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Flocculation process and Increasing sedimentation of total suspended solids in clarifier

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ABSTRACT

Sedimentation is the process of allowing particles in suspension in water to settle out of the suspension under the effect of gravity. The particles that settle out from the suspension become sediment, and in water treatment is known as sludge. Several factors can affect the sedimentation process including physical and environmental conditions. Increased pretreatment may be necessary when adverse conditions are present. Factors that affect the sedimentation process include the shape and size of particles, the density of particles, water temperature, Alkalinity of water, particle charge, dissolved substances in the water, environmental effects, and characteristics of the basin. Flocculation is the slow mixing process that causes smaller particles to merge into larger particles that settle more easily. Polymer flocculants are used to promote solid-liquid separation processes in potable water and wastewater treatment by controlling the rate of impacts between particles as they gain size. In this paper, the effect of increasing substance A23 to B90 polymer flocculant on the deposition of suspended solids is investigated. The results showed that by adding A2٣, the amount of particle sedimentation increases and water turbidity decreases, in addition by adding substance A23 to the polymeric flocculant, less amount of B90 flocculant polymer is required to increase the sedimentation efficiency.

1. Introduction

In wastewater treatment plants as well as in a variety of industrial processes, sedimentation tanks are used to separate suspended solids from water [1]. Sedimentation by gravity is the most common and extensively applied treatment process for the removal of solids from water and wastewater. Generically, such solids-liquid separation processes are sometimes referred to as clarification processes [2]. Several factors can affect the sedimentation process including physical and environmental conditions. Factors that affect the sedimentation process include the kind of flocculant shape and size of particles, the density of particles, water temperature, water PH, particle charge, and dissolved substances in the water, environmental effects, and characteristics of the basin [3,٤]. Smaller particles do not settle out easily and their size must be increased with coagulation and flocculation [5]. Smoother particles with less jagged edges settle out quicker and easier. Temperature decreases will cause the settling rate to decrease. The settling rate or velocity decreases when the water temperature is colder. Chemical dosage rates need to be adjusted during colder periods of the year or lower flows are necessary for the flocculation basins. kind of effective flocculant depends on particle charge and chemical activities of a particle in different PH Based on the functional group we have eleven groups of flocculants. Table.1 [6]

The function of anionic flocculant is based on latex polyacrylamide emulsion with high molecular weight.

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Latex polyacrylamide has a functional group of sulfuric acid, phosphoric acid, and carboxylic acid. High solubility and molecular weight make the polyacrylamide a suitable anionic flocculant. Anionic flocculants with water, form a soft gel and this soft gel covers the coagulated material all around, thus increasing its consistency. Important effective factors of polyacrylamide acid as **an**anionic flocculant are the ability of this compound to form hydrogen bonds and covalent bonds**and** the electronegativity of these compounds.

1. Flocculation Mechanism: According to recent reports, the flocculation mechanism in the presence of polysaccharide flocculants is considered to be due to the two main mechanisms: (a) charge neutralization; and (b) polymer bridging [7, 8]. Anyways depend on the kind of adsorption of polymer on particle surfaces as a result of electrostatic interactions, hydrogen bonding, hydrophobic interactions, complexation, or ion bridging by macromolecules [7].

1.1. Charge Neutralization: as shown in Figure 1. Charge neutralization (CN) can take place if the polymer has an opposite charge to that on the surface of the colloidal particles, in this case, the particle surface charge density is reduced by adsorption of the macromolecules which results in the destabilization of this particle [9].

A certain variation of this method is the so-called electrostatic patch model, which involves partial neutralization of the charge, which occurs in the presence of polyelectrolyte of not very high molecular weight. This process involves incomplete neutralization, thus the formation of positively and negatively charged fragments on the surface of the same molecule. (Shown in Figure 2b).

