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## The Effect of HLB Factor on Surfactants Used in Flotation Deinking

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THE EFFECT OF HLB FACTOR ON SURFACTANTS  
USED IN FLOTATION DEINKING

by

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A Thesis submitted  
in partial fulfillment for  
the Degree of Bachelor of Science

Western Michigan University

Kalamazoo, Michigan

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## ABSTRACT

The objective of this study is to determine the role of surfactants in flotation deinking through the use of their HLB factors. As an aside a comparison of surfactant and a product called Serfax NP-10 was made along with a study looking at the effect of surfactants and Serfax on a closed water system. It was found that an HLB of 13.5 worked best for flotation deinking and this points to the conclusion that the surfactant is working as a detergent. The Serfax product seemed to work as well as the best surfactant without any detrimental results in the closed water system. The brightness seemed to go down when the surfactant was used in the closed water system.

## INTRODUCTION

More and more the paper industry is using recycled fiber. Most of this recycled fiber must first be deinked before it is used. Flotation deinking is relatively new in the U.S. and could be the choice of deinking in the future. The variables involved in flotation deinking are many and one of them is the surfactants used. The role these surfactants play in flotation deinking is the basis of this study. Also, the effect of surfactants in a closed water system and comparison between surfactants and a product called Serfax NP-10, used in Europe, was made.

## OVERVIEW OF FLOTATION DEINKING

Flotation deinking has just recently started to gain popularity in the U.S. compared to the conventional washing deinking systems. Both conventional and flotation deinking systems start out the same by repulping the waste paper in a pulper with chemicals. This step of the process removes the ink from the fibers. It is the next step, where the removed ink is separated from the fibers, that the difference between washing and flotation deinking becomes evident. In the washing system the stock is either screened or squeezed to remove the ink from the fibers. In the flotation system the ink is removed by floating it away with air bubbles in the presence of a collector (16,17). One of the advantages of flotation is a higher yield, 85 to 95%, compared to 70 to 75% for conventional washing systems (6,9,10). Other advantages include being able to close the water circuit more easily and less water use (1,3,9,10). Closing the water circuit helps to save the chemicals and cuts down one of the costs of flotation deinking (14). Also, using less water helps to cut down on the amount of effluent that has to be treated because the ink is removed in a more concentrated form (9). It has also been claimed that flotation deinking helps to get rid of light contaminants (9). Energy savings have also been realized by Georgia Pacific at their Kalamazoo, MI mill which is one of the first U.S. mills to use flotation deinking (2). There are disadvantages

and these included higher chemical and capital costs than conventional deinking. Flotation deinking will also not remove inorganic fillers, fines, and other contaminants. These objects must be removed by some kind of pretreatment and cleaning (2,10).



## FLOTATION

In a flotation system particles are carried out of suspension upward and then held in a froth, or float, because they are attached to an air bubble. This froth is then removed. Flotation has been used for years in the mining industry to separate low grade ores inexpensively. It has only been recently, however, that the paper industry has started to use flotation methods for some processes such as deinking.

### THEORY

In flotation there are three phases. These phases are; 1) liquid, 2) solid, 3) gas. The liquid involved is water. To this, various chemicals are added which give the desired properties needed for successful flotation. These chemicals include collectors, foamers, and modifiers.

The gas used in flotation is most often air. It is supplied by either injection of compressed gas or by agitation.

The solid phase is probably the most important in flotation (19,28). Solids do not usually attach themselves to an air bubble and float to the surface. A collector is added to act as the go between for the solid and the air. This collector must therefore be able to connect to the solid and be attracted to the air bubble (31).

The collector is very important and must be discussed further. Collectors, or surfactants, are surface active

agents. When present at low concentrations they change the system. They do this by adsorbing onto the surfaces and interfaces of the gas, liquid, and solid and changing the free energies of these surfaces or interfaces. Surface is defined as the boundary between the liquid and the gas. Interface is the boundary between any two phases (29).

Surfactants are able to do this because they have one polar and one non-polar area (30). They can also be non-ionic (no charge) or zwitterionic (both positive and negative). The polar group is hydrophilic and the non-polar group is hydrophobic (12,29). Because of this the surfactant will arrange itself at the surface of a liquid with the hydrophobic head towards the air and the hydrophilic head towards the liquid reducing the surface tension.

