Studying the Effect of High Molecular Flocculants on Separation of Distillation Suspension - the Main Waste of Soda Ash Production

M H Kurbangaleeva¹

¹Department of General Chemical Technology Ufa State Petroleum Technical University, Sterlitamak branch pr-t Oktyabrya 2, Sterlitamak, 453118, Russia

E-mail: mhk2014@bk.ru

Abstract. Distillation suspension is a volumetric waste of soda ash production by the ammonia method which is discharged into sludge collectors (so-called "white seas") occupying hundreds of hectares of land and requiring large investment costs for their construction and maintenance. In order to reduce the volume of this waste, a method of filtering the distillation suspension is offered which results in formation of a clarified liquid and a solid part (cake). The effect of high molecular flocculants on the settling acceleration of solid part of distillation suspension is studied. To make a comparative analysis of various flocculants during the precipitation of solid part of distillation suspension, laboratory tests were conducted. For the experiments, the following flocculants were used: Praestol, Flopam, and Besflock. In laboratory experiments, 1% solutions of flocculants were used which were subsequently diluted to the desired concentration. Proceeding from the results of laboratory tests, it was shown that the effect of flocculants on the settling process acceleration of solid part of distillation suspension was different. Thus, it is established that the use of flocculants can be recommended to intensify the separation process of the solid part of distillation suspension - the main waste of soda ash production.

1. Introduction

At present, the manufacturing soda ash by the ammonia method remains the main one due to the usage of inexpensive and easily extracted raw material. The method of producing soda is well studied; technological processes are well-established and stable. With that, the resulting soda ash has a high quality at a comparatively low cost value.

Ammonia method of soda production continues to be the main one; however, serious drawbacks are inherent in this method. The main disadvantage is the low level of use of the feedstock that leads to formation of a large amount of highly mineralized aqueous solution, the so-called distillation liquid (distillation suspension) formed in the amount of 8-10 m³ per 1 ton of soda. This is predetermined by technology itself, due to which full utilization of raw materials is impossible [1,2].

2. Relevance and scientific significance with a brief review of literature

At present, the problem of waste utilization of soda ash production by ammonia method is rather acute in all countries producing soda by this method. The applied technologies of processing,
utilization and use of distillation liquid solve the problem only partly because of large amount of waste generated.

Basically, inefficient way of sewage treatment, namely sedimentation using slurry storages (so-called "white seas") occupying hundreds of hectares of land and requiring heavy investment costs for their construction and maintenance, is implemented. To reduce the volume of the distillation liquid formed, a method based on filtration of distillation liquid which results in formation of clarified liquid and solid part (cake), is offered. The process of separation of solid and liquid phases, namely the settling of the resulting suspension is time consuming task because the rate of separation of suspension depends on a number of factors: chemical composition of precipitate, deposition conditions, nature of floculent etc.

Recently, high-molecular flocculants have been widely used to intensify the separation of slurry suspensions [3-8]. Most of high molecular flocculants are represented as polyelectrolytes dissociating in water to ions. To date, the process of accelerating the separation of distillation liquid in the manufacture of liquid calcium chloride has been investigated, in which synthetic water-soluble polymers K-4, K-6, K-8 [9-11] are used. In the works [12-20], the process of separation of industrial suspensions by means of polyacrylamide is also considered. It is shown that almost instantaneous flocculation, rapid sedimentation and good compaction of the sludge takes place in the presence of polyacrylamide.

3. Formulation of the problem

Studying the influence of high-molecular flocculants on the process of separation of suspension into the solid and liquid phases.

For research, it was used the distillation suspension (main waste from soda ash the production) which is formed at the stage of distillation in the process of manufacturing soda ash and discharged into the sludge collectors of "white sea". Distillation suspension consists of following components (g/dm³): CaCl₂ - 115-125; NaCl – 55-58; suspended sedimentation CaCO₃-Ca(OH)₂, CaSO₄, Mg(OH)₂ - 20-25.

For experiments, the following floculants purchased at the company of Flocculanty.Ru (Kazan) were offered:
- Praestol 2510 (high-molecular electrolyte of anionic activity based on acrylamide of anionic co-monomer);
- FlopamAN 956 VHM (anionic polyacrylamide floculant);
- Besflock 4045 (high-molecular anionic floculant with high charge density).

During the tests, diluted aqueous solutions of floculants with a mass concentration of 0.0001% were used.

The experiments were carried out as follows: 250 g of distillation suspension was poured into the reaction flask; calculated amount of floculant solution was added; the contents were mixed for 5 minutes by means of magnetic stirrer, then the mix was poured into a graduated cylinder. After that, the rate of separation of the slurry suspension was observed. The sedimentation process lasts on the average 30 minutes.

Table 1 shows the results of investigation of the effect of floculants on concentration on the thickness of clarified layer of distillation suspension.

As can be seen from the Table 1, all the floculants under study more or less influence the rate of separation of suspension. At different concentrations of floculants, intensification of separation of the solid part of distillation suspension for the same time period is different. So, it is noted that sedimentation increases with increasing the concentration of floculants; maximum value is reached at concentration of 0.0003-0.0004% by weight.

It is established that the concentration of the additive is of great importance for the coagulation process, with the increase of which above the optimum the mixture stabilizes and the rate of separation slows down. Too high concentration of floculant deteriorates the cohesion of particles, since
supposedly the coating of particles of dispersed phase of suspension takes place and a protective layer preventing their coagulation is formed.