1.2. Polymer Bridging: In the case of the bridging mechanism (Figure 2), some polymer segments are adsorbed on the surface of colloidal particles, resulting in loops and tails suspended in the solution [8], which can attach to adjacent particles to form larger aggregates— flocks

The jar test is a common laboratory procedure used to determine the optimum operating conditions for water or wastewater treatment. This method allows adjustments in pH, variations in coagulant or polymer dose, alternating mixing speeds, or testing of different coagulant or polymer types, on a small scale to predict the functioning of a large-scale treatment operation **.**

In this study, Laboratory results have been collected by test jar and experimental results confirm this**.** we use the Jar test to investigate the effect of substance A23 on increasing the chemical activity of B90 as an anionic flocculant by increasing the alkalinity. As a result of this change sedimentation rate increased and suspended particles and turbidity amount decreased.

Table 1. Eleven groups of flocculator in terms of functional groups

Flocculant group	**Flocculant type**	**example**	**General mechanism**
Cationic polyacrylamide	High molecular weight (Mw) Low electric charge (Cd) density	Colloidal effect on anionic structures of latex polyester	bridging
Cationic polyethylene amine	High molecular weight (Mw) Low electric charge (Cd) density	Calcium carbonate suspension	Charge Neutralization bridging Electrostatic patch
Diallyl dimethyl ammonium chloride	Cationic polyacrylamide	Suspension of silk structures	Charge Neutralization bridging Electrostatic patch
Cationic polyacrylamide type two	Cationic polyacrylamide	Calcium carbonate suspension	bridging
Cationic polyacrylamide type three	Cationic polyacrylamide	Calcium carbonate suspension	bridging
Chemical coagulants	Inorganic Metal salts		Charge Neutralization
Chemical flocculant	Polyelectrolytes with high Mw and low Cw, Polyelectrolytes with low Mw and high Cw		Charge Neutralization bridging Electrostatic patch
Bio flocculant	Cationic Chitosan		Charge Neutralization bridging
Transplanted flocculant	Amphoteric, cationic, anionic		Charge Neutralization bridging

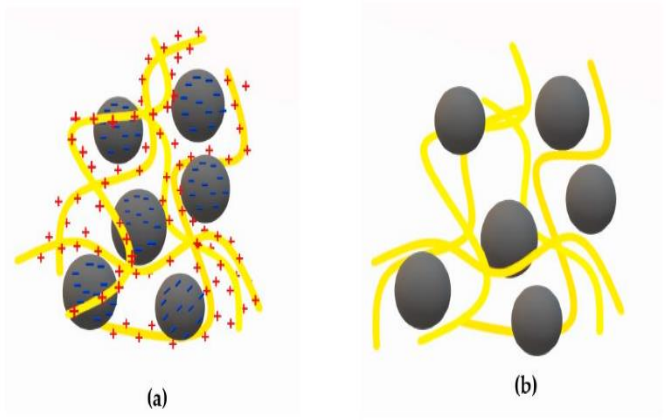

Figure1. Scheme of flocculation mechanisms (the curved lines represent polymer chains adsorbing to the spherical colloidal particles): (a) charge neutralization; and (b) polymer bridging

