Improved Flotation Deinking of Sorted Office Papers by Flocculation of Ink Particles

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ABSTRACT

Flotation deinking of recovered office paper was conducted with solutions of a surfactant blend (polyalkylene oxide and fatty acid) and a flocculant (copolymer of sodium acrylate and acrylamide) using a 2L Denver flotation cell. Addition of flocculant to the solution chemistry schedule of the pulp during flotation caused a reduction of the dirt count in the pulp product as well as an increase in brightness of the product. Examination of the interfacial activity of the flocculant and optical microscopy study indicate that synthetic copolymer adsorbs on the hydrophobic surface of the ink, bridging ink particles together through the flocculation process.

KEYWORDS: Deinking, Flocculation, Flotation deinking, Paper recycling, Surface forces

INTRODUCTION

Flotation is one of the primary methods used to deink printed-paper pulp. It works by collecting dispersed ink particles on air bubbles and trapping them in a froth layer. The spectrum of chemicals added to the flotation circuits include ink particle collectors (fatty acid or alcohol ethoxycarboxylates), collector activator (calcium ions), frothing agents (nonionic surfactants), and pH regulators (NaOH or Na₂CO₃) [1-4].

The flaky shape and the smooth surface of the ink particles slow down the process of ink collection by air bubbles in the flotation cell [5]. The separation of ink particles from pulp is further complicated by the low inertia of ink particles caused by their low density, small sizes, low concentration of particles in the pulp, high viscosity of pulp, and the formation of a complex net of cellulose fibers that reduces the rising velocity for gas bubbles and entraps the ink particles [6]. Therefore, it is still not uncommon to test new chemicals and technological alternatives in an attempt to improve the flotation process.

The challenge for technological innovation in the area of paper deinking using flotation separation is still open. Many current research activities around the world concentrate on more efficient flotation machines and cells, and improvements in the design of solution chemistry that promote agglomeration of ink particles and/or reinforce changes in the shape of ink particles [7,8].

In the flotation process, if the particle size is too small, the particle's inertia is negligible and it tends to follow streamlines around the air bubble. This leads to a smaller probability of collision with an air bubble and therefore the particle has less of a chance to be captured. Usually, ink particles present in the pulp are of a very broad size distribution. For example, the size of ink particles range from about 10 μm to 600 μm [9]. Fine ink particles with a diameter less than 30 μm are particularly resistant to flotation [3]. Therefore, any coagulation or flocculation process initiated in the pulp before flotation separation (during the pulping stage) might improve the efficiency of flotation deinking. This has been observed for many years by using fatty acids and calcium ions [10]. New chemicals promoting toner agglomeration are recently being tested as well; see Borchardt et al. [11] for review.

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Page 38
Flocculating polymers are not yet used by paper recycling mills in flotation deinking. Polymers might initiate flocculation of both cellulose fibers and ink particles, reducing the selectivity of flotation and causing a loss of cellulose fibers. Both components of the pulp, cellulose fibers and ink particles, have surfaces that are negatively charged in water. Thus, a selection of polyelectrolytes based on zeta potential measurements cannot be recommended here. However, both ink and cellulose often differ significantly in hydrophobicity; cellulose fibers are usually hydrophilic whereas oil-based ink particles are hydrophobic. Therefore, it seems to be logical to use selective organic flocculants, which selectively adsorb at hydrophobic ink particle surfaces. The selective adsorption would promote flocculation of ink particles leaving hydrophilic cellulose fibers outside the ink-ink aggregates. The flocculation could be especially attractive for fine ink particles that resist flotation.

In this study, flotation deinking experiments using a synthetic flocculant, copolymer of sodium acrylate and acrylamide, and a frothing agent were carried out to test the hypothesis whether addition of flocculant to the pulp can improve the performance of the flotation process. Measurements of hydrophobic tip-ink interfacial forces by atomic force microscopy and ink hydrophobicity through contact angles have been carried out to analyze the interfacial activity of flocculant.

EXPERIMENTAL

Materials and Reagents

Flocculation experiments were carried out using the pulp received from Great Lakes Pulp & Fibre paper recycling mill. Pulp used in the flotation experiments was allocated from pulped, screened, and detrashed recovered office paper. Recovered office paper was principally composed of color-dyed, photocopy, and laser-printed paper.

Additionally, a model pulp was prepared in the laboratory using 750 g of sorted office paper, a mixture of laser-printed and xerox-printed paper. The shredded paper was mixed with warm water and sodium hydroxide and digested in a food processor at consistency of about 10% (pH>12) for about 2 minutes in order to produce uniform pulp.

