Journal of
Chemical Engineering & Process Technology

zhe et al., J Chem Eng Process Technol 2015, 6:4
DOI: 10.4172/2157-7048.1000246

Research Article Open Access

A Novel Flocculant of Poly Aluminum Silicate Sulfate-Polyacrylamide Hybrid

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Abstract

A novel flocculant based on polyacrylamide-poly aluminum silicate sulfate (PAM-PASS) has been synthesized using a redox initiation system ($(NH_4)_2S_2O_8$–$NaHSO_3$) at 40℃ in aqueous medium. In this paper, the influence of the concentration of acrylamide, the mole ratio of aluminum to silicon, and pH value on the activation of silicate, which was prepared with the sodium silicate with the modulus of 3.3, was investigated. The results showed that the optimal process conditions for preparing PAM-PASS were as follows: silica concentration of 7%, aluminum silicon ratio of 3:1, and pH value of 3.0, acrylamide mass fraction of 20.7% of total material, aluminum hydroxide accounted for 7.5% of total material quality score with ammonium persulfate and sodium bisulfite as initiator, reaction temperature 40℃, PAM - PASS the synthesis of 3 hours.

The PAM-PASS was prepared at the optimal conditions mentioned above and used for the treatment of waste water. The rates of turbidity and color removal were 99.6% and 98.2%. Place the PAM - PASS in the air for 100 days the rate of deturbidity in a more than 90%. Respectively, when the dosage of PAM-PASS was 15 mg/L.

The PAM-PASS was characterized by viscometer, IR spectroscopy, TEM, SEM, conductivity, and TGA. It was found that an ionic bond exists between Al colloid and polyacrylamide (PAM) chains in the PAM-PASS; Silicon and aluminum form the amorphous polymer and the flocculation efficiency of PAM-PASS is much better than that of commercial polyacrylamide (PAM) and PASS.

Keywords: Flocculants; Organic-inorganic hybrid; PAM-PASS; Stability

Introduction

Flocculant including inorganic flocculant and organic flocculant. The advantages of inorganic flocculant are low price, safe and low toxicity, wide sources, low price, but it also have the shortcomings such as, small flocs formed, flocculant dosage, easily affected by the water quality and pH. On the contrary organic flocculant adsorption bridging capability is strong, small dosage, floc close together, but organic flocculant having some weakness: the weak of the abilities of neutralizing electric, the price is high, it is difficult to biodegradation exist the possibility of secondary pollution. In view of the merits and demerits of the two kinds of flocculants and complementarity on the performance and cost of the both, the research of inorganic-organic composite flocculants gradually becomes a hot spot. Inorganic-organic composite flocculants through the synergy of both of them, on the one hand, floc adsorption by inorganic flocculant, electricity neutralization and cohesion; On the other hand also through organic polymer bridging role, adsorption on the activity of organic polymer base, so that the other impurities particle coagulation together, play better than that of single flocculant flocculation effect [1].

Polysilicate flocculant was developed with polysilicic acid (PS) on the basis of the metal salt developed a kind of inorganic flocculant in the 1990s. The metal ions of polysilicic acid can not only improve the abilities of neutralizing electric charge, also combined with adsorption and the effect of capture which have widely research and application in recent years.

Poly aluminum silicate as the representative composite flocculant polysilicate products, still exist poor stability, flocculation of small flocs, floc is not quite close together, shortcomings and so on easily broken. Therefore, this article puts forward polyacrylamide is obtained by *in situ* dispersion polymerization -aluminum silicate composite flocculant (PAM-PASS), study the stability of poly aluminum silicate flocculant in and flocculation effect of improvements [2].

Experimental

Materials and instruments

Acrylamide was purchased from Tianjin blodi chemical Co., Ltd, chemical grade. Aluminum sulfate, ammonium carbonate, ammonium persulfate, sodium bisulfite, sodium hydroxide, vitriol were analytical grade. Distilled water was used throughout the experiments. Kaolin clay (1250 mesh) was purchased from Sinopharm Chemical Reagent Co., Ltd, Beijing, China. Nitrogen was purchased from Sizhi gas co., Ltd, Tianjin, China. Commercial sodium silicate (3.3M) was supplied by Shengpeng Chemical Company, Qingdao, China.

The main instruments are used in this study:turbidity meter measure (HI93703-11, Hanna, Italy), conductometer (FE30, Mettler Toledo, Switzerland), TEM (HT7700, HITACHI, Japan), SEM (SU-1510, HITACHI, Japan), TGA (Q50, TA Instruments, America), infrared spectrophotometry (WQF-51, Beifen-ruili, China)

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Received September 14, 2015; **Accepted** September 21, 2015; **Published** September 30, 2015

Citation: zhe L, dingwei C, wenjie W (2015) A Novel Flocculant of Poly Aluminum Silicate Sulfate-Polyacrylamide Hybrid. J Chem Eng Process Technol 6: 246. doi:10.4172/2157-7048.1000246

Synthesis

This paper experiment with *in situ* dispersion polymerization: for inorganic-organic complex compound, *in-situ* polymerization is evenly mixing nanoparticles with monomer, and under the condition of proper [3].

