THE EFFECT OF CATIONIC SURFACTANTS ON XEROGRAPHIC TONER AGGLOMERATION UNDER ALKALINE PULPING CONDITION

Cuixia Wang,[a] Yungchang F. Chin,[b,]* and Guolin Tong [a]

1-octadecanol is known to be a highly effective agglomerating agent for nonimpact-printing toners. However, it was found that some xerographic toners did not agglomerate under alkaline conditions. The effect of alkali on the agglomeration was studied with two different toners, one carrying no surface charge and one carrying a negative charge. The effect of the addition of a cationic surfactant on the agglomeration under neutral and alkaline conditions was then studied using two different cationic surfactants. It was found that both toners agglomerated better under neutral conditions than under alkaline conditions. The toner carrying no surface charge agglomerated much better than the toner carrying a negative charge under either alkaline or neutral conditions. The addition of a cationic surfactant greatly improved the agglomeration of the toner carrying a negative charge but had relatively small effect on that of the toner carrying no surface charge. It is recommended that agglomeration of mixed office waste with 1-octadecanol should be carried out under neutral conditions with the addition of a small amount of a cationic surfactant.

Keywords: Toners; 1-octadecanol; Cationic surfactants; Agglomeration; Surface charge

*Contact information: a: Jiangsu provincial Key Laboratory of Pulp and Paper Science and Technology, Nanjing Forestry University, Nanjing 210037, China; b: Special professor of Nanjing Forestry University, Nanjing 210037; * Corresponding author, frankchin2004@yahoo.com.cn*

INTRODUCTION

Using "mixed office waste" as a source of recycled fiber for printing and writing grades has become popular due to environmental reasons. For countries that are short on forest resources, using recycled fiber to produce paper becomes even more important. This type of recycled paper contains nonimpact-printed paper (laser printed and photocopier paper), computer print-outs (CPO), coated paper, and small amounts of non-acceptable materials such as brown grades, file folders, and plastic wrap.

The main problem of using mixed office waste is that it contains a high percentage of papers printed by nonimpact-printing processes. Most toner for this type of paper is inert to the saponification reaction under alkaline conditions. The plate-like shape and wide ink particle size distribution of toner during pulping stage makes deinking by conventional methods of washing, flotation, centrifugal cleaning, and screening inefficient (Zabula et al. 1988; Odada et al. 1991). Further, toner often is incompletely detached from fibers during pulping, thus resulting in low flotation removal efficiency (Johnson et al. 1995; Chen et al. 1997). These difficulties have led to the development of agglomeration processes following the liquid bridge principle, by which the toner is agglomerated into larger particles using combinations of chemicals, heat treatment, and mechanical mixing (Synder et al. 1994; Chang et al. 1996; Chen et al. 2004). The larger, more spherical agglomerated particles can then be readily separated from the fiber slurry by screening and centrifugal cleaning, yielding a clean, high quality deinked pulp (Borchardt et al. 1997). Among all agglomeration chemicals, 1-octadecanol has been known as a very effective chemical that acts well under neutral to alkaline conditions. It has been found that the agglomeration chemical also helps in liberating the toner from the surface of fibers, thus improving the flotation efficiency (Chen et al. 1997). A co-agglomeration system has also been proposed by using non-ionic surfactants with phenolic structure and HLB (hydrophilic-lipophilic balance) value of about 10 or below together with 1-octadecanol to improve the agglomeration efficiency (Welf and Venditti 2001).

Mixed office waste, which is a common grade of office waste paper nowadays, contains quite a large amount of oil-based ink or coated paper. When these types of ink and printed coated paper occur in the mixed office waste, it is found to interfere with the 1-octadecanol agglomeration. A solution was proposed by using a pulping temperature of 75^{o}C and pH 11 to completely detach the oil-based ink from both coated paper and copy paper, resulting in complete deinking when carried through a subsequent flotation stage (Chen et al. 1999). Cationic starch has been proposed as another interfering material if the toner is negatively charged. It can be expected to have a negative effect on the 1-octadecanol agglomeration. A positively charged surfactant CTAC (cetyl-trimethyl ammonium chloride) can eliminate the negative effect in a model system. However, it did not work on commercial printing paper (Chen et al. 2004). Also, positively charged materials such as polyamine and poly-DADMAC (poly-diallyldimethyl ammonium chloride) did not alleviate the agglomeration problem (Chen et al. 2004). Thus, the effect of negative charges on this type of toner agglomeration needs to be further clarified. A couple of patents issued to Richmann and Letscher described the use of surfactants having HLB values of 10 or less for the agglomeration of toner printed waste paper, sometimes in conjunction with an aliphatic hydrocarbon with a backbone of 8-12 carbon atoms in length (Richmann et al. 1991, 1992). As a result of these patents, an ink densification process was developed using a combination of suitable surfactants. Under alkaline and medium consistency pulping condition, the toner of mixed office waste will agglomerate and form ink particle with density greater than 1.0, which can be effectively removed by forward cleaners (Letscher et al. 1993).

Most of above research showed no disadvantage of toner ink agglomeration under alkaline pulping conditions, which are known to help fiber swelling and fiber surface ink detachment. However, due to the development of nonimpact-printing machines toward higher printing speed, the toner formulation may have been changed to accommodate the development. The paper additive and sizing technology has also been changed. These brought our attention to study the recycling ability of these printed papers via agglomeration technology. Indeed, our recent laboratory research work found that some toner printed ink could not be agglomerated by 1-octadecanol under weakly alkaline pulping conditions.

The objectives of this research were to identify the reason for interference with the agglomeration of 1-octadecanol under alkaline pulping conditions and to find a solution to make it perform normally.

EXPERIMENTAL

Materials

The copy paper used was a commercial product "GOLD BALL", made by APP Co., China. Photo-copied paper was printed from the same original by using two different Japanese xerographic machines and copied with toner made by the same company: Kyocera KM-1635 (Toner A) and Canon iR3300 (Toner B) copy machines. Toner A carried no charge and Toner B carried slightly negative charge. All other chemicals were purchased locally. Detail information for these materials are listed on Table 1.