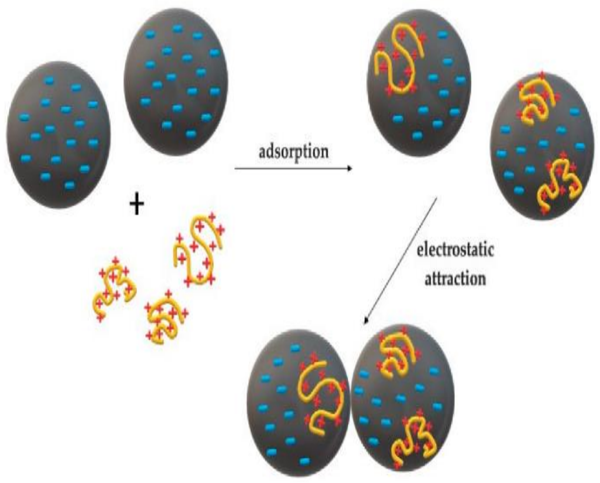

Figure 2: Mechanism of electrostatic patch model for flocculation

2.Experimental

The jar test is used to determine the amount of flocculant and substance 2 required as well as the optimum pH for flocculation. First, ۰/۵ grams of flocculant is poured in 1000 ml of water and slowly stirred until to dissolve all solid particles of flocculant. Then we add 7cc from A23 in B90 flocculant solution, obtained solution in different volumes added in six 500 ml beakers of Jar Test contain 500 ccs of water from the reduction process. (Table 2) The Jar Test Equipment (JTR90-ZAG Chemise, Iran, set to 150 rpm for 3 min, 100 rpm for 2 min and 50 rpm for 1min then beakers of sample water are stirred at certain speeds, after the stirring, we wait for two minutes then PH, Turbidity and EC parameters Was measured. PH measured with Lab pH meter inoLab® pH 7110 and EC with WTW - Portable conductivity meter ProfiLine Cond 7110 and turbidity HACH TL2300 Tungsten Lamp Turbidimeter.

Table 2: Solutions Concentration of B90 and Volume of sample water used in the jar test

Row	The Volume used from 500 ppm solution of B90 (cc)	The volume of sample Water	Solution concentration(ppm)
1	0.2	500	0.2
2	0.4	500	0.4
3	0.5	500	0.5
4	0.6	500	0.6
5	0.8	500	0.8
6	1	500	1

3. Results and Discussion

Process of Direct Reduction of Iron ore interring suspended solid particles, colloidal particles, and dissolved substances in process water. Their removal can take place as a result of the force of gravity (this applies to larger particles), and in the case of charged particles—in the process of flocculation. However, the most considerable difficulty in the treatment of water polluted with finely divided particles.

Flocculants are the agents used to bring about flocculation. Polymer flocculants are polymers with charged functional groups and are used to promote solid-liquid separation processes in potable water and wastewater treatment. This kind of flocculant can induce flocculation by neutralizing the surface charge of particles or by forming bridges between individual particles. Therefore, the preferred and commonly used method is flocculation, which most frequently requires the use of particular substances—flocculants (also called flocking or clarifying agents).

Factors Affecting Flocculation: The flocculation process and its effectiveness are influenced by many factors, such as the chemical structure and properties (including charge) of both the removed substance and flocculant (in the case of polymers important is also average molecular weight and its distribution), their concentration, environment pH, ionic strength, temperature, rate of mixing, and mechanism of the process [7, 10]. The most important factors discussed in recent studies are presented below.

1. Effect of Salt: As mentioned above, the electrolyte can play the role of coagulant which destabilizes colloids and initiates the aggregation process. Particles suspended in the solution are surrounded by a double electric layer which determines their mutual repulsion and the stability of the solution. Adding electrolyte (inorganic salt) causes a reduction of the double electric layer and formation and settlement of flocs [11]. The introduced electrolyte contributes to a change in the ionic strength of the solution. The rate of settlement generally increases with the salt concentration. However, excess salt can cause the opposite effect.

2. Effect of Shear Rate: The stability of flocs, necessary for their settlement, depends on the strength and number of interfacial interactions between agglomerated particles. If there are only weak and sparse contact points, the flocs can easily break into smaller and separated parts. One factor for the disintegration of the flocs is intensive mixing with high shear forces [12].

3. Kind and dose of flocculant: An important factor that significantly impacts the flocculation process is the concentration, or strictly speaking optimal dose of flocculant, both an insufficient and too high concentration makes the process ineffective. Another factor is the appropriate flocculation time, which depends on the type and number of impurities in the solution and the kind of flocculant. Since the size, shape, density, and speed of sediment settlement change over time, the changing hydrodynamics of sediments also affect the course of flocculation [١2,13].

4. Effect of pH: The study of the effect of pH on the collected samples shows that with increasing the pH of suspended solids, the output decreases, and the particle deposition rate increases [١4]. PH is one of the most important and effective factors in sedimentation. The effect of a coagulant and flocculant usually depends on the pH. The pH level is especially important in the selection of chemicals such as flocculant selection, corrosion control, and sediment control in the water pipes. Different types of water, based on their pH, need different coagulants. According to the diagram of Figure 3, to investigate the effect of pH on the sedimentation rate, a pulp sample was prepared as an experimental sample and the sedimentation rate of solids was measured with a pH between 8.7 and 11.43 (drawing the sedimentation curve of the sample at different pHs. And the sedimentation rate of each part was calculated. (As the pH increases, the sedimentation rate increases until it reaches its peak at PH = 11.37, and then the sedimentation rate decreases again [15, 16].