Silicic acid activation: Silicic acid activation was prepared by dropping 5 wt% dilute sulphuric acid into 7 wt% sodium silicate adjustment of PH value of 3.0, stir in 200 r/min, activation of activated silicic acid.

Preparation of poly aluminum silicate (PASS) [4]: Mixing aluminum sulfate and activated silicic acid solution in proportion, under 200 r/min for a period of time, we get the PASS.

Preparation of polyacrylamide-poly aluminum silicate (PAM-PASS): $Al(OH)_3$ colloidal solution was prepared by slowly dropping aqueous ammonium carbonate into aluminum sulfate under strong stirring at room temperature.

According to a certain proportion of acrylamide, aluminum, silicon, poly aluminum silicate, aluminum hydroxide colloid, acrylamide monomer to join the reactor, general nitrogen oxygen discharge reactor, water bath heating to 40℃, slowly add ammonium persulfate solution and sodium bisulfite solution as the initiator. Reaction after three hours and stop the reaction.

Characterization of PAM-PASS

Flocculation behavior: Kaolinite was used to make simulate wastewater (91-95 NTU chef turbidity) for flocculation experiment. Adding some flocculant mixing 10 min in 40 ~ 60 r/min speed, then stop stirring let stand for 10 min, use turbidity meter measure(HI93703-11, HANNA, Italy)before and after the treatment respectively turbidity, calculating the turbidity rate:

$$\text{Turbidity rate (\%)} = \frac{NTU_0 - NTU}{NTU_0} \times 100 \quad (1)$$

(1),NTU_0: turbidity removal before

NTU: turbidity removal after

Decoloration test: Will be in addition to the turbidity detection used in the wastewater treatment before and after the water samples, deal with ultraviolet-visible spectrophotometer (UV-2550PC, SHIMADZU, Japan) respectively scanning wavelength of visible light, scanning range is 400 ~ 700 nm, find out, the wavelength of visible light absorption peak corresponding to the largest in the water samples were measured under this wavelength absorbance, decoloring rate according to the type of calculation.

$$\text{Color removal rate (\%)} = \frac{A_0 - A}{A_0} \times 100 \quad (2)$$

(2),A_0:Absorption removal before

A:Absorption removal after

COD test: The COD based on the open tube digestion method. The principle is the same as open tube digestion using sulfuric acid and traditional potassium dichromate reflux method, but it does not require complicated reflux device, time is short through the verification test, the open tube digestion method and potassium dichromate method experimental results are the same [5].

COD:

$$COD(O_2,mg/L) = \frac{8 \times 1000(a - b) \times C}{V} \quad (3)$$

(3), a: Titration blank group of ferrous ammonium sulphate solution (mL)

b: Titration sample group of ferrous ammonium sulphate solution (mL)

C: The concentration of a solution of ammonium ferrous sulfate (mol/L)

V: The volume of water sample (mL)

Intrinsic viscosity [η]: The intrinsic viscosity [η], which is proportional to the viscosity average molecular weight (Mw) according to the Mark-Houwink equation, of PAM-PASS in water was measured by viscometry. The measurements were carried out using an Ubbelohde viscometer at 30 ± 0.02℃. The flux-times were recorded with an accuracy of ± 0.05 s. Extrapolation from data obtained for five concentrations of solutions was used to evaluate [η] from the Huggins equation [6].

$$\eta = a M_i^b \quad (4)$$

(4), η: intrinsic viscosity

Mv: viscosity average molecular weigh

a: 3.73×10^4

b: 0.66

IR spectroscopy: The PAM-PASS was dried under 60℃. Then the samples of PAM-PASS and PAM as KBr pellets were subjected to IR spectral analysis by infrared spectrophotometry (WQF-51, Beifen-ruili, China).

TEM and SEM: The particle sizes of Al, structure of PAM and PASS in PAM-PASS were measured by TEM (HT7700, HITACHI, Japan). Status of flocs observed by SEM (SU-1510, HITACHI, Japan).

Conductivity measurement: The conductivities of PAM, PASS, and PAM-PASS were measured by conductometer (FE30, Mettler Toledo, Switzerland) at 20 ± 1℃ with a magnetic stirrer in deionized water [7].

TGA measurement: The thermal degradation test was conducted on TGA (Q50, TA Instruments, and America) at a heating rate of 10℃/min under a static atmosphere. The change in the weight differential difference with temperature was recorded.