#### STRUCTURES OF SURFACTANTS

There are thousands of surfactants but here are some examples of the different types (29):

- 1) Anionic-the surface active portion has a negative charge such as  $R-\overset{\overset{O}{\parallel}}{C}-O^{-}Na^{+}$  (soap),  $RC_6H_4SO_3Na^{+}$  (alkylbenzene sulfonate).
- 2) Cationic-the surface active portion is positively charged such as  $RNH_3^{+}Cl^{-}$  (salt of a long chain amine),  $RN(CH_3)_3^{+}Cl^{-}$  (quaternary ammonium chloride).
- 3) Zwitterionic-both positive and negative charges may be present such as  $R^{+}NH_2CH_2COO^{-}$  (long chain amino acid),  $RN(CH_3)_2CH_2CH_2SO_3^{-}$  (sulfbetaine).
- 4) Nonionic-nocharge such as  $RCOOCH_2CHOHCH_2OH$  (monoglyceride)

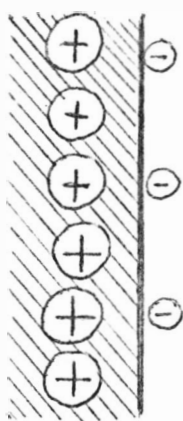
of a long chain fatty acid),  $\text{RC}_6\text{H}_4(\text{OC}_2\text{H}_4)_x\text{OH}$  (polyoxyethylenated alkylphenol). The ones most commonly used in flotation deinking are the soaps (anionic) and the derivatives of long chain fatty acids (nonionic) (8,12).

#### SURFACTANT ADSORPTION

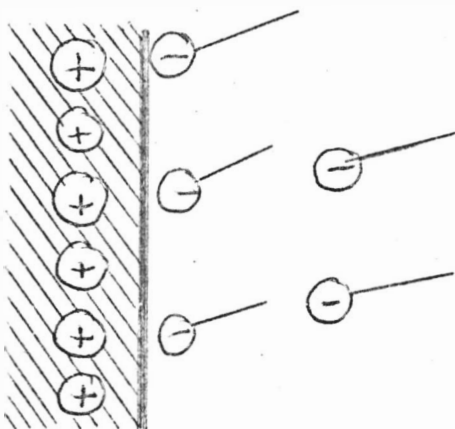
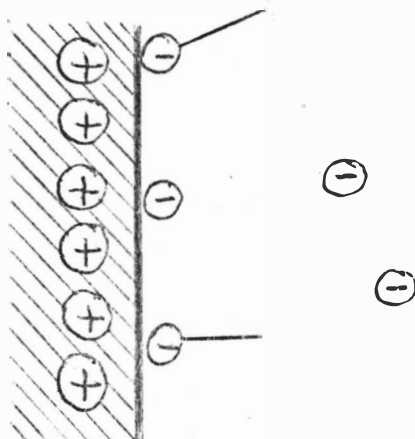
The amount of adsorption of the surfactant at the solid/liquid interface is influenced by at least three factors (29): 1) the type and structure of the groups on the solid surface-whether positive or negative, polar or non-polar; 2) the structure of the surfactant-ionic or nonionic, whether the hydrophobic group is long or short, straight or branched chain, aliphatic or aromatic; and 3) the nature of the liquid. The various ways surfactants adsorb are (29):

- 1) Ion exchange (Fig. 1)-ions that the solid has adsorbed from the solution are replaced by the surfactant ions.
  - 2) Ion pairing (Fig. 2)-ions from the surfactant are adsorbed onto oppositely charged locations on the solid.
  - 3) Hydrogen bonding (Fig. 3)-hydrogen bonds are formed between the surfactant and the solid.
  - 4) Polarization of  $\pi$  electrons-when the surfactant has electron-rich aromatic nuclei and the solid is strongly positive.
  - 5) Dispersion force-by the London-van der Waals dispersion forces acting between surfactant and solid molecules.
- This type occurs more readily as the molecular weight of the surfactant increased and it is important not only by

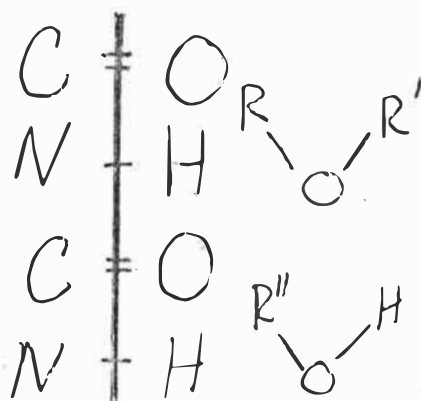
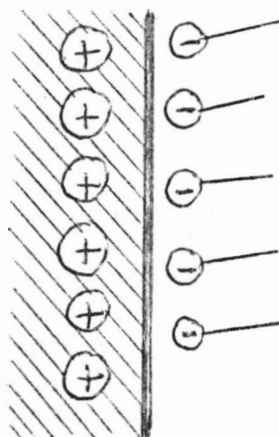
solution



