BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXII No. 1/2010	96 - 100	Seria Tehnică

Iron (III) Chloride as Coagulation Agent in Cooling Waters

Ileana Cameniţă, Maria Moraru, Alexandra Şchiopescu

Universitatea Petrol-Gaze din Ploieşti, Bd. Bucureşti, 39, Ploieşti
email: imcamenita@yahoo.com

Abstract

This paper approaches a very important problem: industrial waters conditioning. Some aspects of coagulation phenomena in cooling water have been reported. The coagulant action of iron (III) chloride upon the feed water of cooling systems, with different addition of Mg-lignosulphonate and Na-tripolyphosphates was studied.

Key words: *coagulation agents, controlling turbidity*

Introduction

The turbidity of industrial water should be as low as possible. One of the waters treatment operator's primary tasks is controlling turbidity.

The measurement of turbidity is based on the optical obstruction of light rays passed through a water sample when compared, under the same conditions, with an arbitrary standard turbidity scale.

The turbidity of waters results from finely divided suspended particles.

Coagulation is required to agglomerate the suspended particles. Coagulants, chemicals that are added to the water to achieve coagulation, should have the following three properties [1-2]:

– trivalent metallic cations or polymers whose effectiveness as coagulants has been determined;

– nontoxic and without adverse physiological effects on human health;

– insoluble or low solubility in the pH range common in water- treatment practice. This is necessary in order to have an efficient coagulation process and to be able to leave the lowest possible residual of the chemical in the treated water.

The most commonly used coagulants in water and wastewater treatment include: aluminum sulphate, sodium aluminate, iron sulphate (II), iron sulphate (III), iron (III) chloride, polyelectrolyte coagulants (polyaluminum chloride and organic polymers) [3].

The trivalent ions are ten times more effective than the divalent ion.

It is thought that the coagulation of an aluminum or iron salts produces finely divided precipitates of the hydrous oxide. Neutralization of the positive charges by negative ions such as sulfate and chloride in the water causes coalescence of the fine particles, thus forming a porous precipitate of large volume.

For each coagulant there is an optimum pH zone for best coagulation.

The best pH for this precipitation is dependent not only on the coagulant, but also upon the mineral characteristics of the water.

The temperature of the water also affects the process of coagulation.

In general, successful coagulation involves three main factors [4]:

- the presence of a minimum quantity of aluminum or iron ions to form an insoluble floc;
- the presence of a strong anion such as sulphate or chloride;
- the pH of the water must be controlled within a definite range.

It is not possible to predict from the analysis of water which will be the best coagulant to use, the quantities that will be required or the optimum pH for control of the process.

Ferric coagulant may have some advantages when coagulating certain types of water: first, coagulation is effective over a wider pH range, usually from pH 4 to 9; second, a strong and heavy floc is produced, which can settle rapidly; third, ferric salts are more effective for removing color, taste and odor – producing matter [5].

For most efficient and economical coagulation it is necessary that laboratory tests be made with different coagulants at varied concentrations and varied pH levels.

Experimental Details

In this paper it was studied the coagulant action of iron (III) chloride ($FeCl_3 \cdot 6H_2O$) upon the feed water of cooling systems, with different addition of Mg-lignosulphonate (LGS-Mg) and Na- tripolyphosphates (IPF-Na).

The characterization of cooling waters has been reported (table 1).

Table 1. Characterization of cooling waters

Feed water sample	pH	HCO_3^- mg / l	Hardness mval Ca^{2+}/l	Conduct. µS/cm	Resistivity Ohm	TDS ppm	Salinity ppm
1	7.46	274.5	8.40	1300	756.6	792.7	675
2	7.97	274.5	9.04	1286	766.3	781.0	663
3	6.84	201.3	11.36	1643	598.6	1003.0	861

By treating of waters used in cooling systems with scales and corrosion inhibitors (Mg-lignosulphonate and Na-tripolyphosphates) at high temperatures, solid particles are formed in suspension or in colloidal state [6-7].

The studied mixtures were prepared from the feed water, by adding different quantities of Na-polyphosphates and Mg-lignosulphonate. These mixtures were heated and maintained at 90^{o}C, for 60 minutes.

The composition of the prepared mixtures is given in table 2.

The determination of turbidity was performed at 25^{o}C, by using the WTV430IR turbidimeter which measures the intensity of light scattered at 90 degrees as a beam of light passes through a water sample.

Table 2. The composition of the prepared mixtures

Water samples	Prepared mixtures composition
A	500 ppm TPF
B	500 ppm TPF + 100 ppm LGS-Mg
C	500 ppm TPF + 100 ppm LGS-Mg + 250 ppm $FeCl_3 \cdot 6H_2O$
D	500 ppm TPF + 100 ppm LGS-Mg + 500 ppm $FeCl_3 \cdot 6H_2O$

Results and Discussion

The results obtained for the turbidity values, expresses in NTU (Nephelometric Turbidity Units), have been reported in tables 3-6.