Data processing method: The test data is the average results of three times repeated test. Kaolin simulated wastewater (initial turbidity is 91-95 NTU) is used for flocculation experiment and the quantity of reagent is 15 mg/L. We use the Origin for data processing.

Results and Discussion

The process conditions of preparation of PAM-PASS

In this part, we search for the process conditions of preparation of PAM-PASS, investigate the influence of the concentration of acrylamide, the mole ratio of aluminum to silicon, and pH value on the activation of silicate (which was prepared with the sodium silicate with the modulus of 3.3).

From Figure 1a shows, the effect of PAM adding quantity on PAM-PASS flocculation under 16% of the total material is lower than the range increase with the content of acrylamide, within the range of 16-45% is good except for the effect of turbidity, further increase, for the amount of acrylamide flocculation effect decreased. For the amount of acrylamide is proportional to the molecular weight PAM-PASS. When total quality score is very low, the number of reaction system monomer is very small, chain growth slow, polymerization reaction is incomplete so solid content is very low. When we increase the monomer mass fraction, can effectively increase the degree of polymerization reaction, makes the shorter of reaction period. Monomer concentration continued to increase the growth rate and caused a chain reaction system of viscosity increases, the product easy to implosion, the system of free radical increased at the same time, the chain termination probability, does not favor the chain growth to continue [8].

Figure 1b, the influence of molecular weight of PAM-PASS to the removal rate of turbidity has increased before the first decreases. This is due to the low molecular weight polymer, molecular adsorption on the surface of the suspended particles, flocculant do not produce bridging role, but in the role of dispersion stabilizer, suspended particles sedimentation; with the increase of molecular weight of PAM-PASS, enhanced speed of adsorption bridging flocculation. But when the polymer molecular weight is too high, the early formation of the floc settling velocity become faster, doesn't lead to many small flocs by adsorption and residue in the supernatant liquid, lead to in addition to the material rate is not high [9].

As shown in Figure 1c, with the increase of silicic acid activation pH value, the PASS rate of turbidity removal showed a trend of decrease after the first increase. Silicate activated pH value is less than 1.5 in addition to the low rate of turbidity, When the pH >1.5, rate of turbidity removal increased rapidly, effect remarkable enhancement. And the pH value of 3.0 the rate of turbidity removal maximum, pH value continues to increase, rate of turbidity removal decreased obviously. pH 1.5, or less PASS flocculation effect is not good, may be the flocculant of the degree of aluminum content is less, less able to participate in the flocculation process of aluminum. pH >4.0, PASS degree of polymerization increases, easy gel preparation process, and the degree of polymerization of acrylamide is reduced, so the flocculation effect is poorer. Therefore, when the pH value of 3.0 in addition to the rate of turbidity is bigger [10].

In Figure 1d, in Al-Si mole ratio of 3:1, the best flocculation effect. Al-Si Moore is small, PASS has occurred in the process of curing gel, because the amount of aluminum ion, the flocculation effect is poorer. As Al-Si mole ratio increases, the amount of aluminum ion increases, polysilicic acid in the process of curing and no gel, and the amount of aluminum ion is not enough to package polysilicic acid, at this time PASS flocculation effect is better; As Al-Si mole ratio continues to increase, for the amount of aluminum ion polymer surface is aluminum silicate ion packages, flocculation process cannot make full use of its adsorption bridging role, and the flocculation effect is not ideal. So the Al-Si when the mole ratio of 3:1 PASS turbidity removal effect is good.

As is shown in Figure 1e, polysilicic acid can form gel at PH 5 or more, the polymerization of acrylamide in alkaline conditions easy aggregation, therefore, should try to increase the PH of reaction system, and acrylamide in joining aluminum hydroxide easy aggregation, reducing the amount of initiator, with the aluminum hydroxide to adjust the PH of the reaction system, at the same time, keep the overall Al-Si mole ratio, reduce the addition amount of aluminium sulfate [11].

Join the amounts of aluminum hydroxide on the PAM-PASS have a greater influence on the flocculation effect. With the increase of aluminum hydroxide the rate of turbidity removal showed a trend of decrease after the first increase, the aluminum hydroxide account for 7.5% of the total mass concentration in the material, product the highest rate of turbidity removal.

