Application of Highly Charged PAC and Polyamine admixture in Neutral Papermaking

YANYONG-XIANG*, CHEN FU-SHAN†, WANGLI-JUN† ZHOU LIN-JIE‡

* Doctor Student, † Professor, ‡Master Student
Tianjin Key Lab of Pulp and Paper, Tianjin University of Science & Technology, Tianjin, 300222, China
yongxiangyan@126.com

ABSTRACT

Studied that the relationship between the charge density of PAC and its alkalinity, as well as the influences of PAC in paper sizing. Study results showed that PAC with higher charge density brought higher sizing degree when the same amount of Al_2O_3 content was dosed. However, there was no direct relationship between PAC charge density and its alkalinity, and higher PAC alkalinity can't improve its charge density. It was also found that the admixture (PPAC) of polyamine and PAC had higher charge density than PAC. The effects of PPAC on DRS and RAKD sizing were better than PAC sizing, when dosage and other sizing condition were the same.

INTRODUCTION

PAC is usually used as precipitator in rosin sizing[1-2]. In the middle of 1980s, neutral sizing with rosin size came into being in Europe, where calcium carbonate was used as filler. One big breakthrough might be the application of PAC as precipitator instead of alum. Later on, some of paper mills began to put this technology into use in North America and other places. Sizing with PAC and DRS(dispersed rosin size) can greatly reduce cost, and overcome the shortcomings(fugitively, size reverse, slippery problem etc.) of AKD sizing [3].

In recent years, the rapidly increasing of rosin price, higher than AKD, and the improvement of stability and cure time of AKD sizing, which challenges the future of this technique. So decreasing PAC dosage, improving rosin sizing efficiency, and developing new rosin sizing technology are very important and realistic. In the current paper, we studied the relationship between the charge density of PAC and its alkalinity, and investigated the effects of PPAC on DRS and RAKD sizing. It was found that PPAC was a more effective precipitator compared with PAC. Sizing with PAC and AKD could improve the efficiency of AKD sizing and shortening cure time from 24h to 8 when the admixture of rosin and AKD was created through the bridging effect of PAC, and the effect of PPAC were much better.

Experimentation

Material

PACs with different alkalinity were laboratory made. Dispersed rosin size was obtained from Tianjin AoDong Co.; bagasse pulp was obtained from Nanning PuMiao pulp plant; polyamine, PA:charge density5.83 meq/g;
Poly diallyldimethyl ammonium chloride , PDADMAC) :charge density 4.36 meq/g; CPAM: charge density3.56 meq/g

Experimental Instrument

WH8401-50 many Function Elect motion Beater, 23Type Beating Machine, Standard Paper Sheet Molding Implement, PCD03 Charge Determine Instrument , SZP06 Zeta potential Determine Instrument, 90Plus Particle Size Analyzer

Methods

Preparation of PPAC

Extremely pure PAC with the alkalinity of 46.8% was mixed with PA for 30min under the temperature of 50-60℃, during which the stirring speed is 300rpm/min.

Preparation of the PAC modified cationic dispersed rosin size

(200g PAC or PAC admixture containing 15% Al_2O_3 was put into a breaker, respectively; then add slowly dispersed rosin size(rosin: Al_2O_3=1:0.4) into the breaker with a stirring bar of 500-900 rpm at room temperature for premixing [4-5]. Stabilizer A was added and further stirred for 15 minutes, then poured it into another breaker for use.)

Preparation of SAKD

50ml water and PAC or PPAC with 50meq charge amount were dosed into three-mouthed flask mixing under certain condition, later on 20g dispersed rosin size was added into and premixed, 15min later 160g AKD(12.5%) emulsion was added into, keep stirring for 15min.

Preparation of CS and GCC blends [6]

100g water was added into 200ml beaker, put 2.5 CS into it and keep stirring, transferring it into 250ml three-mouthed flask, mixing for 30min at 95-100℃, dilute it into 2%.

2% starch paste was mixed with GCC by 1:1 weight ratio, keep stirring for 5min.

Paper Sizing [7]

Bagasse pulp(36°SR) at 2%consistence, sizing with 1% PAC/DRS or PPAC modified RAKD, mixing them completely and diluting to 0.5%, later by starch and calcium carbonate were dosed, CPAM was charged at last. Paper sheet was made by canandian standard formation.

sizing condition: cationic starch 1%, calcium carbonate 20%, CPAM 0.02%, basis weight 60 g/m^2.