Table 1. List of Materials

Materials	Names (or grades)	Source
Paper	APP copy paper, 70 g/m^2, AKD sized, filled with $CaCO_3$, 16% ash content (ingited at 525^oC), dual purpose for xerographic, laser, bubble jet and offset printing	APP Co., China
Toner A	Kyocera KM-1635	Kyocera Co., Japan
Toner B	Canon iR 3300	Canon Inc., Japan
1-octadecanol	Chemical pure	Shanghai Jiu yi chemical reagent co.
NaOH	Sodium hydroxide, purity > 96%	Nanjing Chemical Reagent Co.
CTAB	Cetyl trimethyl ammonium bromide, cationic surfactant, chemical pure	Shanghai Ling Feng chemical reagent co.
SDBAC	Stearyl dimethyl benzyl ammonium chloride, cationic surfactant, chemical pure	Shanghai Jin wei chemical co.ltd.
HCA	Poly-diallyldimethyl ammonium chloride, cationic standard titrant	BTG Mütek GmbH
PVSK	Potassium sulfate ester of polyvinyl alcohol, anionic standard titrant	BTG Mütek GmbH

Pulping

The photocopied paper was torn to 1cm x 1cm pieces before pulping. A home-made 1.0 L stainless steel pulper with a screw type rotor driven by a variable speed motor was used for pulping and agglomeration. Before pulping, 465 mL of distilled water was added to the pulper and heated up to 70^{o}C by partially submerging the pulper in a water bath maintained at a little bit higher than 70^{o}C. 1-octadecanol (0.6 g, 2% based on paper) and different amount of surfactants were added and mixed at 300 rpm for three minutes to ensure that the 1-otadecanol was molten. To the pulper, 30 O.D. grams of photo-copied paper was added and disintegrated at 813 rpm for 15 minutes. After 15 minutes, the rotor speed was reduced to 443 rpm for 45 minutes for toner agglomeration. After pulping, the pulp slurry was transferred to a plastic bag and cooled down in tap water. Six handsheets, each with basis weight of 60 g/m^2, were made according to TAPPI Standard Method T205 OM-8. The handsheets were air dried for 24 hours and evaluated by image analysis system with a Canon LiDE100 Scanner. The software used was Autospec V4.0 Image Analysis System (State Key Laboratory of Pulp and Paper Engineering; South China University of Technology).

Surface Charge of Toners

Toner collected from the copy machine was cured at 150^{o}C for 5 min. on a glass plate and then removed from the plate and then ground by a mortar and screened to sizes between 50 and 100 mesh. Toner (0.2 g) was added to a 150 mL glass beaker with 40 mL of distilled water and then adjusted the pH value to 12 by NaOH. The beaker was then put on an electric heater with automatic temperature control and mixed with a speed controlled Teflon rotor for 60 minutes at 70^{o}C.

After being cooling to room temperature, cationic polyelectrolyte (0.001N HCA, 5 mL) was added to the mixture and allowed to react for 30 min. After the reaction, the filtrate was separated from the slurry with a 200 mesh ceramic filter to collect the filtrate. The filtrate was then back-titrated using an anionic polyelectrolyte titrant (PVSK) to determine the surface charge of each toner. The end point was determined with a streaming current detector (PCD-03 Mütek, BTG).

Screening

After pulping, the pulp slurry was transferred to a plastic bag and cooled down in tap water. The pulp slurry was then transferred to a 0.15 mm slot screen (Somerville Fiber-bundle Screener, PTI, Austria) for fiber and ink particle separation. The screening took approximately 7 minutes to finish when there was no fiber on top of the screen plate. The screening accepts were collected by a two layer cloth bag with very tiny holes to make sure there was no loss of any fine ink particle. Handsheets preparation and residual ink evaluation followed the same procedures as that used in the pulping process.

RESULTS AND DISCUSSION

1-Octadecanol Agglomeration under Neutral Pulping Condition

Agglomeration performance of 1-octadecanol under neutral conditions was evaluated by pulping photocopied papers copied with the two toners. No sodium hydroxide was added. The pH value was slightly affected by the filler of $CaCO_3$, which started at 7 and ended at 8.3. After pulping, handsheets were made from the pulped slurry directly and followed by image analysis. The results are shown in Table 2.

Table 2. Performance of 1-octadecanol Agglomeration

Toner	1-octadecanol (%)	NPM (number/m^2)	PPM (mm^2/m^2)	Average particle size (mm^2)
A	0	664184	21113	0.0318
	2.0	23085	7057	0.3057
B	0	286824	14343	0.0500
	2.0	59204	6394	0.1080

It is clear from Table 2 that both toners agglomerated under neutral pulping conditions. However, Toner A agglomerated much better than Toner B. For Toner A, the number of ink particles per square meter (NPM) was reduced by more than 96% and the average ink particle size was increased by ten times, from 0.03 mm^2 to 0.3 mm^2, after agglomeration with 1-octadecanol. Toner B, on the other hand, was less efficiently agglomerated. The reduction of NPM value was only 79%, and the average particle size was increased by only 2 times. These data indicate that toner ink was agglomerated by 1-octadecanol under neutral pulping conditions, but the efficiency varied between the two toners. These results are consistent with earlier studies (Chang et al. 1996; Chen et al. 1997; Chen et al. 1999).

Effect of Alkali

Although it was reported that 1-octadecanol agglomeration was not affected by pH change during the pulping stage (Chang et al. 1996; Chen et al. 1999), it was found that pH has a great influence on agglomeration for the two toners studied presently, as shown in Figs. 1 and 2. Since the copy paper used $CaCO_3$ as the filler, the pH value was also changed during the pulping process. The relationship between the pH value and the amount of NaOH used is listed in Table 3.

As can be seen in Fig. 1, the NPM after pulping was moderately changed from 30,000 to 50,000 along with the increment of sodium hydroxide for Toner A. However, the NPM value of toner B was changed dramatically from 50,000 to 170,000 with the addition of even a small amount of NaOH. This indicates that both Toner A and Toner B do not agglomerate well and are very sensitive to alkaline conditions, especially Toner B.

The average ink particle size after pulping is shown on Fig. 2. It is clear that both Toner A and B were affected by alkali. The average ink particle size of Toner A was reduced from 0.3 mm^2 to 0.1 mm^2 when the alkali dosage exceeded 0.25%. The average ink particle size of Toner B was reduced from the level of 0.1 mm^2 to 0.04 mm^2 even with the addition of a small amount of alkali, indicating that Toner B was not only more difficult to agglomerate but also much more sensitive to the negative effect of alkali.

