Deinking chemistry: part 1

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This article discusses the chemicals used in deinking operations and the role of chemistry in the pulping, flotation, washing, deposit control, and water clarification processes.

Chemistry is involved in many of the key processes in a deinking mill: pulping, flotation, washing, deposit control, and water clarification. This paper addresses the chemistry of each of these sections except bleaching, which is the subject of another paper.* The chemistry for both newsprint and fine paper will be discussed, including the strategies involved for dealing with flexographic inks and fused-toners (laser, xerox) inks, as well as short sequence or pulper deinking. Many good review papers have been written on deinking chemistry, and they are worth assembling as a possible core of references on this subject *(1–14)*.

Most of the chemicals used for deinking are fairly standard commodity products, e.g., caustic soda, hydrogen peroxide, and talc. On the other hand, some other chemicals are quite complex, e.g., the surfactants and clarification polymers. Each chemical has a specific function, and it is a good rule of thumb not to add anything unless it is absolutely necessary. Chemistry plays a role in fiber swelling, ink removal, wetting, anti-redeposition, dispersion, flocculation, agglomeration, oxidation reduction of chromophores, etc. It is important to remember that some of the chemicals have more than one action, not all of which may be desirable. For example, caustic soda makes the fibers more flexible and helps to remove the ink; but, in newsprint furnishes, it will cause alkali darkening, or undesirable yellowing of the stock. Here it may be helpful to observe that the chemicals react with the resin portion of the ink particles and not on the colored or black pigment particles themselves.

Table I lists the principal deinking chemicals and their potential point of application. Each chemical (except for the bleaching agents) is discussed in this paper.

I. Principal deinking chemicals

Chemical	*Application*
Sodium hydroxide	- pulper, bleaching
Sodium silicate	- pulper, bleaching
Chelating agents	- pulper, bleaching
Hydrogen peroxide	- pulper, bleaching
Surfactants	- pulper, flotation, washing
Collector chemicals	- pulper, flotation
Agglomeration chemicals	- pulper, cleaners
Calcium chloride	- flotation
Dispersants	- washing, stock preparation
Sodium hypochlorite	- bleaching
Sodium hydrosulfite	- bleaching
Formamidine sulfinic acid	- bleaching
Contaminant control	- pulper, storage, stock prep.
Clarification polymers	- clarification

II. Typical pulper chemistry*

Chemical/ conditions	*Wood-containing*	*Wood-free*	*Short sequence*
Chelant	0.15–0.4%	-	-
Sodium silicate	1.0–3.0%	-	-
Sodium hydroxide	0.8–1.5%	1.0-1.5%	-
Hydrogen peroxide	0.5–2.0%	-	-
Surfactant/collector	0.25–1.5%	0.25-1.5%	0.25-1.5%
Temperature	45–55°C	50-60°C	30-50°C
pH	9.5–10.5	10-11	4.5-6.0
Consistency	5–15%	5-15%	3-10%
Time	4–60 min	4-60 min	4-60 min

*Percentages given as 100% for peroxide and caustic, sodium silcate as 41°Be, DTPA as 40% active, collector and surfactants as supplied.

The deinking pulper

The function of the pulper in a deinking operation is to defiber the paper and to detach the ink particles from the fibers, while keeping the contrary (undesirable) materials large enough to be removed by the cleaners and screens. The flotation unit has often been referred to as the "heart" of the deinking system, it is reasonable then to think of the pulper as the "brains" of the system. If the pulper does not work properly, or if the chemistry is unbalanced, the batch has little chance of success. The reason for adding the chemicals to the pulper is to assist in the removal of the undesirable materials, e.g., ink and stickies, from the paper and to make them accessible for flotation deinking.

The principal chemicals involved in the pulper are: sodium hydroxide, sodium silicate, chelating agents, hydrogen peroxide, surfactants, agglomeration, and collector chemicals. Not all of these chemicals are used for all batches. Each chemical is discussed and, when relevant, the interaction between the chemicals will be presented. **Table II** gives a typical formulation range for wood-containing old newspapers (ONP), wood-free, and short-sequence pulpers. Every furnish will require careful optimization.

*Ferguson, L.D., TAPPI 1992 Deinking Seminar Notes, TAPPI PRESS, Atlanta.

