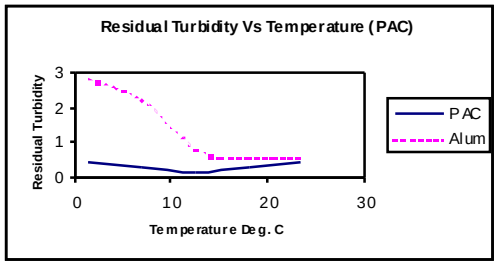
10

pH Fall Vs Coagulant Dose



11

Residual Turbidity Vs Temperature



12

IS specifications for liquid PAC (IS15573:2005) & Alum (IS 299: 1989)

SN	Characteristics	Unit	PAC High Basicity grade	Alum
1.	Aluminium as Al_2O_3, Min.	%	10.2	15.0
2.	Chlorides as Cl^-, Max.	%	10.5	N/S
3.	Basicity, Min.	%	64	0.5
4.	Sulphate as SO_4^{2-}, Max.	%	2.5	N/S
5.	Specific gravity at 25° C, Min.		1.18	N/S
6.	Viscosity (dynamic) at 20° C	mPa	3-30	N/S
7.	Insoluble, Max.	%	0.5	0.5
8.	pH (5% solution)		2.5-4.5	2.7
9.	**Toxic substances, Max.**			
	i. Mercury (as Hg)	ppm	0.2	N/S
	ii. Arsenic (as As)	ppm	5	6
	iii. Cadmium (as Cd)	ppm	6	N/S
	iv. Lead (as Pb)	ppm	30	30
	v. Iron (as Fe)	ppm	100	700
	vi. Manganese (as Mn)	ppm	15	N/S
	vii. Aluminium (as Al)	ppm	0.2	N/S

Advantages of PAC/PACS

1: High Performance/Efficient

A) Strong Coagulating Capacity – Low consumption
B) Only 30 – 50 % consumption of alum
C) Effective over wide pH, Temp. & Turbidity range – No need of additional chemicals for pH adjustment

Advantages of PAC/PACS:

2. User Friendly:

A) Available in ready to use liquid form
B) Saves labor, power & handling hassles

Chemical	Quantity per day	Solution Volume	Dose per hour	Ratio Volume
Alum	300 Kg	6000 Ltr. 5 % solution	250 Ltr.	60
PAC	120 Kg	100 Ltr. Neat	4.2 Ltr.	1

Advantages...

- 3. Eco-friendliness:
- Less chemical loading due to low rate of application (30-50% of alum)
- Low requirement of Aluminium
- Less sludge formation (30-40% of alum)
- Less ionic load in treated water (~15% of alum)
- Less wastage of water in back washing and sludge disposal

Intangible Benefits

1. More effective removal of pathogenic bacteria, viruses, heavy metals, dissolved organic carbon
2. Reduction in frequency of back wash of filters
3. Savings due to less sludge disposal
4. Higher yield of treated water due to less sludge formation (30-40 % of alum)

Comparison of chemical loading on the system

Item/ Quantity	Aluminium	Sulphate	Chloride	Total added TDS Excluding Al.
Alum 1000 gm	86 gms	460 gm	Nil	460 gms ~ 46 ppm
PAC, 400 gm	21 gm	8 gm	40 gm	48 gms ~ 5 ppm

Dosage : Alum 100 ppm (1 kg/10 M^3 of water)
PAC 40 ppm(0.4 kg/ 10 M^3 of water)

Advantages in DM process

1. Lesser increase in ionic load on the system
2. Reduced resin regeneration cost due to reduced consumption of HCL & Caustic
3. Savings in raw materials (natural resources) like power (eg. for 1MT caustic 3000 KW power)
4. Increased life of expensive ion exchange resins
5. Reduced water loss

Comparative usage of PAC vis-à-vis alum in a Water Treatment cum DM Plant

(Capacity – 2400 M^3/day, Turbidity RW – 100 NTU)

Chemicals for clarification	Consumption Per month(Kg.)	Cl^-	SO_4^{--}	Ca^{++}	Total Kg.	Caustic lye Eq.Con) @Rs. 11 per kg* 70% efficiency	HCl @ Rs. 3.50 per kg 80% efficiency	Total Savings (Rs.) per month
Alum 80 ppm (192 Kg/day)	5760 Kg	–	2490 kg	–	2490 Kg	6150 Kg Rs. 67650/-	–	
Lime 20 ppm 48 Kg/day	1440 Kg	–	–	780 Kg	780 kg	–	6000 Kg. Rs.21000/-	
Total:Alum & Lime 240 Kg./day	7200 Kg				3270 Kg	6150 Kg Rs. 67650/-	6000 Kg. Rs.21000/-	
PAC@40 % 32 ppm 76.8 Kg/day	2304 Kg	230.4 kg	36.84 Kg	–	267 Kg	864 Kg. Rs. 9504/-		
Difference PAC Vs Alum	4900 Kg.	+ 230.4 kg	-2453 KG	- 780 kg	- 3003 kg	5287 kg Rs. 58157/-		Rs. 79157/-