Table 3. The Relationship Between NaOH Dosage and pH Values

	NaOH (% on paper)	0%	0.25%	0.5%	0.75%	1.0%
pH	Before pulping	7.0	11.6	11.9	12.1	12.2
	After pulping	8.3	11.1	11.3	11.6	12.0

Visual observation clearly showed that not only the particle size but also the particle shape were different between the two toners. After agglomeration with 1-octadecanol, the ink particles of Toner A were spherical, whereas those of Toner B were flat. These difference in size and shape can greatly affect the screen efficiency (Carr 1991; Borchardt et al. 1997).

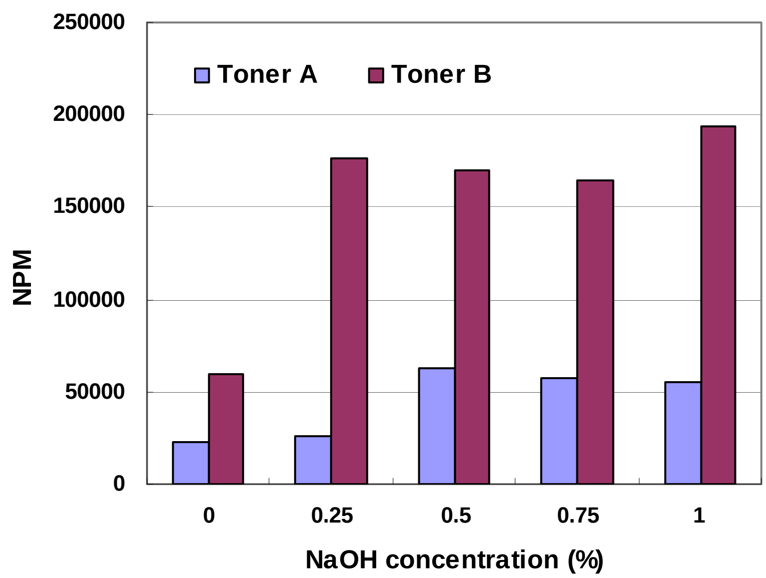


Fig. 1. The effect of sodium hydroxide on 1-octadecanol agglomeration of different toners

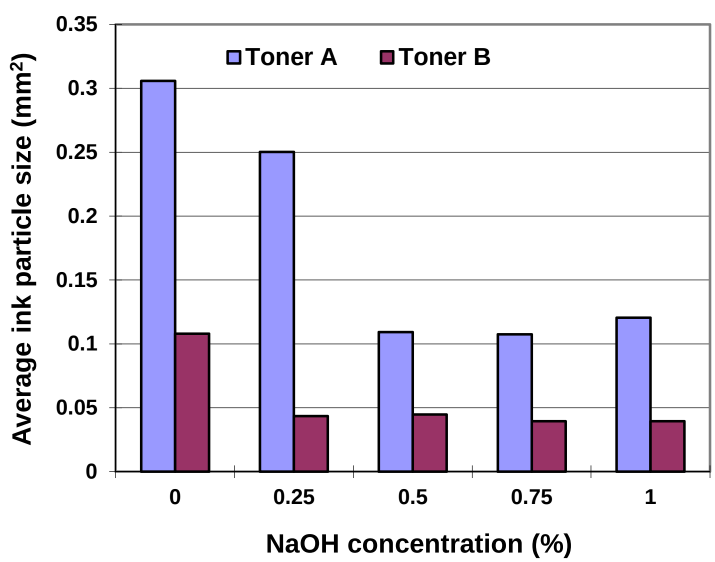


Fig. 2. The effect of sodium hydroxide on 1-octadecanol agglomeration of different toners

In order to verify the effect of size and shape of the ink particles on screening efficiency, the pulps agglomerated with 1-octadecanol were screened through a 0.15 mm slot laboratory screen. The results are shown in Figs. 3 through 6. As shown in Figs. 3

and 4, most of the ink particles of Toner A could be removed by screening if the agglomeration was carried out without or with the addition of less than 0.25% NaOH. Again, the data in Figs. 3 and 4 clearly show the negative effect of alkali conditions. But even when agglomerated at high alkali dosage, substantial amounts of Toner A ink particles were removed by screening. On the contrary, the screen efficiency of Toner B after agglomeration was much lower than for Toner A.

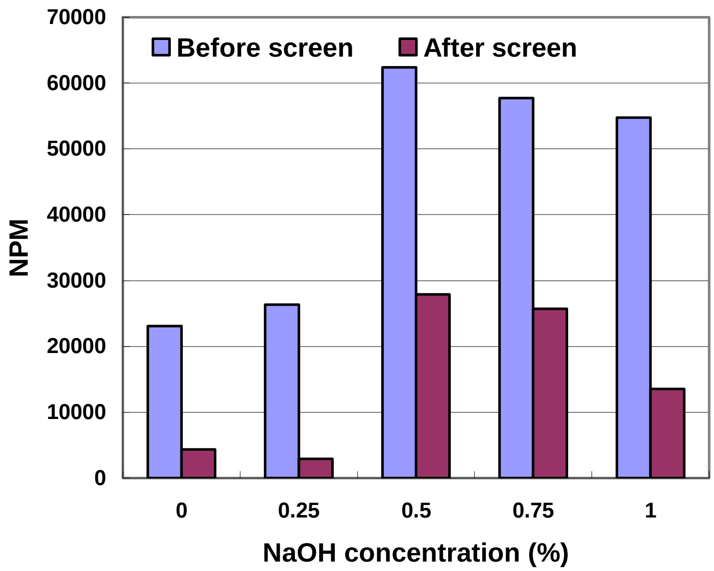


Fig. 3. Effect of sodium hydroxide on the agglomeration of Toner A before and after screening as determined by NPM

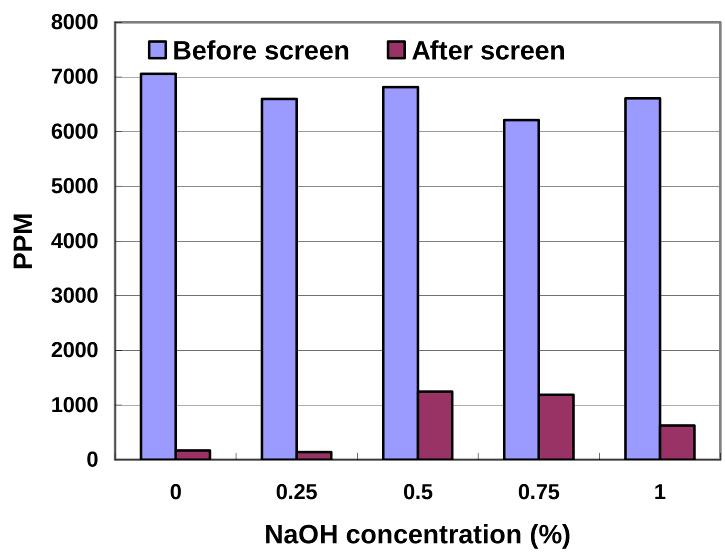


Fig. 4 Effect of sodium hydroxide on the agglomeration of Toner A before and after screening as determined by PPM