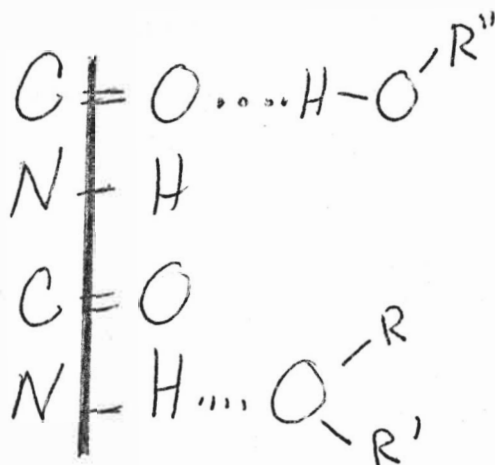
Ion Exchange  
Fig. 1



Ion Pairing  
Fig. 2



Hydrogen Bonding  
Fig. 3



itself, but also as a supplement in all other types of surfactant adsorption.

6) Hydrophobic bonding-when both the attraction between the hydrophobic groups of the surfactant and their inclination to leave an aqueous surrounding becomes great enough to enable the surfactants to adsorb by aggregating their chains. Surfactant molecules will also adsorb onto other surfactant molecules already adsorbed by this method.

If the adsorption of the surfactant onto the solid occurs so that the hydrophobic end is facing the solution the solid becomes more hydrophobic and it will want to leave the liquid. This is what is needed to help flotation. If air is put into the system these hydrophobic groups will join the air bubbles because of the same reason that the surfactant wanted to join the solid. It is at this stage of flotation that the contact angle becomes important as illustrated in Figure 4 (20).

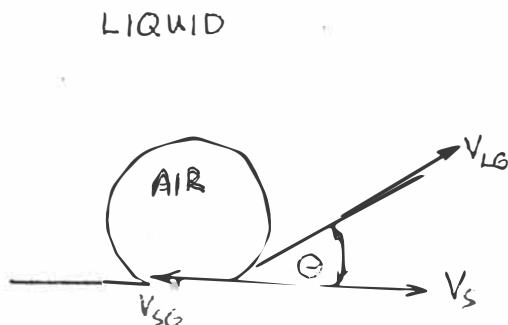


Fig. 4 Equilibrium contact between an air bubble and a solid in a liquid.

The tension is expressed through Young's equation (20):

$$V_{SG} = V_{SL} + V_{LG} \cos \theta$$

Where  $V_{SG}$  - Interfacial tension between the solid and the air.

$V_{SL}$  - Interfacial tension between the solid and the liquid.

$V_{LG}$  - Interfacial tension between the liquid and the air.

$\theta$  - The contact angle.

If the contact angle on the particle is too low the liquid wets the particle and air/particle contact is not achieved. Contact angles above 90 degrees show indifference of the solid for the fluid. For flotation the contact angle should be between 50 and 75 degrees (20).

Other additives besides surfactants are important to the flotation process. Foamers, which help to stabilize the foam that is formed, are also added. The best foamer additive seems to be long chain, water insoluble, polar compounds with straight chain hydrocarbon groups that are about the same length as the hydrophobic group of the surfactant that is used (29). Pine oil is the most common. The foamers work by establishing like charges around the bubble which makes a stable bubble and also helps repel other bubbles so they do not join together until they reach the surface (31).

Modifiers are another important additive. The properties of the liquid phase affect the amount of surfactant

adsorption. The pH, temperature, electrolyte content, and presence of other additives are some of these properties (29). The control of pH is one way to achieve selectivity between the substances to be separated. Materials whose potential determining ions are  $H^+$  and  $OH^-$  are directly affected and in other systems pH indirectly affects the potential determining ions by affecting the chemical equilibrium of the system. The pH also controls the ionization of the surfactant (28).

The temperature of the system affects the adsorption of the surfactant on the solid since it may change the critical micelle concentration which affects the effectiveness of the surfactant. The surfactant works better in ion form rather than in micelles (28).

#### HLB

The HLB factor of a surfactant is a measure of the hydrophilic-lipophilic balance of the groups in the surfactant. The concept was developed by William C. Griffin (34,35). All surfactants contain both hydrophilic and lipophilic groups. The HLB factor is a measure of the weight ratio of these groups. The equation for HLB is (37):

$$HLB = 7 + \Sigma H - \Sigma L$$

Some typical values of H and L groups are in Table I. The higher the HLB number the more hydrophilic the surfactant is. The HLB number of a surfactant determines its uses.

Table II shows the different uses of the surfactants with different HLB numbers (36).