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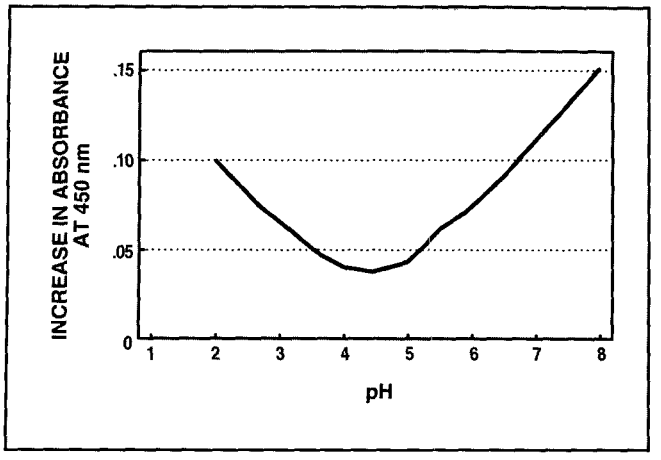
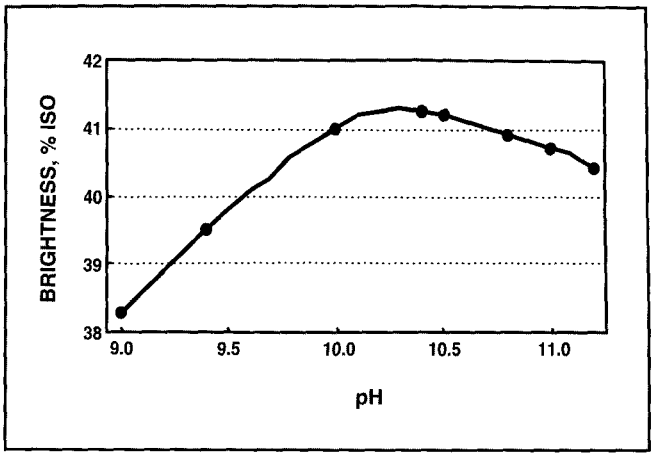
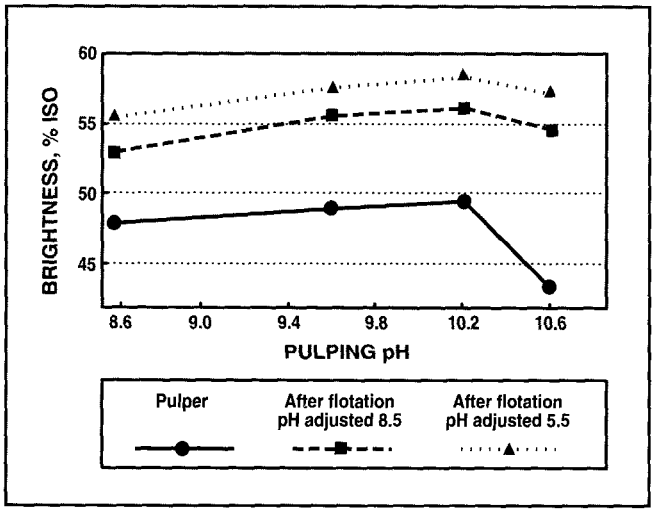
1. Influence of pH on color formation in lignin as indicated by absorbance at 450 nm *(15)*



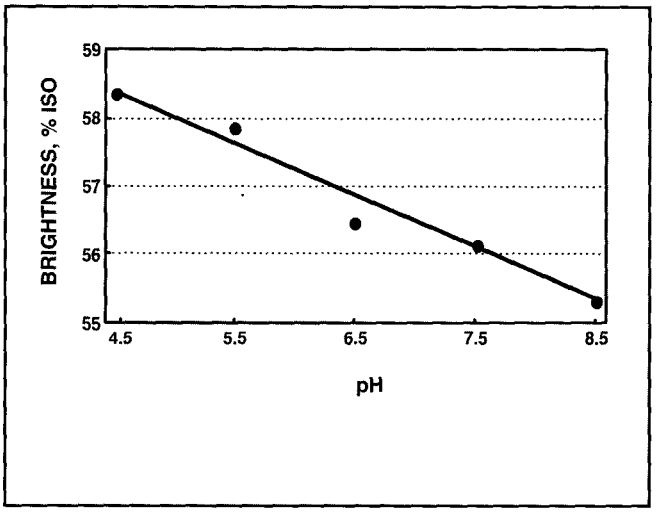
2. Effect of pH on pulper brightness, 70:30 ONP/OMG furnish *(4)*. Conditions: 45°C; no other chemicals present, pH adjusted with 10% NaOH.