RESULTS AND DISCUSSION

the effects of PAC alkalinity on its charge density

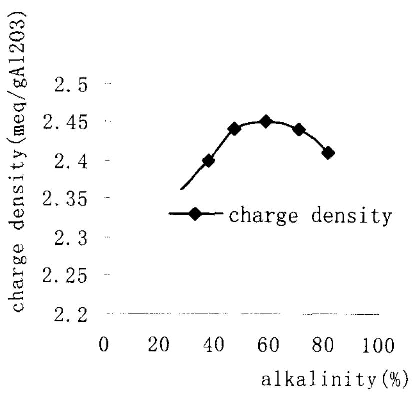

Fig. 1 the effects of PAC alkalinity on its charge density

The effects of PAC alkalinity on its charge density was shown in figure 1. It was shown that there was no direct relationship between PAC charge density and its alkalinity. When the alkalinity of PAC was lower than 60%,extremly purified PAC with the alkalinities of 22.5%、37.5%、46.8%、58.3%、70.6% and 81.6% were diluted to 0.01% (Al_2O_3 content), and the result of colloidal titration showed that it wasn't direct ratio between charge density and alkalinity but as figure 1 showed. From figure 1, we can see that charge density of PAC increased at first and decreased later by following the increasing of alkalinity. The highest charge density reached to 2.44-2.45meq/g when the alkalinity of PAC is at 45%-70%. This phenomenon is related to the content of PAC. PAC is a interim creator between $AlCl_3$and $Al(OH)_3$. Aluminum exists in a state of $[Al(H_2O)_6]^{3+}$, but not Al^{3+}. When pH increased, Cl^- of PAC was substituted by –OH, bridging to dimer, and then creating into or multi-polymer, such as $[Al_3(OH)_4(H2O)_{10}]Cl_5$, $[Al_3(OH)_6(H_2O)_6]Cl_3$ and $[Al_4(OH)_6(H_2O)_{12}]Cl_6$, etc. The reaction leaded to continuously increasing of polymer charge density, as well as its alkalinity. However, when system pH surpassed a certain level, reverse reaction would happen, resulting in the decreasing of polymer charge density.

the effect of PAC alkalinity on rosin sizing

Figure 2 showed that sizing pH remarkably increased following the increasing of its alkalinity when PAC alkalinity is lower than 40%. However, when PAC alkalinity is above 40%, sizing pH slowly increased following the increasing of alkalinity, which means that the effect of PAC on sizing pH is quite small and it's not feasible to increase sizing pH through increasing PAC alkalinity. From figure 2, we also found that sizing degree increased following the increasing of PAC alkalinity. However, when PAC alkalinity is above 55%, sizing degree decreased following the increasing of alkalinity. This phenomenon related to the charge density of PAC, higher PAC charge density leaded to higher positive potential of the admixture of PAC and rosin, which made it easier to bond with fibers. So the retention of rosin was improved and sizing efficiency was better.

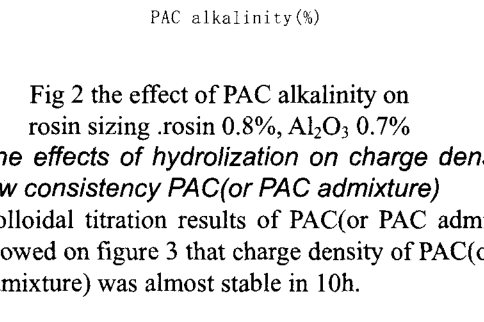

Fig 2 the effect of PAC alkalinity on rosin sizing .rosin 0.8%, Al_2O_3 0.7%

The effects of hydrolization on charge density of low consistency PAC(or PAC admixture)

Colloidal titration results of PAC(or PAC admixture) showed on figure 3 that charge density of PAC(or PAC admixture) was almost stable in 10h.

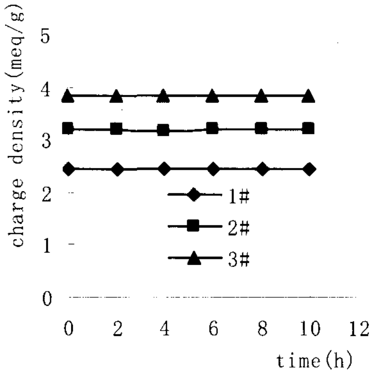

Fig. 3 the effects of hydrolization on charge density of low consistency PAC

the effects of highly charged PAC admixture on pulp zeta potential

Effect of highly charged PAC admixture on pulp zeta potential was shown in figure 4. it was found that 3# extremely purified PAC greatly influenced zeta potential of bagasse pulp, the effects of normal PAC and aluminum sulfate were not so remarkable.

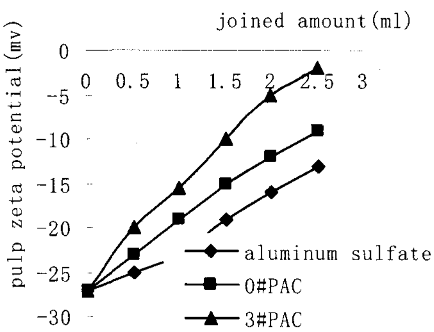

Fig. 4 the effects of highly charged PAC admixture on pulp zeta potential

the influence of charge density on the effects of PAC modified cationic rosin size

It was shown in figure 5 that sizing degree of paper sheets increased following the increasing of charge density of PAC admixture. After dosing same amount of PAC admixture, better sizing degree could be got and sizing pH is higher, when charge density of PAC admixture is higher.