Frothing reagents included Lionsurf 792L surfactant blend (a mixture of polyalkylene oxide surfactant with fatty acid) received from Vinings Industries and polyethylene glycol monoalkyl ether, \( C_{14}E_6 \), purchased from Sigma.

The copolymer of sodium acrylate and acrylamide, Percol 727, of Allied Colloids Inc. was used as a flocculant.

Organic hydrophobic self-assembled monolayers were prepared using 1-hexadecanethiol (92% purity; Aldrich Chemical Co.).

Xerox Dry Ink Plus 5052/1050 was used as a model ink in various experiments. It is composed of a styrene/acrylate polymer (85-90%), carbon black (10-15%), amorphous silica (<1%), and zinc stearate (<1%).

Tap water was used in flotation experiments and contact angle measurements. The analysis report for this tap water provided by the Houghton City water department indicated the following quality: hardness 128 mg CaCO_3/L, chloride 28 mg/L, sulfate 12 mg/L, and sodium 11 mg/L.

Deionized water was used in atomic force microscopy studies.

Flotation Experiments

Testing was performed with a Denver-type flotation machine (model D-1) using a two-liter capacity flotation cell. The airflow rate in the experiments was about 2.4 L/min. All tests were performed at a rotational speed of 1,400 rpm. By convention, 1 wt % pulp was prepared using the pulp and tap water. The flotation experiments were limited to room temperature, although it is a common industrial practice to run flotation at 35-45°C. The pH of the pulp remained at pH 6.8 in flotation tests with the pulp received from the Great Lakes Pulp and Fibre mill and pH 10 in experiments with the model sorted office paper pulp.

The paper was pulped at a consistency of about 3% in approximately 200 ml of water and mechanically agitated for 1-2 minutes before pouring into the flotation cell. Next, the flotation cell was filled with pulp and tap water to 2-liter volume. Reagents were added to the flotation cell and they were conditioned for two minutes prior to flotation. The flotation froth product was skimmed for three minutes. The froth and paper products were then filter pressed, dried and weighed. The vacuum filtered pulp products were air dried to ensure no discoloration from the furnace, and were shipped to Great Lakes Pulp and Fibre for pulp brightness and dirt count analy-
ses. The brightness of the pulp product was determined with a Technidyne TB-1C Brightness Meter. The dirt count was done using a scanner equipped with the Apogee Systems software.

The flotation experiments were duplicated and average values of pulp product brightness are reported.

In selected experiments, a small sample of froth was subjected to optical microscopic observations in order to evaluate the flocculation of ink particles.

Atomic Force Microscopy

The interfacial force measurements were performed using a Nanoscope II atomic force microscope (AFM) from Digital Instruments Inc. All measurements were performed in a fluid cell using freshly prepared solutions with triangle-shaped cantilevers having a spring constant of 0.12 N/m, also offered by Digital Instruments. The cantilever was coated with a thin film of gold and next modified with a monolayer of hexadecanethiol.

A toner substrate with a smooth surface was prepared by melting the Xerox Dry Ink Plus 5052/1050 on a glass slide at approximately 130°C, and next cooling it in water and separating from the glass slide. The side attached to the glass slide was used in the AFM experiments.

Contact Angle Measurements

Contact angles were measured on a melted ink substrate with the Krüss Drop Shape Analysis System using the sessile-drop technique. The ink substrate was placed in a plastic cell on two flat supports. The bottom of the cell was partially filled with water to maintain saturation conditions. A drop of water or aqueous solution of reagents, ranging in volume from 10 μL to 50 μL, was placed on the ink substrate using a microsyringe. The cell was covered with a polyethylene film. The drop was made to advance over the ink surface by increasing the size of the drop and an advancing contact angle was measured in 20-40 seconds after the drop volume was increased. In selected experiments, the drop was left 5 minutes for equilibration and then, the contact angle was measured. The measurements were done at room temperature (20-22°C).

The surface tension of selected solutions used in contact angle measurements was also measured with the Krüss Drop Shape Analysis System using the pendant-drop technique. The measurements were done using a stainless steel needle with a diameter of 2 mm in a plastic compartment covered with a polyethylene foil.