Table I. Typical H and L Values for Calculating HLB Factors

	<u>H</u>		<u>L</u>
$\text{NaSO}_4^-$	39	$\begin{array}{c}   \\ -\text{CH} \end{array}$	.47
KOOC	21	$\begin{array}{c}   \\ -\text{CH}_2 \end{array}$	.47
NaOOC	19	$\begin{array}{c}   \\ -\text{CH}_3 \end{array}$	.47
HOOC	2.1	=CH-	.47
HO	1.9		
-O-	1.3		
$\text{CH}_2\text{CH}_2\text{-O}$	.36		

Table II. HLB Factor vs Use of Surfactant

<u>HLB Number</u>	<u>USE</u>
4-6	Water in oil emulsifier
7-9	Wetting agent
8-18	Oil in water emulsifier
13-15	Detergents
15-18	Solubilizing agents



## FLOTATION DEINKING

The principle of flotation deinking is based on the separation of the ink from the fibers using air bubbles and taking advantage of the different wettability of the ink and fibers (4). The ink is separated in two stages. The first stage is in the pulper where chemical, mechanical, and thermal action break the waste paper into individual fibers and saponify the ink binder. The ink is emulsified and removed from the fibers into a suspension. Chemicals added in the pulper include sodium hydroxide, sodium peroxide, sodium silicate, foamers, and collectors. The second stage removes the emulsified ink from the suspension by the generation of air bubbles in the flotation cell. The foamer helps this by reducing the surface tension of the water. The pigment particles are made more hydrophobic by using a collector which attaches to the pigment and the air bubble. These air bubbles, with the pigment attached, float to the surface and form a foam layer which is removed. In Fig. 5 a diagram of pigment flotation is shown (3.4).

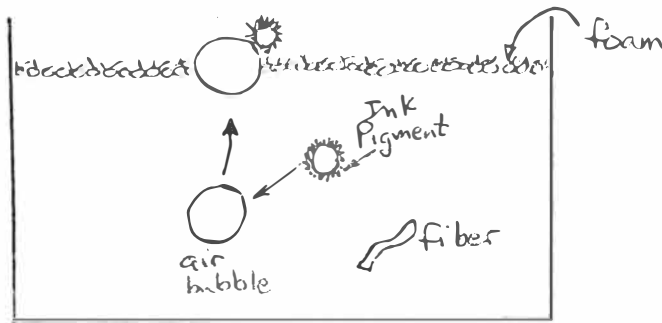


Fig. 5 Flotation Principle

The stability and bouyancy of the foam is determined by the type and amount of foamer and collector chemicals. The ratio of these chemicals is very important to the effectiveness of the system and should be carefully controlled (6).

## DEINKING CRITERIA

The criteria involved when setting up a deinking process are the quality of the waste paper and the nature of the ink, the physical and chemical reactions that are involved in the removal of the ink, and the overall design of the system setup (6). Probably the most important of these is the amount and type of ink that has been applied to the waste paper that is to be deinked. The amount varies but a good average value to use is around 2% with a film thickness of 1.5 to 3.0 microns (6).

## PRINTING INK

The inks used consist of three parts. These parts are the color base (pigment), binders, and assorted additives (4). The amount of ink is not as important as the composition of these three ingredients. The color base consists of inorganic carbon black, white, and other different colored pigments. Organic soluble and insoluble dyestuffs are also used for the color base (4,6,11). The binders, which hold the color base to the fibers, are divided into two categories. They are termed either easy or difficult to remove. The easy ones are natural and synthetic resins, alkyl masing, drying oils, and mineral oils. The difficult ones are asphalts, cellulose derivatives, synthetic latices, phenolic urea, and melamine resins (4,6,11). Additives include many things to add brightness, help in drying, or to improve the hardness of the dried ink to name a few

examples. The additives encountered frequently are natural and synthetic oils, wax dispersions, and optical brighteners (4).

## CHEMICALS

The chemicals used in the pulper include sodium hydroxide, sodium or hydrogen peroxide, and sodium silicates. These are added at the beginning of the pulper run. Collectors and foamers are added at the end of the pulper run (3.6-9). It seems that the alkali involved only produces a stabilized ink-fiber suspension and is not involved in the saponification of the ink binder (6,8). The alkali also helps to break up the waste paper into fibers. The peroxides help to bleach the fibers slightly while they seem to be the ones which do most of the ink bindersaponification (3,6). At low concentrations, alkaline sodium silicates, called meta-silicates, are good emulsifiers and oil based inks are more completely emulsified when these silicates are used (5). Sodium silicates have good detergent action and help to keep the suspended ink particles from redepositing because of their dispersion properties. Silicates also help to give a brighter pulp with less fiber damage than just using sodium hydroxide alone (5). The trend has been to use more sodium silicate and less sodium hydroxide. The pH of the system is also kept from going too low as it would with just sodium hydroxide (8). The silicates help to stabilize the peroxides and help separate the ink from the

fibers (5,12). The amount of chemicals varies but the following averages are followed fairly closely. The percentages by weight of waste paper are usually 3.5 to 5.0% sodium silicate, 1.5 to 2.0% sodium hydroxide, 1.0 to 2.0% peroxide, .05 to .25% foamer, and .3 to .8% collector (6-8).