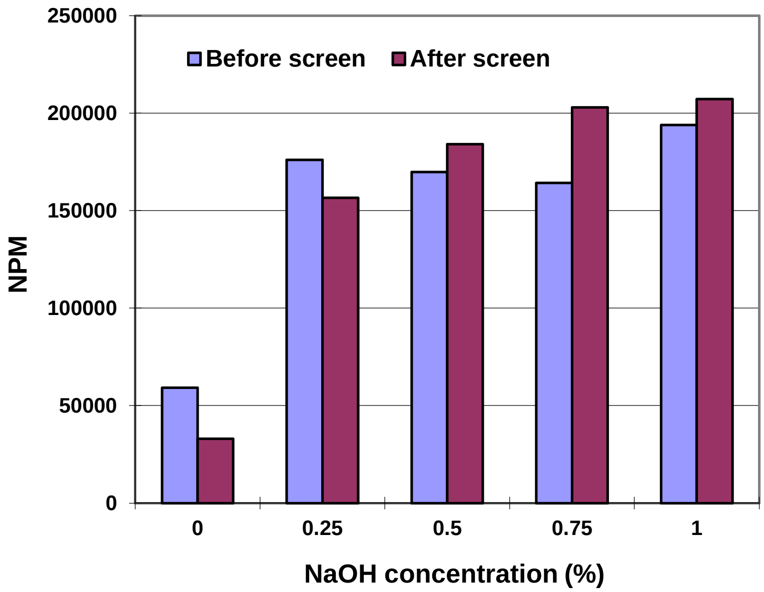


Fig. 5. Effect of sodium hydroxide on the agglomeration of Toner B before and after screening as determined by NPM

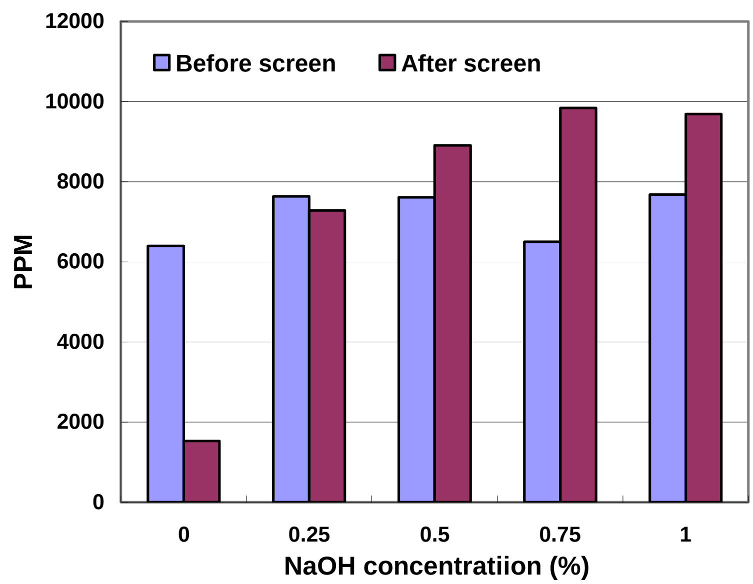


Fig. 6. Effect of sodium hydroxide on the agglomeration of Toner B before and after screening as determined by PPM

When agglomerated under neutral conditions, Toner B gave a 45% reduction in NPM and a 75% reduction in PPM after screening as compared with 80% and 95%, respectively for Toner A, as shown in Figs. 5 and 6. Furthermore, the addition of any amount of alkali during the agglomeration of Toner B made screening completely ineffective. The screening shear force also increased the NPM and PPM values when

NaOH dosage exceeding 0.5%. Thus, not only the particle size but also the particle shape is essential for screening efficiency.

Surface Charge of Toners

It was reported that agglomeration of toner carrying negative charge might be affected by positively charged polymeric paper additives (Chen et al. 2004). Cationic surfactant seemed be able to eliminate the negative charge effect and worked on a model system. However, this system could not apply to commercial printed paper, and the reason was unclear (Chen et al. 2004). Also, the effect of alkali was not investigated.

The charge titration method (Onabe 1982) was adapted to determine the surface charge for both toners. Three sets of experiment were conducted to simulate the surface charge of toner. The first set of experiment was conducted directly without any treatment. The second set was treated with 70^{o}C hot water before measurement. The third set was treated with 70^{o}C hot alkaline water before measurement. In these experiments only the cured toner was added into deionizer water with or without sodium hydroxide to observe the interference caused by sodium hydroxide. Experiment results are listed on Table 4. In Experiment 1, it was found that Toner A carried no charge and Toner B had a slightly negative charge of -0.002±0.001 mEq/g at room temperature without any treatment. When the toner was treated by 70^{o}C hot water of pH=7, the surface of Toner A was still not changed and Toner B was changed from -0.002±0.001 mEq/g to -0.003±0.001 mEq/g, which were both low. When the toner was treated by 70^{o}C hot alkali water of pH=12, the surface charge of Toner A was only slightly changed from 0 mEq/g to -0.0015±0.0005 mEq/g, which is still very low. However, Toner B was dramatically changed from minus 0.002±0.001 mEq/g to minus 0.009±0.001 mEq/g, a much stronger negative charge. This result showed that some anionic groups are generated on the surface of Toner B under alkaline condition, and this might be the reason for poor agglomeration performance of Toner B. Strong negative surface charge would repel toner particles from each other and hence prevent toner particles from agglomeration. To eliminate the negative charge effect, a positive charge donor may be needed for this agglomeration system.

Table 4. Toner Surface Charge at Different Reaction Condition

Toner	Charge, mEq/g (pH=7, Temp=25 ^{o}C)	Charge, mEq/g (pH=7, Temp=70 ^{o}C)	Charge, mEq/g (pH=12, Temp=70 ^{o}C)
A	no detectable charge	no detectable charge	-0.0015±0.0005
B	-0.002±0.001	-0.003±0.001	-0.009±0.001

Note: The HCA was added after slurry was cooled down to room temperature.