RESULTS AND DISCUSSION

Flotation Experiments

Improved quality of the pulp product was achieved during the flotation experiments involving Percel 727 floculant. Figure 1 is a plot showing the effect of floculant concentration on the brightness of the pulp product. Zero concentration corresponds to the experiment that was performed with Lionsurf 792L or C_{12}E_{4} frother alone.

As shown in Figure 1, a brightness of 63.0±0.5 % was approximately the highest value that could be reached with the surfactant blend or pure ethoxylated alcohol for this particular pulp sample when flotation tests were conducted in the 2-liter Denver flotation cell for three minutes. Slightly better flotation results were usually noted for the experiments with Lionsurf 792L surfactant blend rather than with C_{12}E_{4} frother as recorded by an increase of 0.2-0.7 % in brightness for the pulp products.

The use of Percel 727 floculant, along with Lionsurf 792L or ethoxylated alcohol, at a concentration of 0.15 to 0.5 mg/L led to the improvement in the three-minute flotation deinking as shown by a gain of 2-4 points in the brightness of the resulting pulp product. Also, selected analysis of the dirt count in the pulp products from this series of experiments indicated that the dirt count numbers were reduced.

![Figure 1. Effect of Percel 727 floculant on the brightness of pulp product produced in flotation deinking experiments. The tests were carried out in a 2L Denver flotation cell (1400 rpm; 1 wt% solids; pH 6.8; 3 min) using pulp (brightness 58-58%) received from the Great Lake Pulp and Fiber. The Lionsurf 792L surfactant blend (polyalkylene oxide plus fatty acid)(squares) or C_{12}E_{4} (diamonds) was added at a concentration of about 0.03 g/L and 12 μM, respectively, to generate a froth.](image-url)
from 350 ppm to 180 ppm for all dirt sizes, and from 240 ppm to 70 ppm for dirt count sizes smaller than 0.04 mm². Further, it was found that less than 5-10 wt% of the pulp was lost with the froth in all experiments. The use of flocculant at a concentration from 0.05 to 0.5 mg/L had little effect on the flotation of cellulose fibers. However, separate sporadic tests with flocculant concentration a few times larger than 0.5 mg/L indicated a tendency of cellulose fibers to agglomerate and report to the froth product.

Figure 2 shows the effect of flocculant concentration on the dirt count in the pulp product generated in three-minute flotation experiments involving model pulp made of sorted office papers. The results of Figure 2 cannot be directly related to the results of Figure 1 as pulp of different composition was used in each experiment. Additionally, a different pH of the pulp was maintained in these flotation experiments.

The dirt count instead of brightness is presented in Figure 2 because the model pulp made of sorted office papers was very bright (brightness >88%) and removal of even a substantial number of ink particles had little effect on brightness of the flotation product.

As the results presented in Figure 2 prove again, the flocculant had a positive effect on the efficiency of flotation deinking. In these particular tests, the improvement of flotation deinking was observed over the entire concentration of flocculant used, from 0.05 to 0.85 mg/L. There was observed an initial increase in the dirt count for the pulp product produced in the flotation experiments with 0.08 mg/L Percel 727 as compared to the dirt count in the pulp product from flotation experiments without flocculant (Figure 2). This probably resulted from the effect of ink fines, with the size of less than 6 microns, on the number of particles counted during the analytical procedure. The fine ink particles with a dimension less than 6 microns are smaller than the resolution of the scanner used in the analysis of the pulp product. A small amount of the flocculant such as 0.08 mg/L probably promoted agglomeration of the fines first, due to large surface area of the fines. Enlarged particles made of agglomerated ink fines became countable in the dirt count analysis.

The results from these flotation tests with flocculant shown in Figures 1 and 2, although not drastically changing the performance of the flotation operation, are encouraging from both practical and fundamental points of view. A more selective and efficient flocculant than that used in this study, which certainly would be designed for flotation deinking, might provide more than 2-4 points gain in the brightness scale for the pulp product. For example, as we found, the activity of Percel 727 flocculant in flotation deinking is not solitary and enhancement of flotation deinking was also observed with Percel 7651 and Superfloc 210+ flocculants (not shown).

The reasons for the improved flotation deinking can be several including: i) flocculation of ink particles to aggregates; ii) flocculation of mineral filler-ink particles to aggregates; iii) adsorption of polymeric flocculant at interfaces and formation of links between ink particles and gas bubble (bridging effect); iv) adsorption of flocculant at interfaces causing increased interactions between ink particle and gas bubble; v) synergetic effect of polymeric flocculant on other reagents involved in the flotation deinking, and many others. The following sections present the results of fundamental studies that shed additional light on the interfacial chemistry associated with flotation deinking with the use of flocculant.