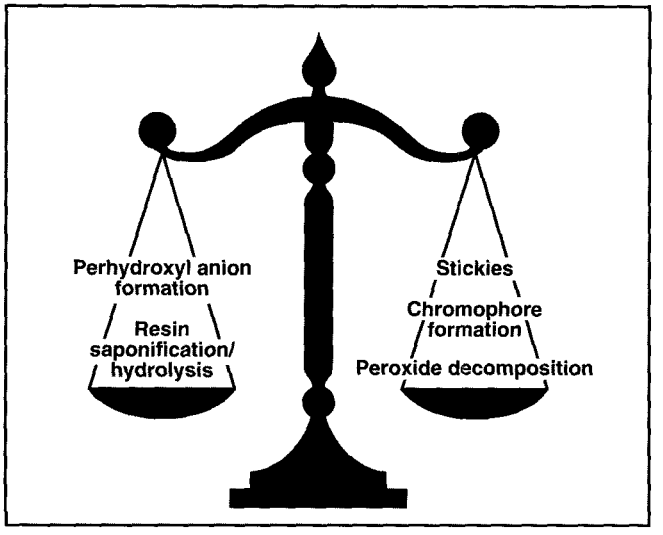
3. Effect of pulping alkalinity on brightness *(4)*. Conditions: 70:30 ONP/OMG, 0.4% DTPA, 2.5% silicate, 1% hydrogen peroxide.



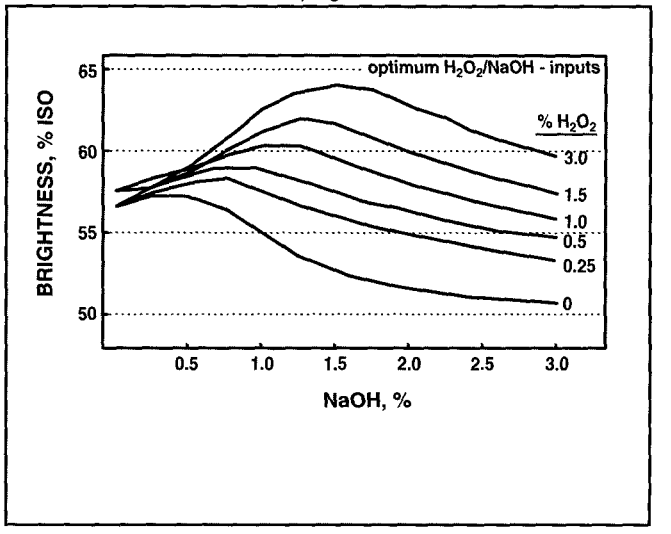
4. "Acid shock": post-flotation brightness as a function of pH *(4)*. Conditions: 70:30 ONP/OMG, 1% NaOH (exit pH 10.2), 2.5% sodium silicate, 1% hydrogen peroxide.



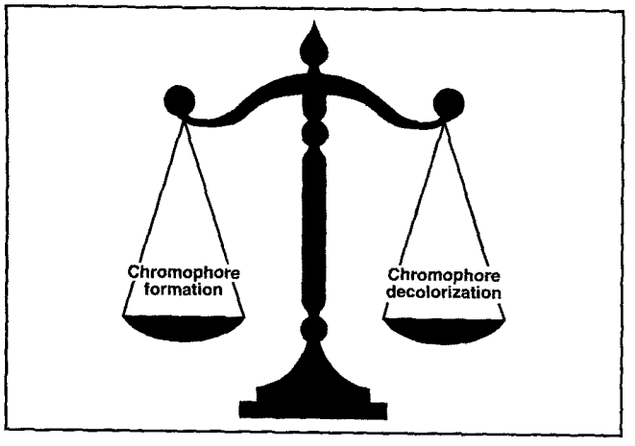
5. Caustic charge balance



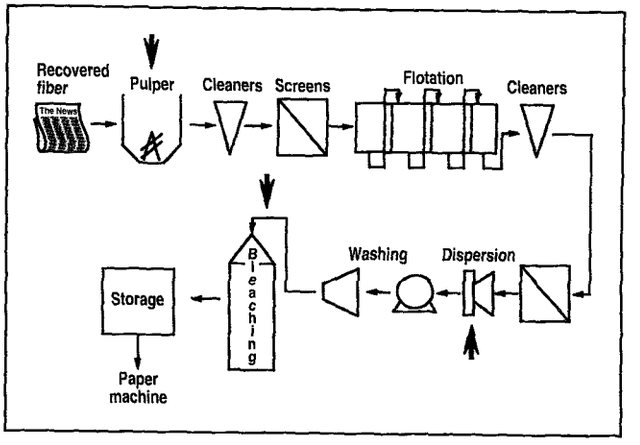
6. Effect of caustic and peroxide levels on brightness. Source: Helmling, Suss, and Eul, TAPPI 1986 Pulping Conference.