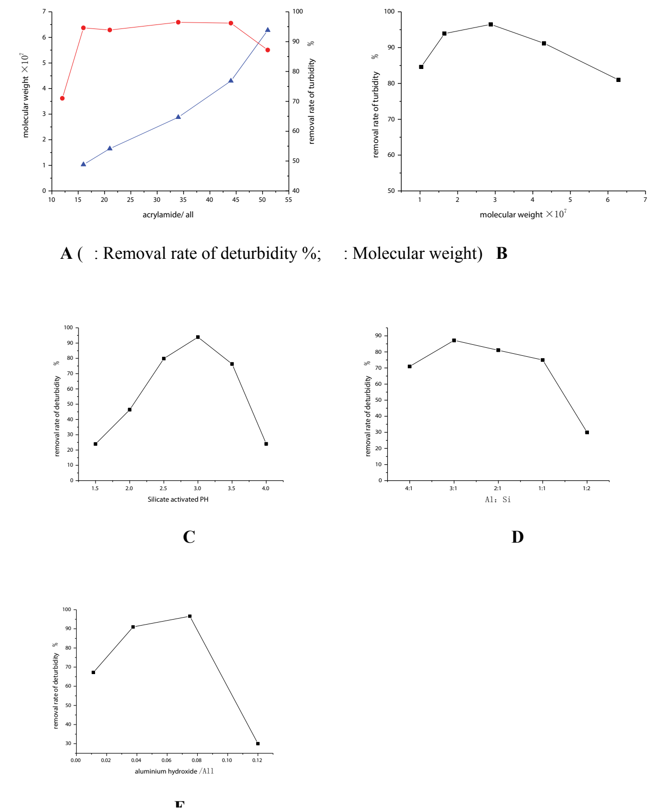

Figure 1: Determination of optimum technological conditions.

To sum up, The results showed that the optimal process conditions for preparing PAM-PASS were as follows: silica concentration of 7%, aluminum silicon ratio of 3:1, and pH value of 3.0, acrylamide mass fraction of 20.7% of total material, aluminum hydroxide accounted for 7.5% of total material quality score with ammonium persulfate and sodium bisulfite as initiator, reaction temperature 40℃, PAM - PASS the synthesis of 3 hours. Molecular weight of about 1.5×10^7 [12].

Under the optimum technological conditions, three sets of parallel tests are carried out; under the condition of the volumes of 15 mg/L in kaolin simulated wastewater in addition to the average rate of turbidity was 96.3%.

PAM-PASS performance study

PAM-PASS stability: In this section, we discuss the amount of acrylamide in PAM-PASS the effect on the stability of the composite flocculant. Preparation: 2:3:1 (best conditions), 1:3:1, 3:6:2, 6:3:1 composite flocculant, is its stability, and mixed with homemade PASS as well as the physical stability of PAM-PASS the comparison. Among them, the physical mixture of PAM-PASS using commercially available 1.0×10^7 molecular weight of PAM and homemade PASS by physical mixing, respectively in the process of experiment in wastewater.

(a: PASS; b: physically mix PAM and PASS; c: 1:3:1; d: 3:6:2; e: 2:3:1; f: 6:3:1)

Figure 2 is the stability of the different product contrast, because

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of the crosslink of PASS polysilicic acid and the formation of the characteristics of gel, PASS failure in 20 hours, polyacrylamide and poly aluminum silicate physical mixing place will be a day after delamination failure, poor stability [13]. PAM molecular weights (1.0 × 107) have good stability, but the flocculation effect is poor, is only 61%.

PAM - PASS the stability of the different proportion of differences, with the increase of the amount of acrylamide, presents the tendency of increasing first after stability, in AM:Al:Si=best stability of 2:3:1, experiment detected the 100th day still have good stability.

Therefore, the advantage of the characteristics of strong stability of polyacrylamide, poly aluminum silicate and acrylamide polymerization, can effectively improve the stability of the product, but the degree of polymerization of acrylamide also affects the stability of the product, by our experiments, the PAM and PASS maintained at the mole ratio of 1:2, viscosity are molecular weight polyacrylamide is about 1.5×10^7 conditions, good stability and flocculating effect [14].

PAM-PASS flocculation effect of wastewater: The synthesized under the best conditions of PAM - PASS for four kinds of wastewater treatment, inspects the flocculant to the different waste water flocculation effect. Choose four kinds of waste water are: low turbidity kaolin simulated wastewater (initial turbidity NTU=20.2), the turbidity of kaolin simulated wastewater (initial turbidity NTU=93.6), the printing ink wastewater (initial turbidity NTU=147.7), oil and grease wastewater (initial turbidity NTU=838.5).

Therefore, PAM-PASS has good except the turbidity effect in low turbidity, medium turbidity and high turbidity wastewater, residual turbidity below 5 NTU.

The decoloring effect and the effect of removing COD: We get the effect of Decolorization and removal of COD of wastewater through Uv-vis spectrophotometer and open tube digestion method (through the experiment with potassium dichromate GB method), the following Tables 1-3:

By the table can be seen, for two kinds of wastewater decolorizing flocculant has good processing effects, and flocculating agent on COD removal effect is not good.