Chemicals used in the flotation cell include foamers and collectors. These are usually added at the end of the pulping run and are mixed with the pulp in a mix chest. The chemicals that help to get the ink pigments out of suspension and into the float are the collectors. These chemicals must extract the ink particles out of the ink/fiber suspension and then carry them away after aeration (8). It is very important that the amount of collector is just right. If there is excess there will be machine felt blinding and if there is not enough some of the ink will be carried over to the paper machine (8). For the flotation cell the optimum chemical concentration, once found, should be maintained very carefully (6).

## DEINKING PARAMETERS

The optimum deinking and flotation can be realized by controlling the operating conditions encountered. Some of the parameters are water hardness, pH, consistency, particle size, bubble size, impeller speed, quantity of air present, dwell time, and temperature (17).

### WATER HARDNESS

Bechstein (32) states that maximum flotation occurs when all the hardness agents are used and there is an excess of soap. If the water hardness is too high all the soap is precipitated and nothing acts as a frother. Too much collector leads to fiber loss because of fiber entrainment. Raimondo (17), on the other hand, found that a minimum hardness level worked the best and that excess calcium ions did little to the procell. If hardness was too high it was hard to form bubbles but the brightness of the pulp remained the same.

### PH

The pH in the pulper is very important and should not go below 8.5 or above 10.5. The usual range is 9 to 10. Above 10.5 pH fiber damage is greater than wanted and fiber swelling causes ink and filler particles to be adsorbed back on to the fibers too readily (3.8.15). If mechanical pulp is in the waste paper feed a pH above 10 tends to yellow the stock. A pH below 8.5 gives a pulp with lower brightness and less cleanliness (3). The pH in the flotation

cell is kept between 8 and 9 (6.9). This pH range is considered optimum for the foamers and collectors used in the flotation cell.

#### CONSISTENCY

The consistency in the pulper is not as critical as the consistency in the flotation cell but it is usually kept between 3 to 5% to give effective operation of the equipment. The consistency in the flotation cell needs to be maintained between .8 and 1.2% with consistencies less than 1% being the most favored (1,3,6,8,9,12). The Swemac cell claims operation at 2% and higher but it is not a pure flotation cell so will not be included (7). If the consistency is too high too many fibers are floated away causing a decrease in yield and more dirt is trapped in the fibers (3). Too high of a consistency also affects the bouyancy of the flakes attached to the bubbles causing more dirt to be trapped and resuspended (12). Too low of a consistency caused fibers to be carried into the foam (12).

#### PARTICLE SIZE

The size of the particle to be floated is very important in flotation deinking. Bechstein (32) stated that the amount of ink particles that were not floated is highest in the size area below 5 microns and the frequency of non-floated particles decreases with particle diameter. His theory behind this was that Brownian movement counteracts the tendency of the particles to adhere to the bubbles and be washed out. This shows that forming

conglomerates of these smaller particles is important to remove all the ink.

#### BUBBLE SIZE

The amount and size of the bubbles in the flotation cell is important. If the bubbles are too small they will not be stable in the foam formed and the ink will go back into suspension (4,6). They should be as small as possible, however, because they need to provide the greatest possible surface area with the air supply available (4). If they get too large or too close together they will join up together and this will reduce the available surface area (4,6). Raimondo (17) showed that as pH changes so does the bubble size.

#### QUANTITY OF AIR

The more air throughput for a given cell the larger the bubbles will be. Figure 6 shows the effect of air quantity on bubble size (4).

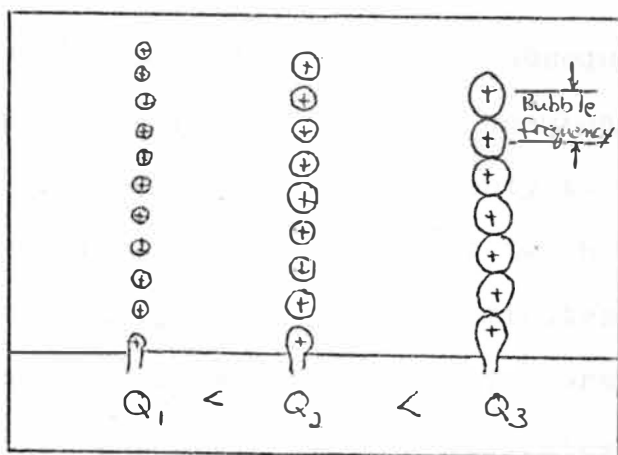


Fig. 6 Bubble formation vs air quantity



If more air is put through the system the bubble diameter increases and the risk of two bubbles joining increases. If the air quantity is increased even more jet aeration occurs. This should be avoided because the bubbles formed here vary in size and number (4).