Ink-Ink Flocculation

The samples taken from the froth layer during the flotation deinking experiments were observed under an optical microscope to reveal whether any flocculation process occurred for the fine ink particles. It was indeed found that the addition of
floculant to the pulp during the flotation separation caused the ink particles to form agglomerates that probably are more suitable for attachment to gas bubbles during flotation than individual fine ink particles. Examples of captured optical images for the samples picked up from the flotation cell during the experiments without and with Percol 727 floculant are shown in Figure 3.

**Adsorption of Floculant**

The adsorption of the Percol 727 floculant on the model ink surface was noted in contact angle and pull-off force measurements. The contact angle data in Table 1 illustrate the effect of floculant on the hydrophobicity of Xerox ink surface.

As shown in Table 1, an addition of the Lionsurf surfactant blend to the solution reduces the contact angles measured at the ink surface. This is in accordance with the previous results on the effect of ethoxylated alcohols on the hydrophobicity of polyethylene and ink [12]. Next, the addition of Percoll 727 floculant to the solution partially restored the hydrophobic properties of ink surface; the contact angle increased (Table 1). The restoration of ink surface hydrophobicity is by a few degrees; although this finding is interesting from a fundamental point of view it might not have any significant practical consequences.

The effect of increasing contact angles recorded in Table 1 cannot be attributed to the time-dependent effects during contact angle measurements. Some of the drops equilibrated for five minutes and the result was very similar (Table 2); floculant indeed improves the hydrophobicity of the ink surface.

The increasing contact angles cannot be attributed to the variation of the aqueous solution surface tension as we have not observed such an effect of the Percoll 727 on the surface tension of water. This conclusion was also supported by our independent froth stability tests (not shown). For example, it was found that a volume of the froth generated in a tube using solutions of the Lionsurf 792L surfactant blend and stability of this froth were not affected by the addition of the floculant. It is thus very likely that the increase in contact angles observed for the solutions on the ink surface could be attributed to the structure of adsorbed molecular layers, composed of surfactant blend components and floculant, on the ink surface.

**Table 1.** The results of contact angle and surface tension measurements for aqueous solutions of Lionsurf 792L surfactant blend and Percol 727 floculant. The solutions were prepared using tap water.

<table>
<thead>
<tr>
<th>Lionsurf 792L Concentration [mg/L]</th>
<th>Percol 727 Concentration [mg/L]</th>
<th>Surface Tension [mN/m]</th>
<th>Advancing Contact Angle [deg]</th>
<th>Adhesion Tension* [mN/m]</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>72</td>
<td>82-84</td>
<td>7-10</td>
</tr>
<tr>
<td>39</td>
<td>0</td>
<td>62</td>
<td>85-79</td>
<td>12-16</td>
</tr>
<tr>
<td>118</td>
<td>0</td>
<td>49</td>
<td>70-73</td>
<td>14-17</td>
</tr>
<tr>
<td>0</td>
<td>0.08</td>
<td>72</td>
<td>86-88</td>
<td>2-5</td>
</tr>
<tr>
<td>0</td>
<td>0.25</td>
<td>65</td>
<td>86-88</td>
<td>2-5</td>
</tr>
<tr>
<td>39</td>
<td>0.08</td>
<td>85-85</td>
<td>6-3</td>
<td></td>
</tr>
</tbody>
</table>

*Adhesion tension is the value calculated by multiplying the surface tension value by cosine of advancing contact angle.

**Figure 3.** Optical microscopy images of ink particles in pulp in the absence (top) and presence (bottom) of floculant (0.85 mg/L). Samples of froth taken during the flotation experiments results of which are shown in Figure 2.

**Table 2.** Sessile-drop contact angles measured for aqueous solutions on Xerox 5023/1020 ink surface.

<table>
<thead>
<tr>
<th>Solution</th>
<th>Contact Angle after 5 min [deg]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water</td>
<td>88</td>
</tr>
<tr>
<td>30 mg/L Lionsurf 792L</td>
<td>65</td>
</tr>
<tr>
<td>30 mg/L Lionsurf 792L + 0.5 mg/L Percol 727</td>
<td>70</td>
</tr>
<tr>
<td>30 mg/L Lionsurf 792L + 1.7 mg/L Percol 727</td>
<td>72</td>
</tr>
</tbody>
</table>
Pull-Off Forces between a Hydrophobic Tip and Ink Surface

Additional proof for the adsorption of the flocculant on the surface of model ink comes from the pull-off force measurements carried out by the atomic force microscope (AFM). Figure 4 shows the correlation between pull-off force and concentration of Percol 727 flocculant. The measurements were carried out for the sharp AFM cantilever tip coated with a film of gold and next self-assembled monolayer of hexadecanethiol. The radius of the tip was not determined in this study and the results shown in Figure 4 are not normalized.