Above all, PAM-PASS flocculant in low and high turbidity wastewater has good flocculation effect, in addition to the rate of

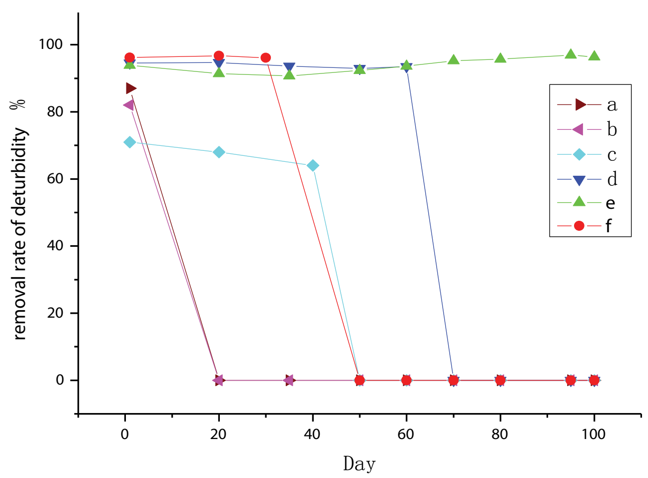


Figure 2: The stability of different products, Flocculation performance.

	Parallel test 1	Parallel test 2	Parallel test 3	Average value	Error
Initial turbidity	93.5	91.0	91.4	92.0	± 1.5
Residual turbidity	3.6	3.2	3.3	3.3	± 0.3
The rate of the deturbidity %	96.1	96.5	96.4	96.3	± 0.2

Table 1: The optimum technological conditions of Products Parallel Test Data.

	Kaolin simulated wastewater (Low turbidity)	Kaolin simulated wastewater (Mid turbidity)	Printing ink wastewater	Grease wastewater
Initial turbidity	20.2	93.6	147.7	838.5
Residual turbidity	1.2	2.9	4.7	2.9
The rate of the deturbidity %	94.1	96.9	96.8	99.6

Table 2: Flocculation Effect comparison of different waste water.

	Maximum absorption wavelength (nm)	Decolorization rate	Effect of removing COD
Printing ink wastewater	575	78.8%	16.9%
Printing ink wastewater	473	98.6%	22.7%

Table 3: Discoloration and effect of removing COD.

turbidity were over 94%, the residual turbidity under 5 NTU; PAM - PASS flocculants in printing ink wastewater and oil wastewater decolorizing rate were 78.8%, 98.6%, PAM - PASS COD removal effect is not too ideal, at 20%, through the stability test, PAM - PASS the placement of flocculant stability in more than 100 days, in this 100 days, in addition to the rate of turbidity remain above 90%. Through the PAM - PASS compared with other products, PAM - PASS has more excellent turbidity removal effect.

PAM-PASS structure research

The molecular weight of PAM-PASS: According to the best experimental conditions, we get four kinds of different molecular weight of PAM – PASS by adjusting the amount of the initiator. According to the detected by ubbelohde viscometer obtain Viscosity-average molecular weight of four kinds of the products: a: 4.6×10^6; b: 8.6×10^6; c: 1.51×10^7; d: 3.26×10^7, discuss the molecular weight of PAM-PASS for stability and flocculation effect, as shown in Figure 3:

(a: 4.6×10^6; b: 8.6×10^6; c: 1.51×10^7; d: 3.26×10^7)

As shown in Figure 3, the effect to the stability of the molecular weight of PAM - PASS is very huge. By A and B product as you can see, with the increase of molecular weight of PAM - PASS, A gradual increase in stability, due to the increasing degree of polymerization of acrylamide, due to the length of the polymer material long chain must have certain can bridge between grain effect between the ions, we get the combination of PAM and PASS to nanoscale through the chemical method introduced PAM into the PASS system, through this method maintain PASS the status quo, to prevent further to form crosslinking between polysilicic acid particles, forming A gel and failure, therefore, when the molecular weight of PAM-PASS increases within A certain range, can improve the stability of the products. But, in the C, D product, with further increase of molecular weight, the degree of polymerization of poly propylene amide also increase, so the product easy to implosion, water-soluble fell, the chain of polyacrylamide molecule formation, reduce the stability of the products [15].

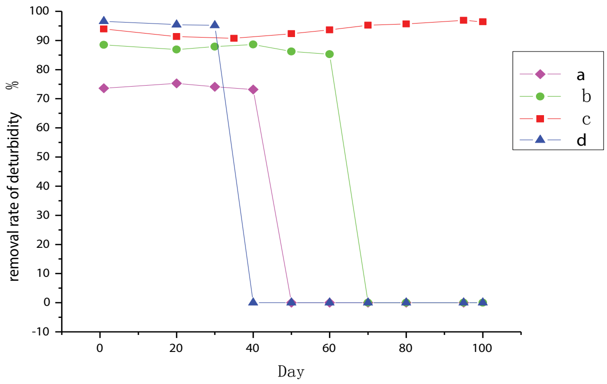


Figure 3: PAM-PASS the influence of molecular weight on flocculation effect and stability.