#### IMPELLER SPEED

In his work, Raimondo (17), showed that for good deinking to take place there must be sufficient turbulence in the flotation cell. He gained a 3.2% increase in brightness in the first 500 rpm increase in speed, followed by a 2.3% increase in the next 500 rpm, and a gain of 1.5% in the next 500 rpm. He found that after 2500 rpm no further increase in brightness increased. This increase may be explained by the gas precipitation theory which states that the quantity of air passing into solution increases with the pressure increase exerted by the impeller (19).

#### TIME

The time in the pulper and the subsequent mixing chest is important in order for the chemicals to have enough time to react. A time of twenty to thirty minutes in the pulper with one and a half to two hours in the chest is the best (3,6,12). Thirty minutes total is the absolute minimum and two and one half hours is the maximum. After this time the peroxides and silicates lose their effectiveness and the ink starts to redeposit back on to the fibers (3,6). For the flotation cell a time of eight

to ten minutes is the norm with six minutes being the minimum. If the time is too long fiber becomes floated. If the time is inadequate the ink is not completely removed (3.6). As time increases the brightness of the stock increases and this is done by providing more than one flotation cell (17).

#### TEMPERATURE

The temperature in the pulper should be maintained between 40 and 45 degrees C (3,8,9). If the temperature is too low the pulping time is longer and there are more rejects (3). If the temperature goes above 45 degrees C the peroxides will decompose and be useless to the process (3). In the flotation cell, Raimondo (17), showed that as the temperature increased so did the brightness. The surface tension of the water decreases with temperature and the volume of air increases with temperature and the combined effect of these two principles may have a maximum in the 40 to 45 degrees C region.

## STUDIES IN FLOTATION DEINKING

In a lab study done in 1958, Kajanne and Ostring (5) studied the effect of varying the types of chemicals used. These included hot water, sodium hydroxide, sodium peroxide, sodium silicate, soaps, surfactants, and solvents. They found that a combination of alkali and soap gave the best results while the addition of surfactants, solvents, and polyphosphates gave no improvement or negative results. They found that using sodium silicate instead of just sodium hydroxide improved the deinking and colored the stock less. Gartner and Wiegand (5), in 1957, saw improvements in deinking with a mixture of sodium hydroxide, sodium peroxide, sodium silicate, and detergents. Rosin soaps or surfactants have been found to help in wetting out oily inks.

One would expect that a complete monolayer of collector on the bubble would give the best flotation because it would provide the greatest contact but this is not so. Gaudin (19) found that particles adhere the most to the bubbles when the layer is only 5 to 15% and that they adhere less with more coverage. The reason behind this is thought to be that when the bubble and particle merge the film of collector on the bubble is penetrated. This locking up between bubble and particle collector film stabilizes the three phase system and is most effective with only partial coverage of the particle with collector (20).

In 1977, Turai and Williams (36), did a study which looked at the effect of HLB factor on deinking efficiency. This study looked at the effect of the HLB factor of surfactants in washing deinking. They found that an HLB factor of 14.5 worked the best. This showed that in washing deinking the surfactant is acting as a detergent.

## EXPERIMENTAL DESIGN

The purpose of this study is to find out what role surfactants play in flotation deinking. As a basis for this judgement surfactants with different HLB factors will be used. The criteria by which the surfactants will be judged will be the final brightness of the pulp as this is one of the main criteria used in judging the effectiveness of deinking. Studies have already been done regarding the efficiency of flotation deinking as judged by the amount of fiber lost so this will not be studied. The second phase of this study will compare the surfactant that worked the best with a product called Serfax NP-10. The Serfax product is fairly new in the U.S. market. It is sold by Stephenson Bros. Ltd. of England. Dr. Herbert Ortnier of Voith suggested that I look at this product as it has been used almost exclusively in Europe. Dr. Ortnier also suggested that I look at what happens when the water system is closed. Nonionic surfactants were used because they are the ones used in industry.

### Phase I. Surfactant HLB Study

#### A. Eight surfactants used.

1. Added by % active ingredient on B.D. fiber

2. Four repetitions of each surfactant

#### B. Variables held constant.

1. Temperature

- a. Pulper

- b. Flotation cell

2. pH
  - a. Pulper
  - b. Flotation cell
  - c. Pads
3. Stock makeup
4. Time
  - a. Pulper
  - b. Deflaker
  - c. Flotation cell.