Results in Figure 4 show the decreasing pull-off forces between hydrophobic sharp tip and hydrophobic ink surface with increasing concentration of the Percol 727 flocculant and clearly indicate the adsorption of the flocculant molecules on hydrophobic surfaces. Decreasing value of the pull-off force is not a desirable result since this indicates that the strength of the gas bubble-ink particles aggregates formed in the flocculant solutions during flotation can be reduced. This effect however, is small at the concentrations of Percol 727 used in this study and also should have no significant impact in practical operations.

Long-Range Interfacial Forces

Interfacial force measurements using atomic force microscopy have helped to explain fundamental mechanisms of flotation deinking [13-15]. This technique was also employed in this study by measuring the interfacial forces between the hydrophobic AFM cantilever tip (regular tip coated with a gold film and modified with a monolayer of thiol) and the ink substrate in Percol 727 solutions. Examples of the measured interfacial forces versus distance between the AFM tip and the ink substrate surface are shown in Figures 5 and 6. Similar results were obtained for multiple measurements in the same and other solutions with the flocculant concentration from 0 to 1.7 mg/L.

As an important outcome of the AFM measurements, it was found that interfacial forces in the AFM tip-aqueous phase-toner systems were not affected by the presence of Percol 727 flocculant at a concentration from 0.051 to 1.7 mg/L to any great extent. For example in Figure 6, the force versus distance correlation for deionized water is compared with that for 0.17 mg/L Percol 727 solution; no substantial difference is noted and scattered results practically overlap. Similar results were also obtained for other solutions with 0.017, 0.051, and 1.7 mg/L of Percol 727 flocculant.

The results in Figures 5 and 6 are not normalized due to the uncertainty in determination of the radius of the curvature for the sharp AFM cantilever tip (R<20-30 nm) that we faced using either scanning electron microscopy or a blind reconstruction technique [16]. Due to the same reason, no attempt was made to fit our results to the theoretical curves.

![Figure 4](image)

**Figure 4.** The effect of Percol 727 flocculant concentration on pull-off force measured between hydrophobized AFM cantilever tip and ink substrate. Solutions were prepared using deionized water having pH 6. Each symbol represents an average of 10-20 measurements and bars show the variation in pull-off force values.

![Figure 5](image)

**Figure 5.** The interfacial force values measured between a hydrophobized AFM cantilever tip and an ink substrate in deionized water (pH 6). The solid line is added to guide the eyes.

![Figure 6](image)

**Figure 6.** The interfacial force values measured between a hydrophobized AFM cantilever tip and an ink substrate in deionized water (circles) and in 0.17 mg/L Percol 727 solution (triangles) (pH 6). The lines are added to guide the eyes.
that could be calculated based on the DLVO theory [17]. Nevertheless, the nature of forces can be deduced from the AFM results.

As shown in Figures 5 and 6, the forces between hydrophobic tip and ink were repulsive at large distances and attractive at distances smaller than 5-8 nm. In all systems, at a distance from about 3.5 to 6 nm strong attractive forces between the cantilever tip and surface exceeded the spring constant of the cantilever and the tip "jumped" onto the ink surface.

Linear force versus distance relationships for semi-log plots in Figures 5 and 6 indicate that at large distances the repulsive forces are due to the overlap of electric double layers surrounding surfaces of the hydrophobic tip and the ink surface (see Israelachvili [17] for details of interfacial forces and theoretical equations describing them). Analysis of electric double layer forces determined that the Debye length (\(1/\kappa\)) for the electric double layer for our systems was 30-40 nm. About 10 nm variation of the Debye length value is associated with a significant scatter of force versus distance data, particularly at larger separations; see Figures 5 and 6 for examples.