GPC test: We discuss the effects of molecular weight of stability through chromatography test, as shown in Figure 4. The molecular weight of PAM-PASS on its stability is obvious, and the molecular weight of high product stability is poorer. At the same time, from the flocculation effect is considered, must ensure that PAM-PASS have a certain molecular weight. Stability is obtained by detecting the best PAM-PASS heavy molecular weight as: 466840, the number average molecular weight is: 448538.

Conductivity test

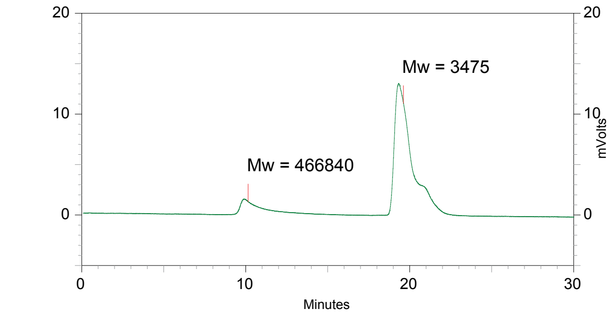
Figure 4 showed the conductivity *K*–concentration *C*-curves of PAM-PASS, PASS, and PAM in water. From the figure, the *K* values of the PAM-PASS and PASS were much larger than that of pure PAM and PAM-PASS same to PASS. Obviously, this is because PAM-PASS and PASS have an inorganic electrolyte, and the neutral PAM has only a few hydrolyzed carboxyl groups on the chain.

It is interesting that the shape of *K*–*C* curves of the PAM-PASS was quite different from that of PAM or PASS, which displayed a discontinuous behavior of the *K*–*C* curve; the *K* value decreases quickly at the beginning, continues a small decrease (discontinuity), and decreases fast again with the decreasing concentration of PAM-PASS [16].

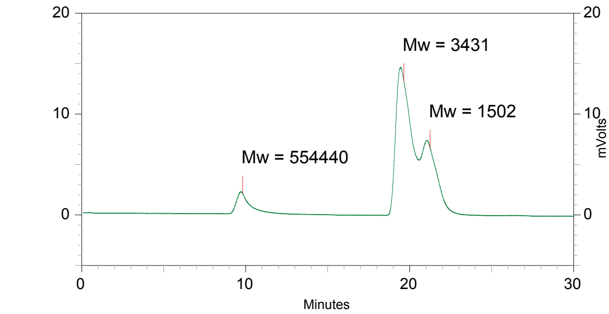
In acrylamide polymerization process, the chain reaction in chain termination will form the basis for sulfate polyacrylamide chains. In PAM-PASS figure line twist phenomenon shows that does exist in the process of dilute end group for sulfate polyacrylamide chain from the positively charged ionization on the surface of the aluminum hydroxide colloid particles, that is, the synthesis of PAM-PASS is ionic bonding between the inorganic organic combinations.

TGA test: From Figure 5 the TGA curves of PAM, PAM-PASS and PASS are shown in Figure. The TGA of PAM-PASS higher than PASS, lower than PAM. In case of PAM, at 250-300 and 350-450 the TGA of PAM very quickly. In case of PASS, at 650-750 the TGA of PASS very quickly. At the same time, PAM-PASS does not have such phenomenon. This further confirms the synthesis of PAM - PASS is ionic bonding between the inorganic organic combination.

Figure 6a and 6b show FTIR spectra of PASS and PAM-PASS. Above, the association in 3199 amino characteristic absorption peak of 2978 in methylene antisymmetric stretching vibration absorption peak vibration, appeared in 1676 and 1603 amide vibration absorption peak, in 1434 the methylene deformation characteristic absorption



(a) Best stability PAM-PASS



(b) Poor stability PAM-PASS

Figure 4: Stability of different PAM-PASS chromatography test.

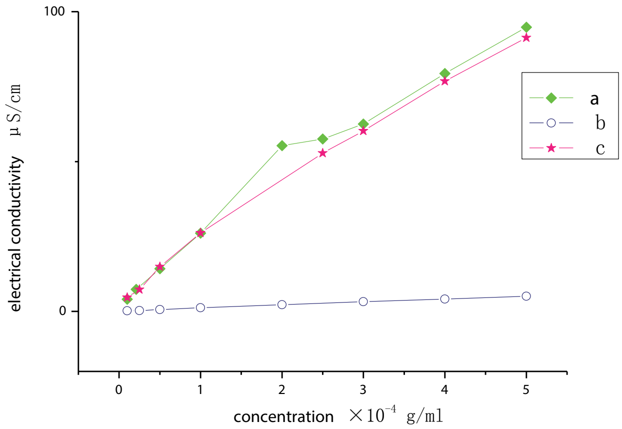


Figure 5: Different products conductivity. (a: PAM-PASS; b: PASS; c: PAM).

peak, in 1096 the vibration of the Si - O - Al peak, in 613, OH vibration absorption peak. Through infrared detection, we can see the preliminary infrared spectrum analysis showed that acrylamide is aggregated into polyacrylamide, poly aluminum silicate is made from aluminium and silicon to form the amorphous polymer, is not a simple mixture material [10].