7. Peroxide charge balance



8. Potential addition points for hydrogen peroxide (Courtesy: Dow Chemical)



Deinking chemicals

Sodium hydroxide

Sodium hydroxide (NaOH), also referred to as caustic soda, is used to adjust the pH to the alkaline region and to saponify or hydrolyze (or do both) the ink resins. The alkaline environment is often reported to "swell" the fibers. This term is more descriptive than reality. At the pH conventionally used for pulping, 9.5–11.0, the fibers would take up some water and become more flexible, rather than puff up like cellulose balloons. The addition rate of sodium hydroxide is usually listed as a percentage on ovendry fiber. This convention can lead to confusion, as the amount of caustic soda that is added to the pulper is the amount required to reach a given pH, not to a given dose on fiber. Another frequent misconception is the idea of a set ratio between the caustic soda, silicate, and peroxide. As will be discussed below, the amounts of each chemical to be added is dependent on the furnish, the water, and the presence of other chemicals. Each chemical should be custom optimized to the furnish for maximum performance.

The addition of caustic soda to wood-containing furnishes will cause the pulp to yellow and darken. This is a phenomenon often referred to as "alkali darkening." The work done by Loras *(15)*, as shown in **Fig. 1**, shows the effect of pH on the formation of chromophores in lignin. Figure 1 shows that the color rapidly increases as the pH rises above 5.5. The impact on color formation, or alkali darkening from adding only sodium hydroxide to a 70:30 ONP/OMG eastern Canadian furnish is shown in **Fig. 2.** No additional chemicals were used.

The amount of sodium hydroxide that is added to a wood-containing pulper must be neither too low nor too high. This requires a careful balancing act between having sufficient alkalinity for good saponification and hydrolysis of the resins, fiber flexibility, and hydrogen peroxide performance while minimizing the formation of chromophores and softening of any contrary material. **Figure 3** shows the effect of alkalinity on the brightness after pulping and flotation deinking. In this example, a full pulper chemistry of caustic soda, peroxide, chelant, and silicate was employed. Figue 3 shows that the pulper brightness slowly increases as the pH is increased from 8.6 to 10.2. Above a pH of 10.2, the brightness starts to decrease. The change in brightness is reflected in the brightness achieved after flotation. The pHs indicated for post-flotation, 8.5 and 5.5, are the pHs at which the handsheets were prepared. The reduction in pH to 5.5 is to simulate the "acid shock" the deinked stock would experience prior to use on the paper machine. **Figure 4** demonstrates the effect of acid shock. It can be seen that as the pH of the post-flotation stock is reduced from 8.5 to 4.5, a significant gain in brightness is observed. The reason for the brightness gain is still not clear, but it is attributed to two main factors—the precipitation or agglomeration of colloidal ink and stickies due to the pH change, and a reduction in the number of chromophores.

Figure 5 shows the balance necessary for wood-containing pulpers with the use of sodium hydroxide. The problem with alkali darkening is of concern only with wood-containing furnishes. Higher pHs (11.0) can be used with wood-free furnishes with no alkali darkening.

Hydrogen peroxide

Hydrogen peroxide (H_2O_2) is used to decolorize the chromophores generated by the alkaline pH in a wood-containing pulper. It is not efficient to use peroxide as a bleaching agent in the pulper. The ink and contraries load present in the pulper reduce the bleaching efficiency of the peroxide. The peroxide reaction with caustic soda is shown in Eq. 1.