Effect of Cationic Surfactants on Agglomeration under Alkaline Pulping Conditions

In order to investigate the effect of the addition of positively charged agent on agglomeration efficiency of the negatively charged toner under alkaline conditions, different amounts of two cationic surfactants, SDBAC or CTAB, were added as the positive charge donator together with 2% 1-octadecanol and 0.5% NaOH. The results are shown in Figs. 7 and 8 for Toner B and Figs. 9 and 10 for Toner A.

Figure 7 shows the effect of the addition of SDBAC on NPM after the agglomeration of Toner B with 1-octadecanol under alkaline conditions. As can be seen, the NPM remained at a high level of 170,000 when the SDBAC dosages were lower than 0.06%. When the SDBAC dosage was increased above 0.06%, NPM started decreasing rapidly and the NPM decreased to approximately 35,000, an 80% reduction, when the dosage reached 0.1%. Above this dosage, the effect appeared to level off. The effect of the addition of CTAB was almost identical to that of SDBAC with two exceptions. First, dosage required for the onset of the reduction of NPM was lower for CTAB (0.04%) than SDBAC (0.06%). Secondly, the NPM value appeared to reach a minimum (12,000) at the CTAB dosage of 0.08 to 0.10%, above which the NMP value appeared to increase. These minimal NPM values of both SDBAC and CTAB are even better than the value obtained under neutral conditions (60,000, Fig. 1).

The effect of the two surfactants on agglomeration of Toner B under alkaline conditions was further manifested by the average ink particle size of the agglomerated toner, as shown in Fig. 8. The average ink particle size increased from 0.04 mm^2 to a maximum of 0.16 mm^2 for SDBAC and 0.36 mm^2 for CTAB when optimal amounts of cationic surfactants were used, confirming the NPM results shown in Fig. 7.

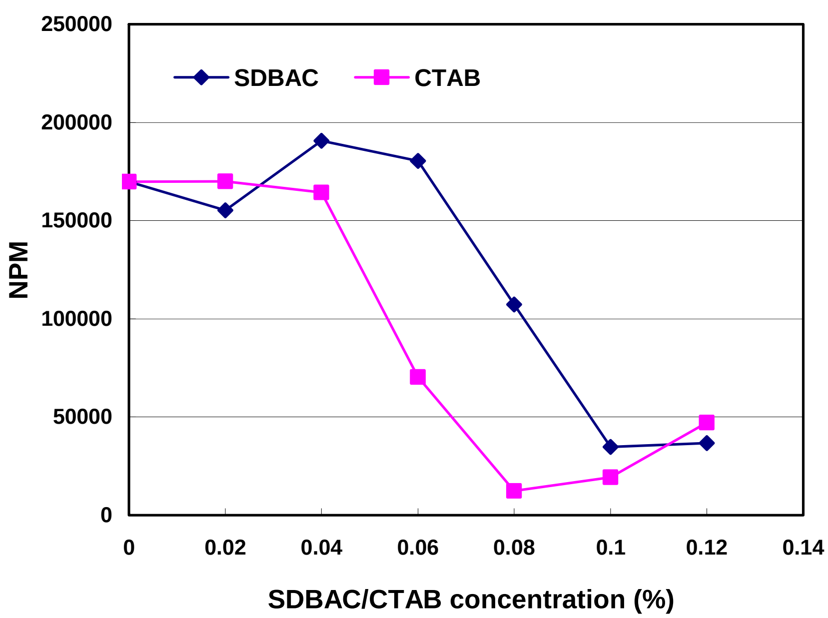


Fig. 7. Effect of SDBAC and CTAB on NMP after agglomeration of Toner B with 2.0% 1-octadecanol and 0.5% NaOH

The behavior of CTAB is especially noteworthy. It appeared to have a very narrow optimal dosage range of around 0.08%; above or below this dosage, the average ink particle size was greatly reduced. Furthermore, the optimal average particle size of 0.36 mm^2 was much high than that obtained by agglomeration under neutral conditions.

Since these experiments were carried out in triplicates and the variation was less than 6.4%, one may rule out the possibility that the narrow optimal dosage is merely a result of random experimental errors. The agglomerated ink at this average particle size should be removed very efficiently by screening.

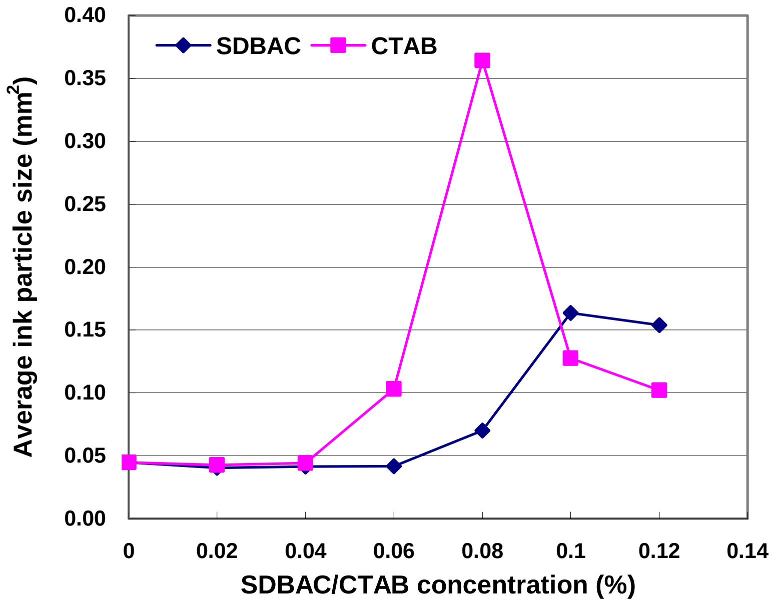


Fig. 8. The Effect of SDBAC and CTAB on the average ink particle size after agglomeration of Toner B with 2.0%1-octadecanol and 0.5%NaOH