C. Results calculated.

1. TAPPI brightness

Phase II. Surfactant vs Serfax NP-10

A. Single run comparison.

1. Results used
  - a. TAPPI brightness
  - b. Visual observation
2. Experimental procedure as in Phase I.

B. Closed water system.

1. Seven runs in cell
2. Results used
  - a. TAPPI brightness
  - b. Visual observation
3. Experimental procedure as in Phase I.
  - a. Water from cell reused

## EXPERIMENTAL PROCEDURE

### Phase I

The first phase involved the study of the eight different surfactants. The experimental procedure for each of the surfactants was the same. A detailed description of the whole procedure can be found in the Appendix.

The paper used was a supply of the Detroit Free Press newspaper. This paper was pulped with NaOH added to control pH. The surfactant was added near the end of the pulping run. The surfactant was added on a basis of 1% active ingredient on a B.D. fiber. The pulp was then allowed to sit so that the surfactant could react. At the end of the reaction time the mixture was deflaked and then floated in a laboratory Voith flotation cell under the following conditions:

- 1) Temperature =  $22^{\circ}$  C
- 2) Consistency = .5%
- 3) pH = 8-9
- 4) Dwell time = 12 minutes
- 5) Water used = Tap water

The surfactants used are in Table III.

Table III. Surfactants used in Experiment

Triton X-15	HLB = 3.6
X-35	7.8
X-45	10.4
X-100	13.5
N-101	13.4
X-102	14.6
X-165	15.8
X-405	17.9

## Phase II

The second phase involved the comparison of Serfax NP-10 with the surfactant that worked the best and also a look at the effect of closed water systems on both the Serfax and the surfactant.

For the comparison the experimental procedure followed was the same one that was used in Phase I. For the closed water system the water from the previous run was used as the dilution water in the cell for the next run. Seven runs were made so that it would be comparable to a commercial operation. The conditions in both the pulper and flotation cell were kept the same as in Phase I.

## Evaluation

Pulp samples were collected after each run. The pH of these samples was neutralized with sulfuric acid. Pads were then made on a Buchner funnel to prevent the washing action of the Noble and Wood or British Sheet Mold machines. These pads were then measured for TAPPI brightness.



## PRESENTATION OF RESULTS AND DISCUSSION

### SURFACTANT HLB STUDY

The effect of varying the HLB factor of the surfactant on the brightness of the pulp can be seen in Figure 7.

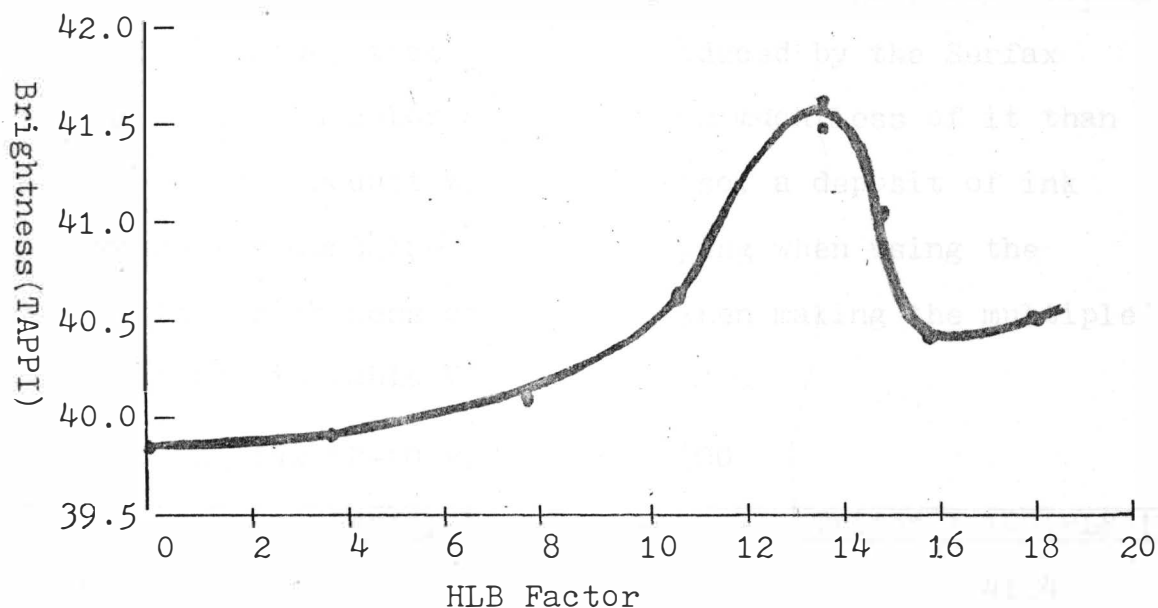


Figure 7 Brightness vs change in HLB factor of surfactant used in flotation deinking.