Also in previous contribution, we determined the zeta potential (\(\zeta\)) of toner to be about -35 mV at pH 6 [18]. A similar value is expected for the hydrophobic monolayer of thiol on the gold film. Assuming that the zeta potential is approximately equal to the surface potential (\(\psi\)), we estimated that the radius of the AFM cantilever tip should be about 20 nm in order to fit the following equation (1) for the electric double-layer force to the force versus distance experimental data generated in this research:

\[
F_{\text{EDL}} = \frac{4\pi \sigma^2 R}{\varepsilon \varepsilon_0 \kappa} e^{-\kappa R} \tag{1}
\]

where \(\sigma\) is the mean surface charge density at the interface, \(R\) is the radius of the tip, \(\kappa\) is the dielectric constant of liquid, \(\varepsilon_0\) is the permittivity of free space, \(\kappa\) is the Debye length, and \(R\) is the distance between tip and toner surface. For more details see [17].

The nature of attractive forces operating at distances smaller than about 10 nm was also analyzed in this study. Certainly the van der Waals interactions are always present in flotation deinking systems and they can be calculated based on the following equation:

\[
F_{\text{vdW}} = -\frac{A_{12}}{6H^2} \tag{2}
\]

where \(A_{12}\) is the Hamaker constant for the three-phase system (tip-water-ink in this case) and was calculated by equation (3).

\[
A_{12} = \left(\sqrt{A_{11}} - \sqrt{A_{22}}\right) \sqrt{A_{13}} - A_{23}\tag{3}
\]

\(A_{11}\) is the Hamaker constant for the thiol monolayer on a gold film (\(A_{11} = 3.9 \times 10^{-20}\) J according to Ederth [19], \(A_{11} = 2.8 \times 10^{-20}\) J according to the approach used by van Oss [20]); \(A_{22}\) is the Hamaker constant for water (\(A_{22} = 3.7 \times 10^{-20}\) J [17]); and \(A_{33}\) is the Hamaker constant for toner (\(A_{33} = 6.5 \times 10^{-20}\) J [15]).

The value of the Hamaker constant, \(A_{123}\), for the three-phase system under study was calculated based on the above-listed Hamaker constants to be very small and probably between -1.6 \times 10^{-24} J and -3.2 \times 10^{-24} J. For the negative \(A_{123}\) value, the van der Waals forces are repulsive and diminish the possibility of attachment of hydrophobic tip to the ink. For a positive \(A_{123}\) value, the van der Waals forces are attractive. However, because of the very small \(A_{123}\) value, the van der Waals forces are not responsible for the cantilever jump to the ink surface at distances from about 3.5 to 6 nm. Other attractive forces are responsible for this effect and they are believed to be of a hydrophobic origin [15].

The jump-in distance observed in this study, 3.5-6 nm, is approximately two times smaller than we reported for the tip with a polyethylene particle having a diameter of 8-15 \(\mu\)m [15]. This is in spite of the fact that the thiol monolayer used in this study is more hydrophobic than polyethylene (112 degrees versus 92 degrees for water advancing contact angles). Two possible reasons might cause this discrepancy. First, the sharp tip could penetrate the ink substrate (nanoindentation effect) causing inaccurate determination of the zero position. Second, the attractive interactions causing the AFM cantilever to jump onto the ink substrate surface are dependent on the tip size. Both possibilities are not ruled out at this stage and are planned to be investigated in the future.

**CONCLUSIONS**

Improved flotation deinking has been accomplished for sorted office papers by using a synthetic
flocculant (Percol 727), copolymer of sodium acrylate and acrylamide, at a concentration of 0.1-0.9 mg/L. The fundamental studies of contact angle and interfacial force measurements indicate that the flocculant adsorbs on the interacting hydrophobic surfaces. It appears from the contact angle measurements that the Percol 727 flocculant causes a slight restoration of ink hydrophobicity in the solutions with a nonionic surfactant-fatty acid blend (Lionsurf 792L). However, no substantial improvement in attractive forces was recorded between a hydrophobized AFM cantilever tip and the model ink substrate in the 0.1-0.9 mg/L concentration solutions of flocculant as compared to pure water. On the other hand, microscopic observations clearly indicate the flocculating power of this copolymer of sodium acrylate and acrylamide in suspensions of ink particles.

The results presented in this paper clearly indicate the opportunity for improved flotation deinking through accommodation of flocculating agents in the solution chemistry of the pulp. This result should stimulate further search for efficient and selective flocculants. The results presented in this contribution are very fundamental and tests with paper mill processing water were not undertaken in this study. Also, the effects of flocculating polymers on properties and quality of the paper product remain unknown.

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LITERATURE CITED