TEM and SEM

TEM of production

TEM analysis was carried out on the products, from Figure 7, the best products in the PASS of dispersion is higher than the other

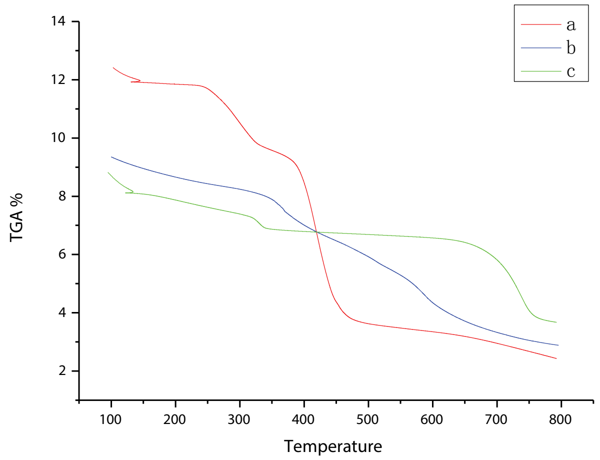
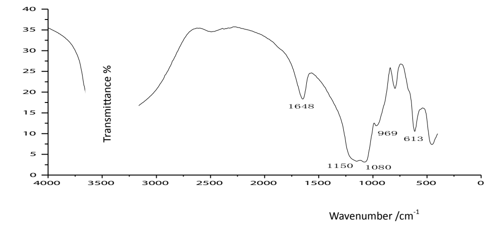
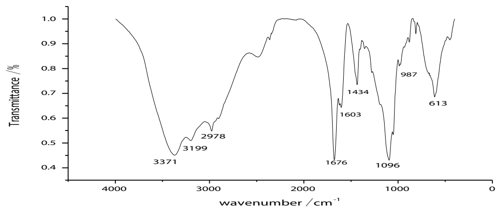


Figure 6: TGA (a: PAM; b: PAM-PASS; c: PASS).

FTIR

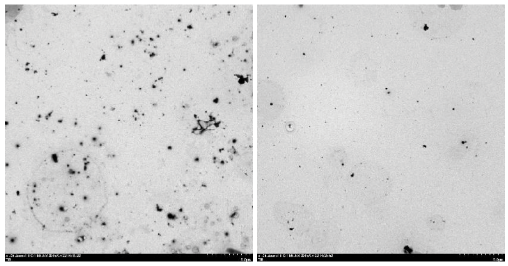


(A) PASS

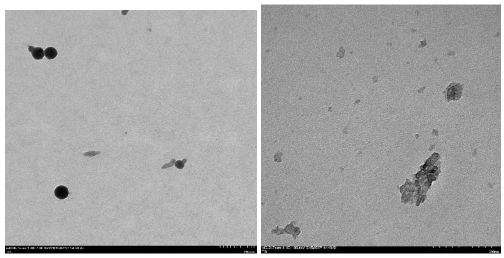


(B) PAM-PASS

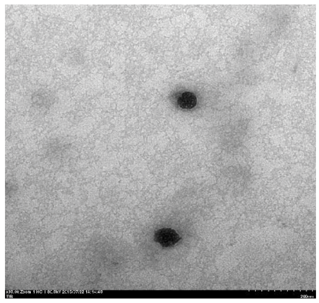
Figure 7: Different product infrared spectrum.



(A) GENERAL PRODUCT (B) BEST PRODUCT

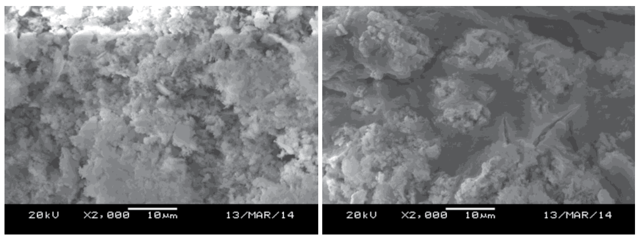


(C) General product (D) PASS



(E) BEST PRODUCT

Figure 8: TEM comparing different products.



(A) PASS (B) PAM-PASS

Figure 9: SEM picture of flocs.

products, formed a nanoscale products. From Figures 8 and 9, PAM chemical compound with PASS can effectively increase the PASS of the dispersion and reunite degree of PASS. From Figure 10 the best products of PAM formed a reticular structure, which has a better flocculation effect and stability.