### DISCUSSION

From the graph of the results it can be seen that an HLB factor of 13.5 worked best for flotation deinking. The best results were in the range from 12 to 14.5. This would lead to the conclusion that the surfactant is acting as a detergent. It is acting as a detergent (HLB 13-15) in lifting the ink away from the fibers. At first glance it would seem that the surfactant is also acting as an oil in water emulsifier (HLB 8-18). It may be doing this somewhat

by creating a stable dispersion of the ink in the system which is then floated out.

#### SURFACTANT VS SERFAX NP-10

The Triton X-100 surfactant worked the best so it was compared to the Serfax product. Table IV shows the results of the brightness tests on pulp from this comparison. Visual observations showed that the foam produced by the Serfax was much darker in color and there was much less of it than when the Triton product was used. Also, a deposit of ink was left on the container during pulping when using the Serfax. The brightness of the pads when making the multiple runs are shown in Table V.

Table IV. Serfax NP-10 vs Triton X-100

	<u>Serfax NP-10</u>	<u>Triton X-100(HLB=13.5)</u>
Brightness	40.9	41.4

Table V. Comparison of Brightness With Closed Water System

Serfax NP-10	41.0	41.0	41.2	41.1	41.2	41.1	41.1
Triton X-100 (HLB=13.5)	41.3	41.1	41.1	41.2	40.7	40.8	40.7
Run #	1	2	3	4	5	6	7

#### DISCUSSION

A comparison of the Serfax NP-10 and Triton X-100 showed that they both did about an equal job. It shows that the Serfax product is also acting as a detergent in the flotation

of the ink. No information was available for the Serfax product so it is impossible to conjecture further about how it is acting in the system.

As far as the effect of a closed water system on both the Serfax and Triton there seemed to be little or no difference in the effectiveness of the Serfax. The surfactant exhibited a fairly steady decline in brightness over the seven runs. The reason for this may be that the surfactant, as it builds up, starts to act more as just a dispersant and does not provide the stabilization of the air bubbles that is needed in flotation deinking.

## CONCLUSIONS

Looking at the whole experiment, the following conclusions can be made. The HLB factor best suited for flotation deinking, in this experiment, was 13.5. The range of HLB factor is 12 to 14.5. This points to the conclusion that the surfactants used in flotation deinking are acting primarily as detergents in lifting the ink away from the ink/fiber suspension that is created through the mechanical action in the pulper and deflaker. The product suggested by Dr. Ortnier seemed to do as good a job as the surfactants currently used in the U.S.

The results shown in the short study with a closed water system showed that exclusive use of surfactants might lead to decreases in efficiency, measured as brightness, after many runs. The Serfax product did not seem to lose its effectiveness with the closed system.

The reader should remember that these results were for a particular system. They should work for other similar systems but there are many variables and the full extent as to how they affect flotation deinking is not at this time known.

## SUGGESTIONS FOR FURTHER WORK

The effect of closed water systems should be looked at more closely. In this study there was a downward trend after only seven repeats which is the standard number for one flotation system. If this is a common occurrence then the use of surfactants might not be advisable in this situation.

There are many variables involved in flotation deinking and because of this there are many areas of study left to be done. Each one of the variables could be studied to see how it is involved in the total picture of flotation deinking. This would be worthwhile because the amount of paper being recycled is increasing and it must be deinked, usually, before it is used.

A study of the effectiveness of combining both the Serfax product and surfactants might be interesting. The surfactants produced much more foam and might help the Serfax remove the ink from the ink/fiber suspension. The Serfax product seemed to remove the ink from the fiber better but did not seem able to keep a stable foam suspension that could be scrapped off easily.

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## APPENDIX I. DETAILED PROCEDURE

The following is a detailed procedure of the experiment:

1) Add 2.5 liters tap water, 100 grams B.D. news, and approximately 1 gram of NaOH (for pH control) to a container.

2) Pulp for 15 minuter at a temperature of 40-45°C, pH of 9-10.

3) At 15 minuter add 1% as active ingredient on B.D. fiber surfactant (or Serfax).

4) At 20 minutes stop agitator and let pulp stand for 90 minutes.

5) After reaction time deflake stock for 5 minutes.

6) Add pulp to flotation cell and dilute to .5 to .6% consistency and 22°C.

7) Float for 12 minutes keeping level in cell constant.

8) Remove pulp samples and neutralize pH with H<sub>2</sub>SO<sub>4</sub>.

9) Make pulp pads on Buchner funnel and dry on hot plate at medium temperature setting to prevent scorching.

10) Measure brightness of pads on a TAPPI standard meter.

For repeated runs:

11) Save the water from previous run by running pulp through Buchner funnel and collecting the water.

12) Follow steps 1-10 above but use this water as dilution water in step 6.

13) Make 7 runs.

Make 4 runs with each surfactant and 5 pads from each

run. Do 5 brightness tests on each pad for a total of 100 tests for each surfactant.