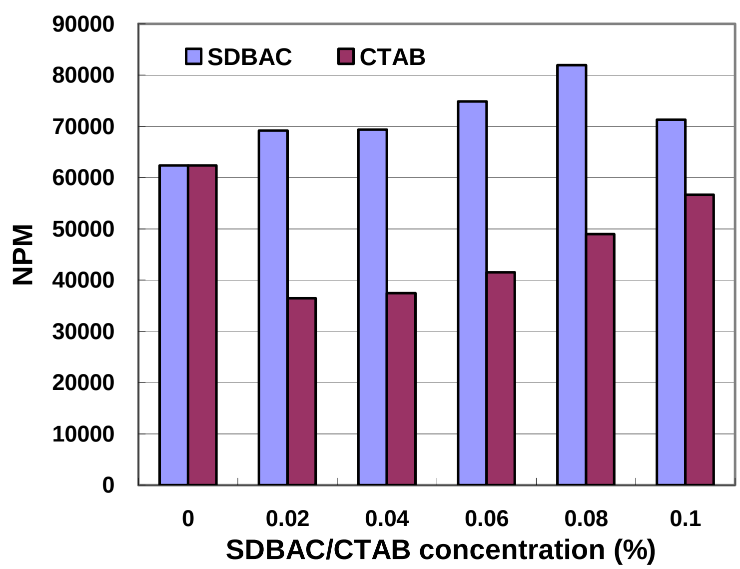


Fig. 9. Effect of SDBAC and CTAB on NPM after agglomeration of Toner A with 2.0% 1-octadecanol and 0.5% NaOH

The same experiment was carried out for Toner A, and the results are shown in Figs. 9 and 10. As can be seen in both figures, SDBAC was ineffective and actually gave negative results, while CTAB showed some positive results. Even with CTAB, the results were still poorer than those of agglomeration under neutral condition without the addition of the surfactant. Thus, it can be concluded that the two toners responded rather differently to the two surfactants and that the two surfactants behaved quite differently under alkaline conditions.

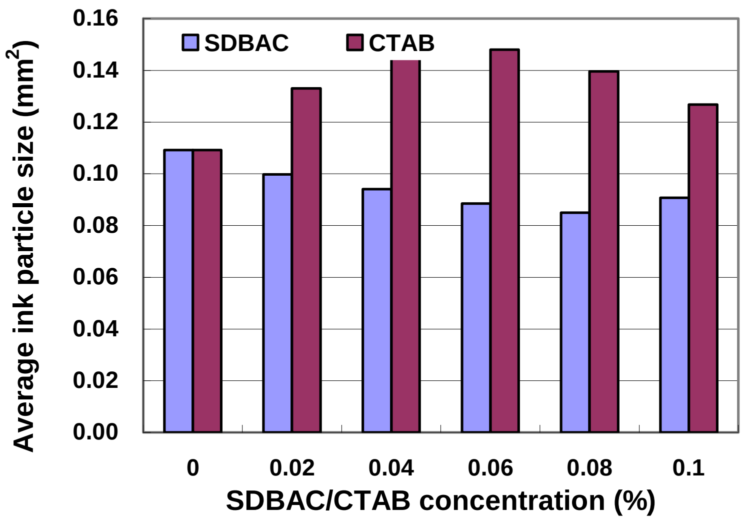


Fig. 10. The effect of SDBAC and CTAB on average ink particle size after agglomeration of Toner A with 2.0% 1-octadecanol and 0.5% NaOH

Effect of Cationic Surfactants under Neutral Pulping Conditions

Although both toners were agglomerated by 1-octadecanol under neutral pulping conditions, it was found the Toner B carried little negative charge and could account for the poorer agglomeration under neutral conditions as compared with Toner A. Thus, the effect of SDBAC and CTAB on agglomeration with 2% 1-octadecanol under neutral conditions was evaluated, and the results are shown in Figs. 11 to 14.

Figures 11 and 12 show the results for toner B, which carries negative charge on its surface. It is clear that the addition of a small amount of either cationic surfactant was effective for the reduction of NPM (Fig. 11) and the enlargement of average ink particle size (Fig. 12) after agglomeration of Toner B under neutral conditions. However, the dosage needed to reach optimal agglomeration was much smaller than in the case of agglomeration under alkaline conditions (0.04% versus 0.08-0.10%, respectively). These results are consistent with the fact that Toner B carries lower negative charge at neutral conditions than at alkaline conditions (Table 4). It is especially noteworthy that the average ink particle sizes after agglomeration with the addition of either surfactant were over 0.4 mm^2. Most of these ink particles should be readily removed by screening with a 0.15 mm^2 slot screen.

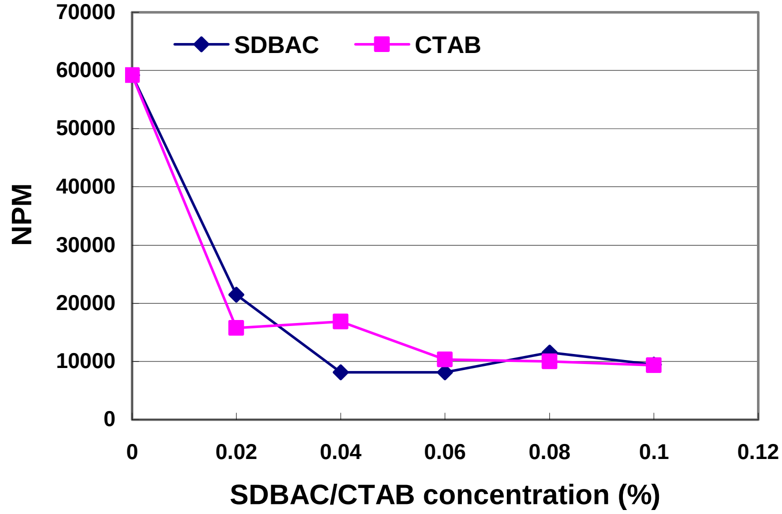


Fig. 11. The effect of SDBAC and CTAB on NPM after agglomeration of Toner B with 2.0% 1-octadecanol under neutral conditions