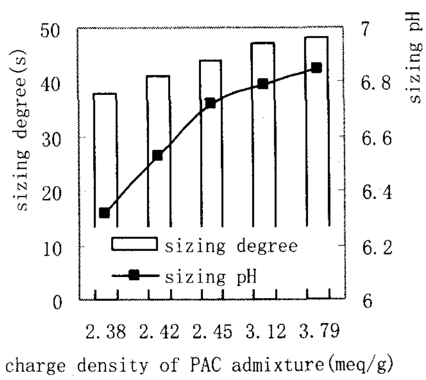

Fig 5 the influence of charge density on the effects of PAC modified cationic rosin size

The effect of PPAC on SAKD sizing

Figure 6 showed that when sizing with PAC or PPAC under the same charge amount, compared with AKD sizing, the sizing result was totally different. The original AKD sizing degree was 21s and cure extent was 10%, SAKD(dosed with PAC) sizing degree was 87s and cure extent was 53%, and SAKD(dosed with PPAC) sizing degree was 105s and cure extent was 55%. Besides, the cure time of sizing with these three sizing agents was different. Curing for 8h, AKD sizing degree was 122s and sizing extent was 66%; SAKD(prepared by PAC) sizing degree was 156s and sizing extent was 92%; SAKD (prepared by PPAC) sizing degree was 177s and sizing extent was 93%.

We can aware from the above results that PAC could promote the combination of rosin and AKD, and the function of PPAC is better than PAC. The main reason is that the reaction of PAC and rosin creating multi hydroxyl aluminum rosinate, which could react with AKD, producing cationic esterifiable substances of larger molecular weight. This ester can bond with fibers directly when aluminum ions exist, and the higher of its charge density, taking more AKD particles, the better of the sizing effect is. Meanwhile, rosin and AKD combined with each other through the function of PAC, greatly shortening the cure time of AKD sizing. By analyzing, we found that the particle size of PPAC modified SAKD was smaller than that of PAC modified SAKD, resulting in bigger surface area and better combination with fibers, and its sizing effect was better.

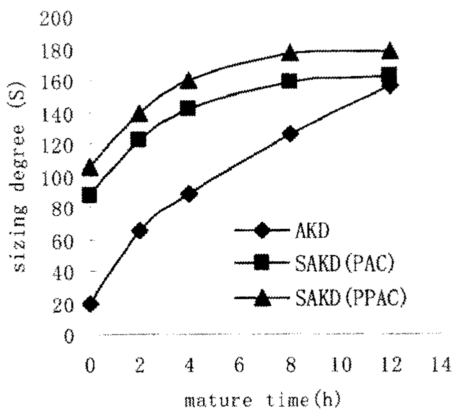

Figure 6 the effect of PPAC on SAKD sizing
SAKD 2.0%, drying temperature 100℃

conclusion

It wasn't direct ratio between charge density and alkalinity， charge density of PAC increased at first and decreased later by following the increasing of alkalinity. The highest charge density reached to 2.44-2.45meq/g when the alkalinity of PAC is at 45%-70%.

Charge density of PAC(or PAC admixture) was almost stable in 10h。

Highly charge density PAC admixture 、PAC and aluminum sulfate compare，When joined Al_2O_3 same amount，The Most Effect o f Highly charge density PAC admixture on zeta potential of bagasse pulp，PAC second，aluminum sulfate least；

PH value of pulp and sizing was direct ratio with charge density of PAC when different PAC with the same charge content was added into pulp. pH value was influenced intensively by higher charge density of PAC admixture. But the change was slower at the higher charge density. The dosage of PAC can decrease with higher charge density at the same pH value and sizing degree.

PAC and PAC admixture have obvious enhanced reactions when rosin and AKD mixing liquid size,and improve the charge density of PAC admixture , stronger synergies of them, not only to achieve a higher initial sizing degrees, but also significantly reduced sizing maturation time of AKD. PPAC and PAC both can promote the combination of rosin and AKD, shortening cure time of AKD sizing to 8h, while PPAC is more efficient.

REFERENCE

[1] Liu Juntai, Comparison of alum and PAC neutral sizing systems, Paper Technology: 36(6):20(1995)

[2] Barbara Wortley, Bonding with polyaluminum chloride makes neutral rosin sizing possible, Pulp & Paper Journal 11:131(1990)

[3] LongZhu.. Studies on Composites of Polyaluminum Chloride-Organic Polymers and Its Application In Papermaking Industry. Tianjin Light Industry College Doctor Paper:13-15(2001)

[4] Dr Juntai Liu. Comparison of alum and PAC neutral sizing systems. Paper Technology June :20-24(1995)

[5] Dr Juntai Liu. Sizing with rosin and alum at neutral pH. Paper Technology October: 21-24(1993).

[6] YanYong-Xiang. Study on the application of a new cation resin size in neutral papermaking. China Pulp and Paper Industry Journal, 27(2):54-56(2006)

[7] Paul S.K. ， Jayasayee V.， Balasubramanian S.， Kasi Viswanathan K.S.， Gopalaratnam N. Neutral Sizing Of Bagasse Furnish-A Laboratory Study. Tappi Journal 9(3):61-68(1997)