Annual Savings on use of PAC-10 ~ Rs. 9.5 Lacs (~Rs. 1.08 per M^3)
For 2000 MW plant averages consumption 2400 – 3000 KL/day – 9-12 lacs/year

Performance of PAC-10 at a Thermal Power Plant – Case Study

	Alum (non feric	PAC
Consumption/day	900 Kg.	320 Kg.
Running Filters for 800 KL/Hr.	4 filters required	Only 2 filters required, saving of 200 KL/day water used for back washing
Chemical Consumption	52.5 gm/KL with 0.1gm/KL PE	Only 18 gm/ KL without Polyelectrolyte
Treatment cost	Rs. 0.26/KL	Rs. 0.12/KL
Treatment cost/annum	11.5 Lacs	4.1 Lacs
DM Water output from resin beds	Lower	Higher (~ 40%)
Desludging Frequency	Higher	Lower(Almost half)
Consumption of NaOH & HCl for resin regeneration	Higher	Lower (Saving of approx. Rs. 0.86 /KL)
Life of Resin	More	Less
Pumping & maintenance Cost	Less	Higher
Dosing Volume	60 times higher	1/60th only

Performance of PAC-10 at a Thermal Power Plant (U.P.), DM Process

- Annual Savings by Using PAC Vs Alum
- Savings in chemical cost/year Rs. 7.4 Lacs
- Savings in energy consumption Rs. 0.44 Lacs
- Savings in maintenance cost Rs. 2.6 Lacs
- Savings of HCl & Caustic Soda Rs. 4.5 Lacs
- Savings in labour cost 0.94 Lacs
- Total Direct Savings : 15.88 Lacs/anum
- Addl. Benefits: Longer resin life – saving in resin make up costs

Plant results PAC in Drinking Water

Summary of Plant Scale Usage

- End result obtained with 3 ppm of PAC dosage is comparable to 10ppm of alum dosage
- This implies, dosage of PAC will be only 30% of that of alum dosage.
- Significant financial savings in chemical cost, labour, electricity & plant maintenance

Comparison of PAC/PACS Vs Alum in drinking water

PAC /PACS

$[Al(OH)_aCl_b]_n$ or $[Al(OH)_aCl_b(SO_4)c]_n$

- Strong coagulating power due to polymeric Al ions, eg. $[Al_{13}O_4(OH)_{24}(H_2O)_{12}]^{7+}{}_n$
- Ready to use, homogenous liquid – saves time, labour and money
- Lower Consumption(30 – 50% of alum)
- Full charge neutralization,
- larger & stable floc formation
- Quick sedimentation

Alum

$Al_2(SO_4)_3 \cdot 18\,H_2O$

- Low coagulating power due to only monomeric & oligomeric ions
- Non-uniform solid, requires Preparation of solution
- Higher consumption
- Incomplete charge neutralization due to smaller & less stable flocs
- Slow sedimentation

Comparison of PAC/PACS Vs Alum in drinking water

- Less pH fall, no need of pH booster
- Effective over a wide range of pH
- Effective over wide temp. and turbidity range
- Low residual Al about ~ 0.05 – 0.2 ppm
- Highly cost effective due to many intangible benefits :
  - Less sludge
  - Less addition of ions
  - Higher output of the plant
  - Less load on ion exchange resin
  - Lower power & chemical demand
  - Less capital cost
  - Savings on labour charges
- Much higher pH fall, alkali needed
- Effective in narrow range of pH, temp. and turbidity
- Higher residual Alumina about 0.2 – 0.5 ppm.
- Less economical, No indirect benefits over PAC.

PAC /PACS for Effluent Treatment

- Major Effluent Constituents
- Suspended solids
- Soluble organics
- Inorganic salts
- Inorganic/organic colloids
- Bacteria

Basis - Liquid-solid separation…..

Conventional Methods of Liquid Solid Separation

- Alum
  - Heavy metals & other impurities
  - Inconsistent treatment
- Ferrous sulphate + Lime
  - Heavy metals & other impurities
  - Re-colouring of treated effluent
  - High Iron Content
  - High sludge volume

Adding impurities……

Ultimate benefits with PAC/PACS

- Better charge neutralisation properties
- Heavy floc formation properties
- Purest form of raw material
- Absolutely non-toxic
- Consistent quality

Eco-friendly treatment of effluent…..

Taking care of environment makes pure business sense !

Summary Benefits at a glance

- Dosages - Lower and consistent
- Small drop in pH value and less/no need of pH booster
- Improved water quality
- Higher out put from the existing plant/ smaller treatment plant is required
- Power saving since no power requirement for making solution
- Reduced chemical loading means less addition of ions(TDS)
- Much lower residual Aluminium
- Easily manageable sludge
- Efficient even at low temperature

Polyaluminium Chloride & Polyaluminium Chloride Sulphate

We do not just supply a chemical for treatment with competent technical support

.....we have a passion for treating water

Thank You