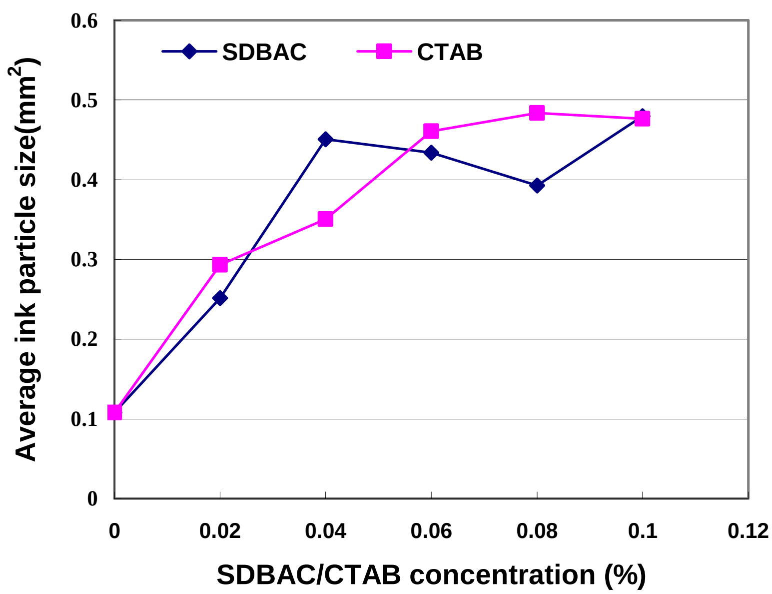


Fig. 12. The effect of SDBAC and CTAB on average ink particle size after agglomeration of Toner B with 2.0% 1-octadecanol under neutral conditions

In the case of Toner A, the story was quite different. Both surfactants negatively affected the efficiency of agglomeration as shown in Fig. 13 for NPM and in Fig. 14 for the average ink particle size. It would be understandable if the two surfactants should show no effect, since Toner A is known to carry no detectable charge under neutral conditions. The negative effect of the two surfactants might be because the surfactant competes with 1-octadecanol for the surface of the toner. Once it is attached to the surface of the toner, it lowers the interfacial energy between the toner and water and hence lowers the tendency of the toner particles to agglomerate. Further research is needed to clarify these results. Regardless of the reason for the negative effect of the two surfactants, the effect was relatively small when only a small amount of surfactant (0.04%) was added. This amount was sufficient to achieve optimal agglomeration of Toner B, especially with CTAB. Thus, in a mixed office waste that has both toners A and B, it is advantageous to agglomerate under neutral conditions with the addition of a small amount of a cationic surfactant.

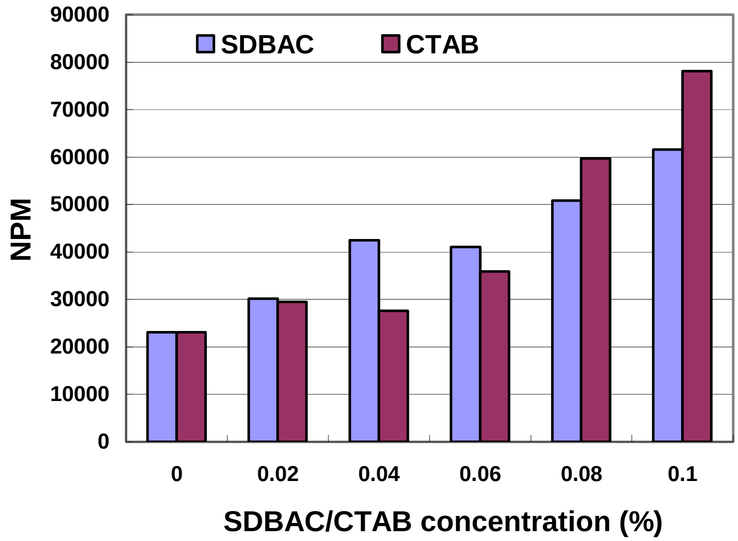


Fig. 13. The effect of SDBAC and CTAB on NPM after agglomeration of Toner A with 2.0% 1-octadecanol under neutral conditions

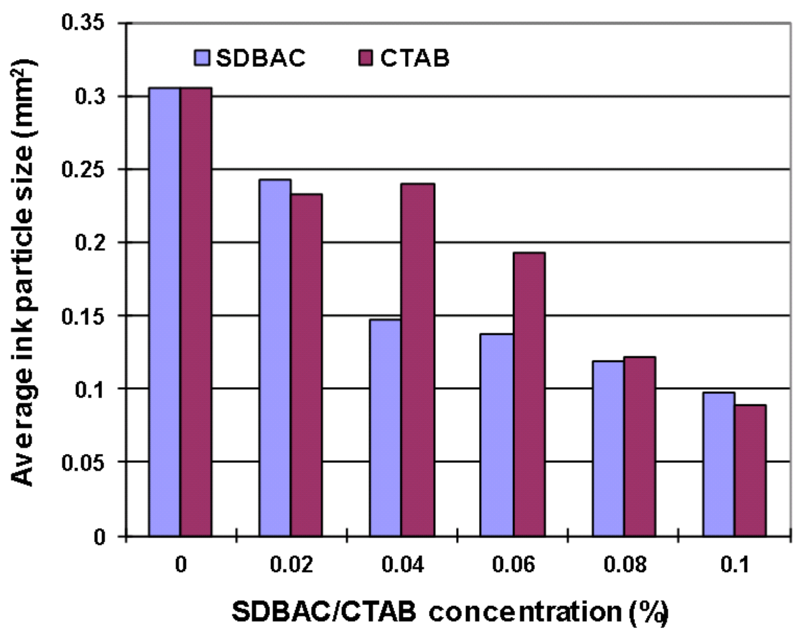


Fig. 14. The effect of SDBAC and CTAB on average ink particle size after agglomeration of Toner A with 2.0% 1-octadecanol under neutral conditions