Table 3. Variation of turbidity with time for water sample A

Time (min)	Turbidity (NTU)	Time (min)	Turbidity (NTU)
0	202	120	86.4
1	190	130	79.8
10	174	136	74.7
25	168	164	58.7
30	165	175	55.8
47	153	193	48.5
66	145	205	45.7
92	114	216	42.1

Table 4. Variation of turbidity with time for water sample B

Time (min)	Turbidity (NTU)	Time (min)	Turbidity (NTU)
0	543	42	285
6	515	62	212
12	475	82	149
17	438	102	98.5
22	409	128	87.8
27	371	158	44.0
32	346	171	41.0
37	317	212	38.8

Table 5. Variation of turbidity with time for water sample C

Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)	Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)
0	605	-	50	52.0	90.42
5	390	28.18	58	45.6	91.60
10	173	68.14	59	41.9	92.28
15	120	77.90	62	39.4	92.74
20	95.6	82.39	67	32.3	94.05
25	88.9	83.63	77	31.7	94.16
30	77.8	85.67	95	27.0	95.03
40	55.4	89.80			

Table 6. Variation of turbidity with time for water sample D

Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)	Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)
0	640	-	26	56.8	89.53
4	562	-	31	50.8	90.64
6	148	72.74	36	47.0	91.34
11	96.8	82.17	46	42.0	92.26
16	73.5	86.46	56	29.8	94.51
21	63.9	88.23	66	28.8	94.70

The variation of turbidity with time for the studied samples is represented in figure 1.

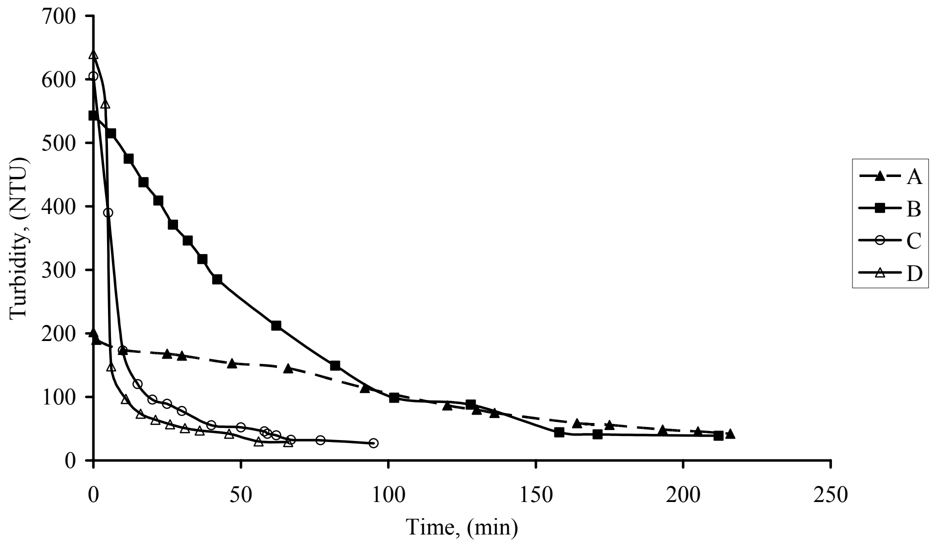

Fig. 1. Variation of turbidity with time for the studied samples

From the experimental data there were observed the following aspects:

- In cooling waters treated with Na-tripolyphosphate, at high temperature, there appeared solid particles in suspension, because of the transition to colloidal state of the complex compounds formed by the polyphosphates with calcium ions from waters.
- By adding Mg-lignosulphonate, there are formed complex combinations with calcium ions, which form colloidal solutions at high temperatures.
- The sedimentation of particles in suspension or in colloidal state is performed with a low rate in the absence of a coagulant agent.
- In presence of iron (III) chloride, the coagulation is performed with a high rate; the coagulation process takes place rapidly during the initiation step of the process. In time, the sedimentation rate decreases and after a period, it is attended an interval.

Conclusions

The coagulant agent – $FeCl_3$ – determines the coagulation and sedimentation of particles in suspension for the studied systems; very good efficiencies (about 90%) are obtained at a concentration of 250 ppm $FeCl_3 \cdot 6H_2O$, attending the admitted values for turbidity ($\tau < 35$ NTU) after approximately 1 hour.

The use of iron (III) chloride as coagulation agent presents some advantages compared to other coagulant agents (aluminum sulphate):

- by using $FeCl_3$, toxic substances do not result;
- the resulted solid residue can be introduced in soil, as a fertilizer while by using aluminum salts resulted aluminum hydroxide, which is toxic to plants and animals;
- iron (III) chloride actions in a large interval of pH (4-11) and it is also efficiently in cold water.

References

1. * * * - *Water Treatment Handbook,* Degremont, 7-th Ed., 2007;
2. Atkins, P., Paula, J. - *Physical chemistry for the live sciences*, New York, Oxford University Press, XVIII, 2006, p. 699;
3. * * * - *Betz handbook of industrial water conditioning*, 6-th edition, Betz, Pennsylvania, 1962;
4. Wang, L. K., Hung, Y.-T., Shammas, N. K. - *Handbook of Environmental Engineering, Volume 3: Physicochemical Treatment Processes*, The Humana Press Inc., Totowa, NJ, 2006;
5. Chifu, E. - *Chimie coloidală,* Editura Didactică şi Pedagogică, 1969;
6. Cameniţă, I., Brânzoi, I.V., Moraru, M., Şchiopescu, Al., Pântea, O. - Coroziune şi controlul coroziunii în apele de răcire, *Revista de Chimie*, Vol. 58, nr. 7, 2007;
7. Satterfield Z., P. E., Tech Brief, *Turbidity Control*, Summer, Vol. 6, Issue 2, 2006.

Clorura ferică utilizată ca agent de coagulare în ape de răcire

Rezumat

Lucrarea prezintă un aspect important: condiţionarea apelor industriale. Sunt prezentate câteva aspecte ale fenomenului de coagulare în apele de răcire. A fost studiată acţiunea coagulantă a clorurii de fier (III) asupra apelor de alimentare în sistemele de răcire, cu diferite adaosuri de lignosulfonat de magneziu şi tripolifosfat de sodiu.