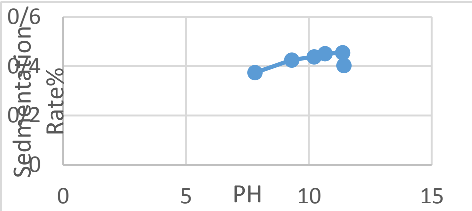

Figure3: Relationship between PH and sedimentation rate maximum amount is in PH:11.37

Table3: Result of jar test with flocculant 90B without A23, the optimal concentration of flocculant B90 in 0.8 pp

1			speed of fist step : 150,		second step 100,	third step 50 rpm
Row	floccoulant	Dosage of 90B (ppm)	Results			
			Turbidity (NTU)	EC((µS/cm)	TDS	PH
1	water Sample witout floccolant	0	346	1637	1022	7.77
2	water Sample+ 90B	0.2	112	1650	1017	7.84
3	water Sample+ 90B	0.4	126	1640	1025	7.86
4	water Sample+ 90B	0.5	126	1653	1025	7.87
5	water Sample+ 90B	0.6	110	1642	1018	7.88
6	water Sample+ 90B	0.8	46	1649	1022	7.87
7	water Sample+ 90B	1	35	1666	1033	7.69

Table 4: Result of gar test with flocculant B90 with 5cc of A23 optimal concentration is 0.5 ppm (PH=8.86)

2			speed of fist step : 150,		second step 100,	third step 50 rpm
Row	floccoulant	Dosage of 90B (ppm)	Results PH:8.86			
			Turbidity (NTU)	EC((µS/cm)	TDS	PH
1	water Sample witout floccolant	0	330	1590	986	7.48
2	water Sample+ 90B+A23	0.2	117	1650	1017	7.61
3	water Sample+ 90B+A23	0.4	39	1640	1025	7.65
4	water Sample+ 90B+A23	0.5	28.9	1653	1025	7.69
5	water Sample+ 90B+A23	0.6	38.7	1642	1018	7.76
6	water Sample+ 90B+A23	0.8	44.4	1649	1022	7.73
7	water Sample+ 90B+A23	1	36.8	1666	1033	7.73

Table 5: Result of jar test with flocculant B90 with 7cc of A23 optimal concentration is 0.4 ppm (PH=9.9)

3			speed of fist step : 150,		second step 100,	third step 50 rpm
Row	floccoulant	Dosage of 90B (ppm)	Results PH:9.9			
			Turbidity (NTU)	EC((µS/cm)	TDS	PH
1	water Sample witout floccolant	0	431	1638	1016	7.71
2	water Sample+ 90B+A23	0.2	40.8	1623	1006	8.06
3	water Sample+ 90B+A23	0.4	21.8	1652	1024	7.98
4	water Sample+ 90B+A23	0.5	28.8	1632	1012	7.95
5	water Sample+ 90B+A23	0.6	26	1625	1007	8.03
6	water Sample+ 90B+A23	0.8	23.9	1621	1005	8.06
7	water Sample+ 90B+A23	1	39.9	1675	1038	7.66