SEM for floccules

By electron microscope graph can be seen that PASS flocculant produced by floccules structure is loose, and susceptible to the effect of external force and make big floccules broken, bring needless trouble to post-processing, sometimes need to undertake secondary flocculating, compound with PAM, floccules obviously become larger, floc structure is compact, even by external effects will not be broken, floccules sedimentation speed.

XRD

Raw materials of sodium silicate in the XRD spectra $Na_2SiO_3.(H_2O)_5$ crystal peaks appears, shows the $Na_2SiO_3.(H_2O)_5$ crystals. PASS the XRD spectrum diagram, figure of no $Na_2SiO_3.\ (H_2O)_5$ and NaAl $(SO_4)_2$ (H_2O), 6 crystal peak appeared, only in 2 theta is 20° ~ 25° peak packet interval.

PAM-PASS the XRD spectrum diagram, the diagram also does not appear Na_2SiO_3. (H2O) $_5$ and NaAl (SO4)$_2$ $(H_2O)_6$ crystal peak appeared, only within the range of 2 theta is 20° ~ 25° diffuse scattering peak package, the area of the peak package PASS a large, and peak position is PASS reduces obviously, instructions will be the PAM and PASS the aggregation, destroyed the crystal structure of silicate, the

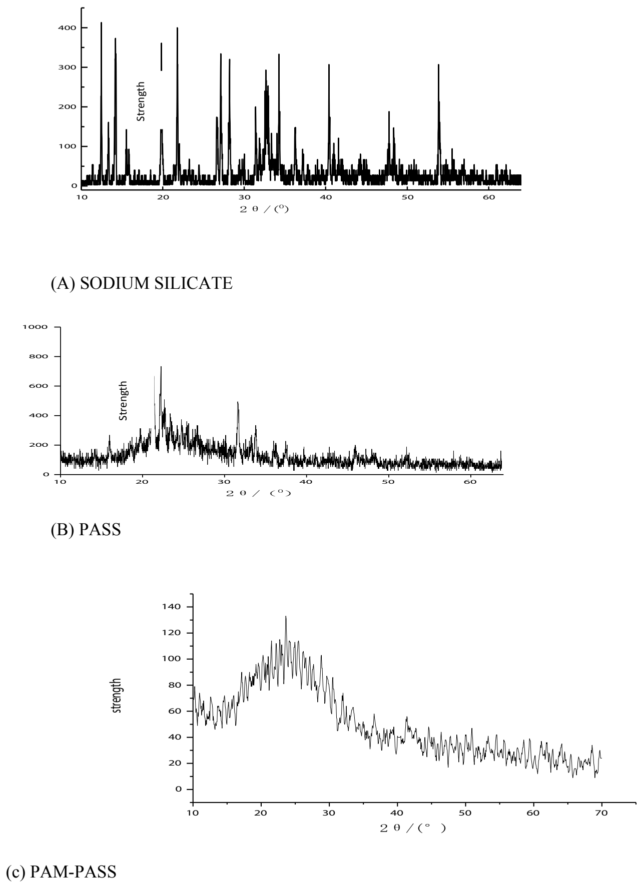


Figure 10: Ray diffraction diagrams of different product.

basic formation without finalize the design of polymer, to improve the flocculation effect of flocculant and its stability [17].

Conclusion

In this paper, the influence of the concentration of acrylamide, the mole ratio of aluminum to silicon, and pH value on the activation of silicate, which was prepared with the sodium silicate with the modulus of 3.3, was investigated. The results showed that the optimal process conditions for preparing PAM-PASS were as follows: silica concentration of 7%, aluminum silicon ratio of 3:1, and pH value of 3.0, acrylamide mass fraction of 20.7% of total material, aluminum hydroxide accounted for 7.5% of total material quality score with ammonium persulfate and sodium bisulfite as initiator, reaction temperature 40, PAM-PASS the synthesis of 3 hours.

The PAM-PASS was prepared at the optimal conditions mentioned above and used for the treatment of waste water. The rate of deturbidity and color removal were 99.6% and 98.2% respectively. Place PAM-PASS in the air in order to test the stability of PAM-PASS, currently testing data for 100 days the rate of deturbidity in a more than 90%. We will continue to test the following date. The dosage of PAM-PASS was 15 mg/L.

The PAM-PASS was characterized by viscometry, IR spectroscopy, TEM, conductivity, and TGA. It was found that an ionic bond exists between Al colloid and polyacrylamide (PAM) chains in the PAM-PASS; Silicon and aluminum form the amorphous polymer and the flocculation efficiency of PAM-PASS is much better than that of commercial polyacrylamide (PAM) and PASS.

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