**Table 1.** Influence of concentration of flocculants on the height of the clarified slurry layer, mm (without additive - 60 mm).

| No | Name of flocculant | Thickness of clarified liquid, mm |
|----|---------------------|----------------------------------|
|    |                     | Concentration of flocculant, % wt. in distillation suspension |
|    |                     | 0.0001 | 0.0002 | 0.0003 | 0.0004 | 0.0005 | 0.0006 | 0.0007 |
| 1  | Praestol2510        | 95     | 100    | 100    | 100    | 95     | 93     | 90     | 80     |
| 2  | Flopam 956VHM       | 100    | 128    | 130    | 150    | 110    | 100    | 93     |
| 3  | Besflock4045        | 95     | 100    | 110    | 130    | 95     | 93     | 90     |

Set of data provided makes to suppose a possible flocculation mechanism for suspension of CaCO₃, Ca (OH)₂, Mg (OH)₂, CaSO₄ affected by the flocculants. The process obviously takes place in two stages: adsorption of the additive by the particles of dispersed phase and the sedimentation of floccules formed due to adsorption.

The adsorption of additives passes through the stage in which only a small fraction of macromolecules bind directly to the particles, while the unbound part of it freely penetrates into the solution and can form bonds with other particles. Figure 1 shows the dependence of thickness of the clarified layer of distillation suspension on time period with the use of flocculants.

![Figure 1](image URL)

**Figure 1.** Dependence of the thickness of clarified layer of distillation suspension on time period with the use of different flocculants: 1 - Flopam 956 VHM; 2 - Praestol 2510, 3 – Besflock 4045.

As can be seen from Figure 1, the maximum thickness of clarified layer of slurry suspension at the same time interval is maximally achieved through the use of flocculant Flopam AN 956 VHM.
4. Conclusion
Thus, as a result of the studies the possibility of intensifying the separation of distillation suspension in the presence of polymer additives has been established. For manufacturing application, flocculants Flopam AN 956 VHM, Besflock 4045 and Praestol 2510 can be recommended.

5. References
[1] Shokin I N 1975 *Soda Technology: Teaching Materials* (Moscow: Chemistry) p 287
[2] Tkach G A 1998 *Production of Soda by Low-Waste Technology: Monograph* (Kharkov) p 429
[3] Weitzer Yu I 1984 *High-Molecular Flocculants in the Processes of Purification of Natural and Waste Water: Teaching Materials* (Moscow: Stroyizdat) p 200
[4] Myagchenkov V A 1998 *Polyacrylamide Flocculants* (Kazan: Publishing house of Technol. University) p 288
[5] Yakovlev S V 1979 *Industrial Wastewater Treatment: Teaching Materials* (Moscow: Stroyizdat) p 320
[6] Zapolsky A K 1987 *Coagulants and Flocculants in Water Purification Processes. Properties. Receiving. Application: Teaching Materials* (Leningrad: Chemistry) p 208
[7] Myagchenkov V A 1998 *Polyacrylamide Flocculants Text* (Kazan: Kazan State Technological University) p 288
[8] Pushkarev V V 1975 *Physical and Chemical Features of Wastewater Treatment from Surface-active Substances: Textbook* (Moscow: Chemistry) p 144
[9] Kurenkov V F 1992 *Polyacrylamide* (Moscow: Chemistry) p 192
[10] Postoronko A I 2003 *Influence of Polyelectrolytes on the Separation of Suspension in the Purification of Natural Brines* (DonNTU: Chemistry and chemical technology Publication 61) pp 58-61
[11] Shrayban S S, Furman A A, Syrkina I G 1960 *Bulletin of Technical and Economic Information* (NIITEKHM No. 10) pp 22-24
[12] Rivny V S, Postoronko A I, Tchaus G S 1976 *Separation of Distillation Suspension in the Presence of Surfactant Additives* Collected book "Problems of chemistry and chemical technology" Edition 45 (Kharkov: Higher School) pp 91 - 93
[13] Dobrov I V 1995 *v Application of Functional Materials Based on Polyacrylamide as Flocculants for Water Purification and Water Treatment* (Chemical Industry. No 4) pp195-198
[14] Akselrud G A 1990 *Intensification of Clarification of Industrial Suspensions Using Modified Polyacrylamide* Journal Chemistry and technology of water vol. 12 No 1 pp 19-21
[15] Author's certificate 1520019 USSR, cl. C02F1/28.1989 *Water Purification from Suspended Solids* Bulletin No 411 p 2
[16] Ismailov Kh R, Zaynutdinov S A, Akhmedov K S 1970 *Interaction of Water-Soluble Polyelectrolytes with Dispersed Systems*1970 (Tashkent: FAN) p 125
[17] Lobanov F I, Korobov A S, Kuzmitsky V G, Spiridonova N N 2005 *Organization of Production of Polymer Flocculants Praestol in Russia and the Experience of their Application in the Municipal and Industrial Enterprises of Russia and the CIS/Materialsof II Int. scientific and practical Conf. devoted to the 1000th anniversary of Kazan (Kazan) pp140-142
[18] Kurenkov V F *Influence of Anionic and Cationic FlocculantsPraestol on the Flocculation of Kaolin Suspensions* Journal of Applied Chemistry vol. 72 No 11 pp1892-1896
[19] Ismailov Kh R, Zaynutdinov S A, Akhmedov K S 1972 *Water-Soluble Polyelectrolytes in Hydrometallurgy* (Tashkent: FAN) p47
[20] Myagchenkov V A 2001 *Dependenceofthe Flocculating Effectof Anionic and Cationic Polyacrylamide Flocculant sand their Mixtureonp Hofitie Medium. Chemistry and Technologyof Water* vol 20 No 3 pp 285-296
[21] Proskurina V E 1999 *Kinetics of Flocculation and Compaction of Ocher Suspension Sediment in the Presence of Anionic and Cationic Copolymers of Acrylamide with a High Content of Ionogen Links* Journal of Applied Chemistry vol 72 No 10 pp 1704-1708