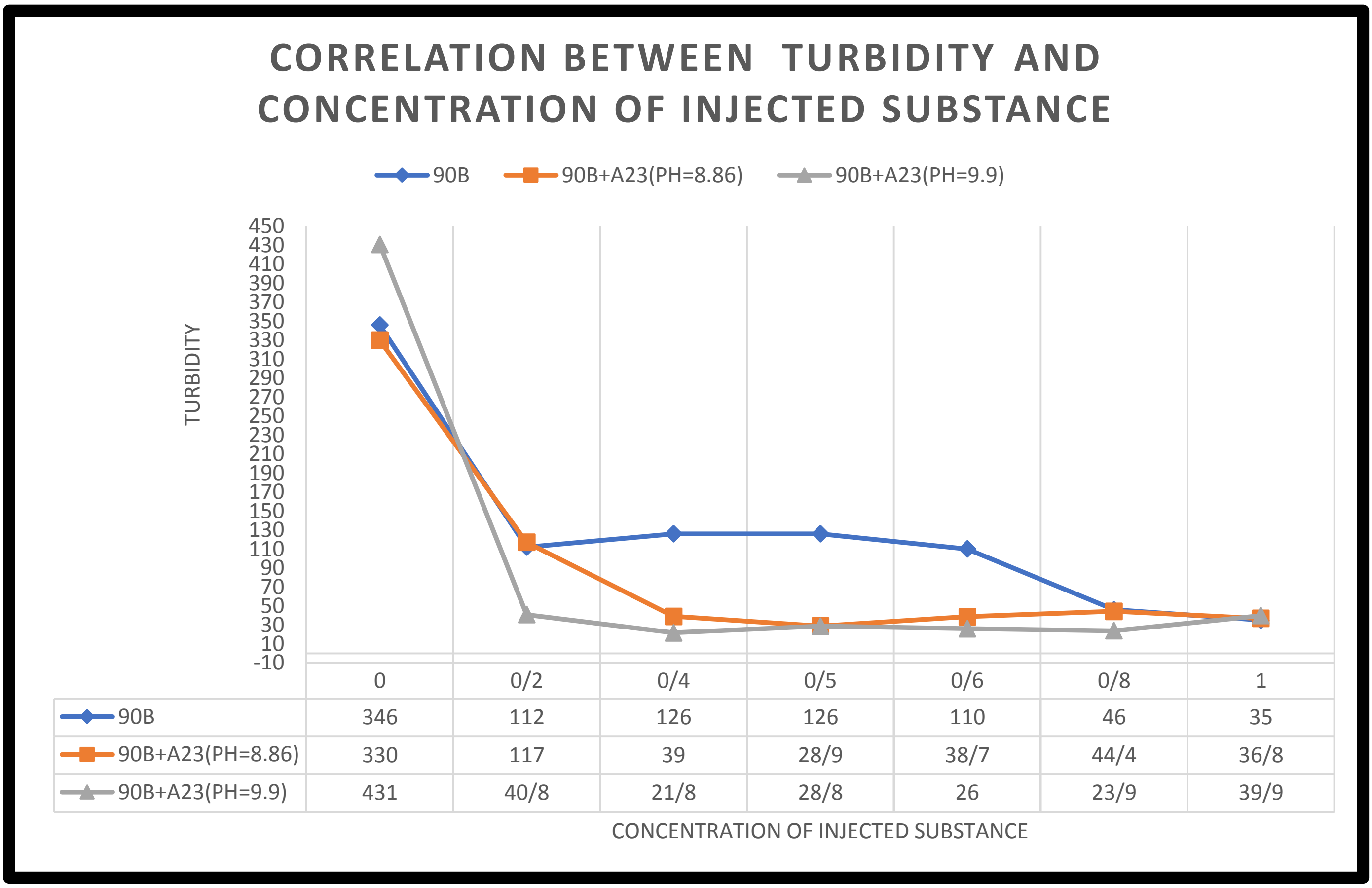

Figure4: Correlation between turbidity and concentration of 90B+A23 substance, the best result is for 90B+A23 (pH=9.9) diagram.

4. Conclusions:

Flocculants found applications in various technological processes that require water purification from different types of suspended particles (inorganic, organic, and microbial). They are used, among others, in the iron ore industry, dairy industry, petroleum industry, mining, metallurgy, papermaking, and in the treatment of drinking water and municipal sewage. Our paper aims to increase the effectiveness of flocculant on sedimentation of total suspended solids. For this purpose, due to the chemical nature of flocculant, substance A23 was added to the solution of B90 and its effect on increasing the sedimentation of suspended particles was confirmed by the Jar test and Reduction of turbidity of solutions

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