BULETINUL Universităţii Petrol – Gaze din Ploieşti	Vol. LXIV No. 1/2012	101-105	Seria Tehnică

Iron (III) Chloride as Coagulation Agent in Industrial Waters

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This paper approaches a very important problem: industrial waters conditioning. Some aspects of coagulation phenomena in industrial waters have been reported. The coagulant action of iron (III) chloride upon the feed water was studied.

Key words: *coagulation agents, controlling turbidity*

Introduction

Characteristics of industrial wastewater vary depending on the type of industry that produces, which means the nature of the pollutants.

Effective methods for the removal of the colloidal substances as well as the suspended solids present in industrial water or surface water are coagulation and flocculation [1, 2].

One of the waters treatment operator's primary tasks is controlling turbidity.

The turbidity of industrial water should be as low as possible.

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:

- 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 work it has been studied the coagulant action of iron (III) chloride ($FeCl_3 \cdot 6H_2O$) on a clay suspensions of concentration 1%, determining the minimum concentration of precipitant agent that produces an evident coagulation.

It was studied also the variation of turbidity for clay suspension with different concentrations of coagulant agent, at a temperature of 25^o C.

Sodium bentonite clay was used. Chemical composition of clay was determined using röntgenographic analysis (fig. 1).

The determination of turbidity was performed at 25^oC, 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.

Results and Discussion

The results obtained for the turbidity values, expresses in NTU (Nephelometric Turbidity Units), have been reported in tables 1 – 3.

The variation of turbidity with time for the studied samples is represented in figure 2.

From the data obtained for turbidity variation vs. time it was observed that the coagulant agent - chloride iron (III)–determines the coagulation and sedimentation of particles in suspension (lowering the turbidity of analyzed suspensions in time).

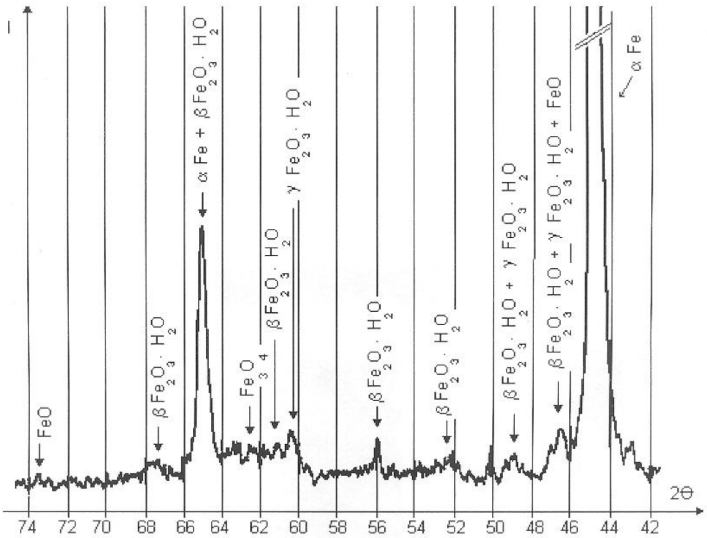

Fig. 1. Röntgenographic analysis of sodium bentonite clay

Table 1. Variation of turbidity with time for clay suspension by adding 100 ppm $FeCl_3 \cdot 6H_2O$ - (A)

Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)
0	170	-
4	178	-
8	175	-
13	172	-
17	171	-
23	166	2.35
50	148	12.94
60	139	18.23

Table 2. Variation of turbidity with time for clay suspension by adding 250 ppm $FeCl_3 \cdot 6H_2O$ - (B)

Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)	Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)
0	170.0	-	13	45.0	73.53
3	86.8	48.94	16	43.4	74.47
5	69.0	59.41	19	41.2	75.76
8	52.7	69.00	30	39.3	76.88
10	48.2	71.64	41	35.4	79.18

It was observed that for the addition of 100 ppm $FeCl_3 \cdot 6H_2O$ (suspension A) the process of sedimentation flows very slowly, without a complete sedimentation in due time (turbidity value decreased after 60 minutes from 170 to 139 NTU, what corresponds to a purge efficiency of this parameter of only 18%).

There was observed good efficiency in the process of suspensions sedimentation for the addition of $FeCl_3 \cdot 6H_2O$ 250 ppm and $FeCl_3 \cdot 6H_2O$ 500 ppm, noting that for the addition of $FeCl_3 \cdot 6 H_2O$ 500 ppm sedimentation is fast, i_{ee} = 80% after 5 minutes (τ < 35 NTU).

Table 3. Variation of turbidity with time for clay suspension by adding 500 ppm $FeCl_3 \cdot 6H_2O$ - (C)

Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)	Time (min)	Turbidity (NTU)	Efficiency, i_{ee} (%)
0	170.0	-	14	14.2	91.65
3	48.2	71.64	17	13.3	92.18
5	31.0	81.76	23	11.5	93.24
8	20.7	87.82	26	10.9	93.59
10	18.7	89.00	39	10.0	94.12
12	16.3	90.41			

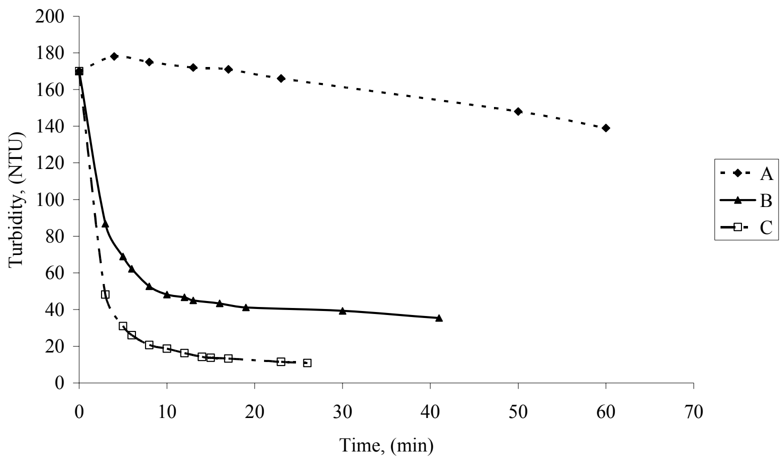

Fig. 2. Variation of turbidity with time for the studied samples (A – 100 ppm $FeCl_3 \cdot 6H_2O$; B – 250 ppm $FeCl_3 \cdot 6H_2O$; C – 500 ppm $FeCl_3 \cdot 6H_2O$)

As it is observed from Fig. 2, for suspensions B and C, the process of coagulation and sedimentation flows with high rates during the initiation stage of the process (the first 10 minutes), reaching practically a plateau profile after a certain time.

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 (τ < 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

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Clorura ferică utilizată ca agent de coagulare în ape industriale

Rezumat

Lucrarea prezintă un aspect important: condiționarea apelor industriale.
Sunt prezentate câteva aspecte ale fenomenului de coagulare în apele industriale.
A fost studiată acțiunea coagulantă a clorurii de fier (III) asupra unor suspensii de argilă.