Pure Toner Agglomeration

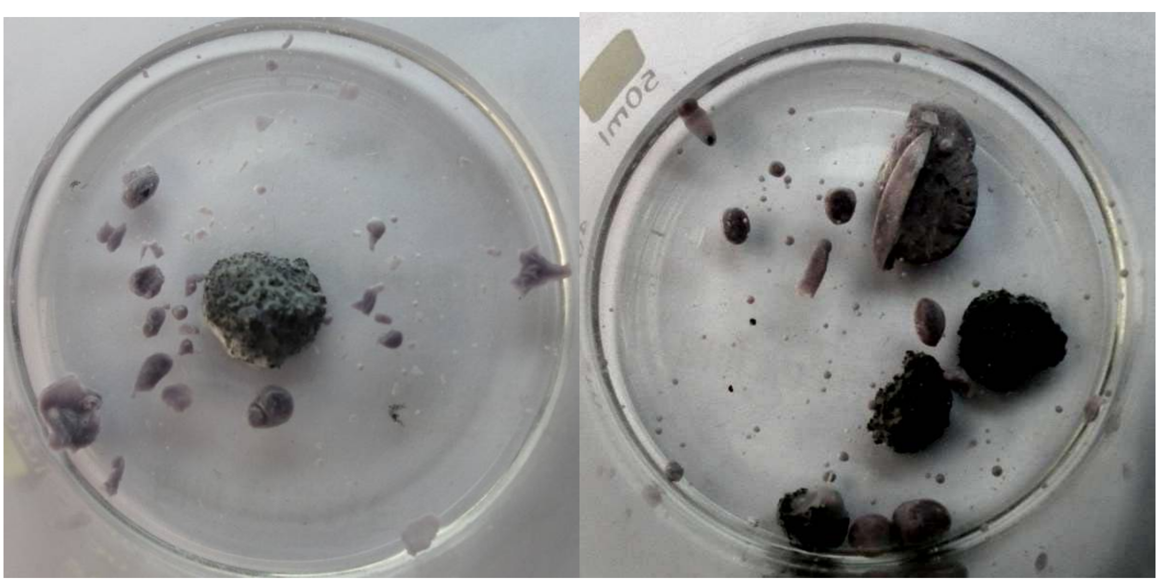
Experiments were carried out for cured toner agglomeration at the same pulping temperature of 70°C with 1-octadecanol. In each of these tests, 0.2 grams of cured toner and 0.6 grams of 1-octadecanol were added into 70°C hot water at two different pH values and various cationic surfactants dosages. One set of experiment were conducted without adding any NaOH, and the pH value was seven.

Another set of experiment used 0.032% (weight percent) of NaOH solution, and the pH value was twelve. The slurry was then slowly stirred for 30 minutes to allow for agglomeration.

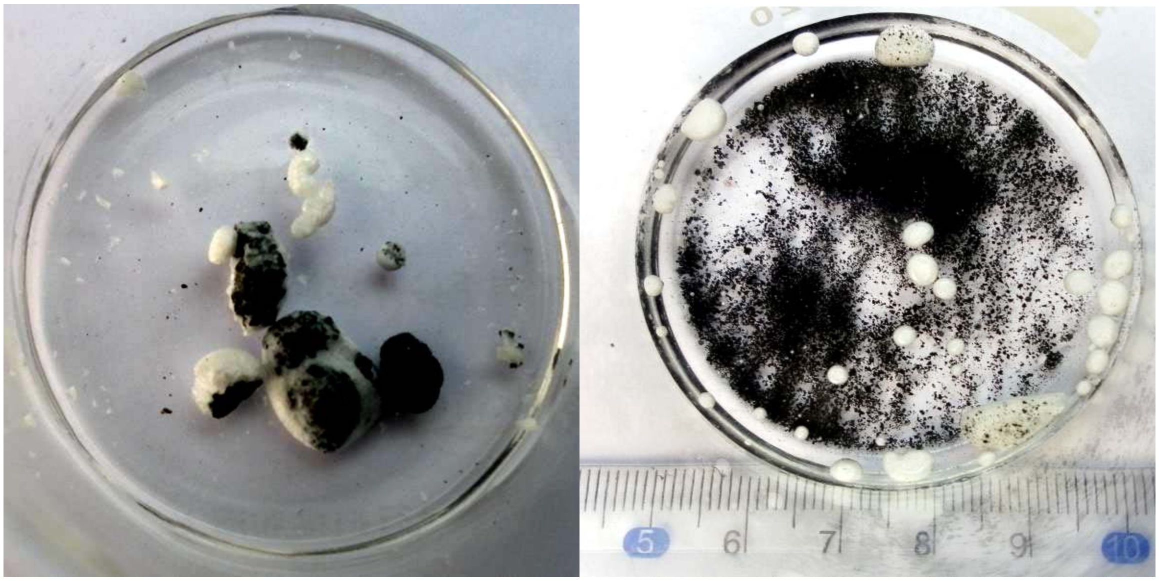
No fiber was added in these experiments to eliminate any possible interference from paper additives and to give a better visual observation on effect of cationic surfactants. After reaction, all reacting materials were collected and transferred into glass beakers of the same size for photo-graphs to be taken.

The results are shown on Fig. 15. Photos (a) and (b) show the results for Toner A. As can be seen, this toner agglomerated well under both neutral and alkaline conditions. All of the 1-octadecanol was consumed, and it was not affected by alkali. Photos (c) and (d) show the results for Toner B. Although some of the 1-octadecanol was not consumed, this toner agglomerated under neutral conditions. But under alkaline conditions this toner was highly dispersed and showed no agglomeration.

Photos (e) and (f) shows the effect of the addition of a cationic surfactant on Toner B under alkaline conditions. It is clear that all the 1-octadecanol was consumed and that the addition of a small amount of cationic surfactant helped the agglomeration under alkaline conditions.



(a) **(b)**



(c) **(d)**

(e) **(f)**

Fig. 15. Results for pure toner agglomeration under different surfactant usage and pH condition. (a) Toner A, 2.0% 1-octadecanol, pH =7 (b) Toner A, 2.0% 1-octadecanol, pH =12 (c) Toner B, 2.0% 1-octadecanol, pH =7 (d) Toner B, 2.0% 1-octadecanol, pH =12 (e) Toner B, 2.0% 1-octadecanol +0.02%SDBAC, pH =12 (f) Toner B, 2.0%1-octadecanol+0.04% SDBAC, pH =12

CONCLUSIONS

1. Both toners were agglomerated well with 1-octadecanol under neutral conditions. But, the toner carrying no surface charge agglomerated better than the toner carrying a negative charge.
2. Under alkaline conditions, agglomeration of both toners was negatively affected. While the toner carrying no surface charge agglomerated poorly, the toner carrying a negative charge did not agglomerate at all.
3. Addition of a small amount of cationic surfactant such as SDBAC and CTAB greatly improved the agglomeration of the toner carrying a negative charge to the level that is better than agglomeration of the toner under neutral conditions.
4. The agglomeration of the toner carrying no charge under alkaline conditions responded differently to the addition of the two cationic surfactants. While CTAB improved agglomeration to some extent, SDBAC had a negative effect on agglomeration. Even with the improvement, the agglomeration was still worse than the agglomeration under neutral conditions without the addition of the surfactant.
5. Under neutral conditions, the addition of either surfactant greatly improved the agglomeration of the toner carrying a negative surface charge, but had a slightly negative effect on that of the toner carrying no surface charge.
6. Based on the results of this study, agglomeration of photo-copied paper should be carried out under neutral conditions with the addition of a small amount of a cationic surfactant, preferably CTAB.

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