$$H_2O_2 + NaOH <=====> HOO— + Na^+ + H_2O \qquad (1)$$

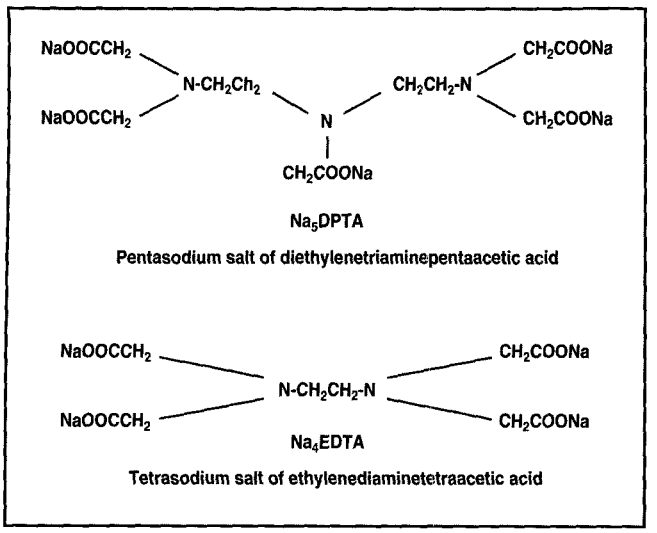
where

pH = 10.0-11.5

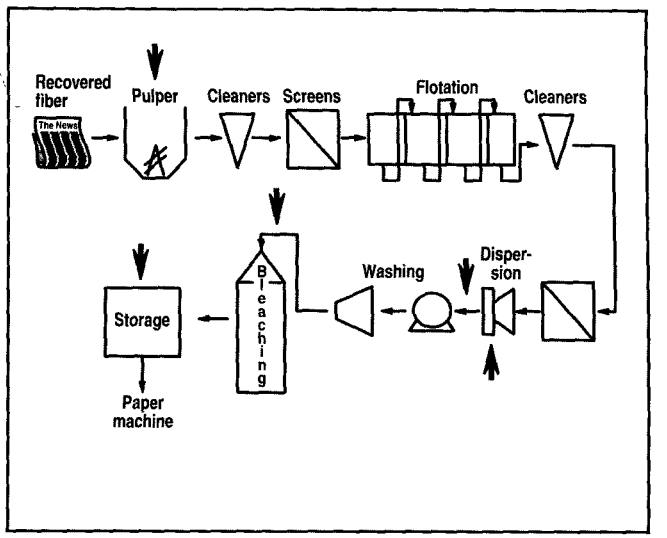
temperature = 40-80°C.

The perhydroxyl anion (HOO—) is the active bleaching agent *(16)*. To get the best use of the peroxide, it is important to maximize the amount of the perhydroxyl anion. The options available are: raise the pH by increasing the caustic level, raise the temperature, reduce the competing side reactions, and increase the amount of peroxide. The competing reactions are those that can decompose peroxide such as the presence of

9. Structures for DTPA and EDTA



10. Potential addition points for chelating agents (Courtesy: Dow Chemical)



heavy metal ions like manganese, copper, and iron and enzymes such as catalase and high pH and temperature *(15-20)*. The decomposition reaction is shown in Eq. 2.

$$\text{metal}^{++} + H_2O_2 \xrightarrow[\text{pH, temp}]{} 1/2\ O_2 + H_2O \qquad (2)$$

The peroxide decomposition products and conditions have been identified as contributing to the loss of brightness in wood-containing virgin pulps *(15, 17)*. It is reasonable to expect a similar effect with recycled pulps. The decomposition of peroxide can be reduced by the addition of stabilizing agents such as chelants and sodium silicate. These chemicals do not stabilize the hydrogen peroxide itself, but stabilize the environment within which the peroxide works.

Figure 6 shows the interrelationship between peroxide and caustic soda on brightness that is achievable from an ONP/OMG (old newspaper/old magazine) deinked furnish. It can be seen in Fig. 6 that the optimum brightness keeps moving to the right as the dose of peroxide and caustic increase, but the optimum dose is not a fixed ratio between the caustic and the peroxide.

Hydrogen peroxide is also used as post-bleaching agent. The balance between how much peroxide should be added in the pulper versus how much in the bleaching stage must be optimized for each furnish. Again, as shown in **Fig. 7**, it should be remembered that the peroxide is added to the pulper simply to offset the formation of chromophores created by the alkaline pH. The potential points of addition for hydrogen peroxide are shown in **Fig. 8.**

Chelating agents

DTPA (diethylenetriaminepentaacetic acid) is the most commonly used chelant, although EDTA (ethylenediaminetetraacetic acid) is also used. The role of the chelant is to form soluble complexes with heavy metal ions *(21, 22)*. The structures for DTPA and EDTA are shown in **Fig. 9.** The complexates prevent these ions from decomposing the hydrogen peroxide. The five "legged" structure of DTPA is what contributes to the ability to chelate more strongly than the four "legged" structure of EDTA. The amount of chelant that is necessary is directly dependent on the amount of heavy metal ions in the pulper. The metals can be sourced from the waste-paper or from the mill water (fresh or white water). DTPA will chelate metals in the following order of priority *(21)*: $Ni^{++} > Cu^{++} > Co^{++} > Fe^{++} > Mn^{+++} > Pb^{++} > Zn^{++} > Fe^{+++} > Ca^{++} > Mg^{++} > Al^{+++}$.

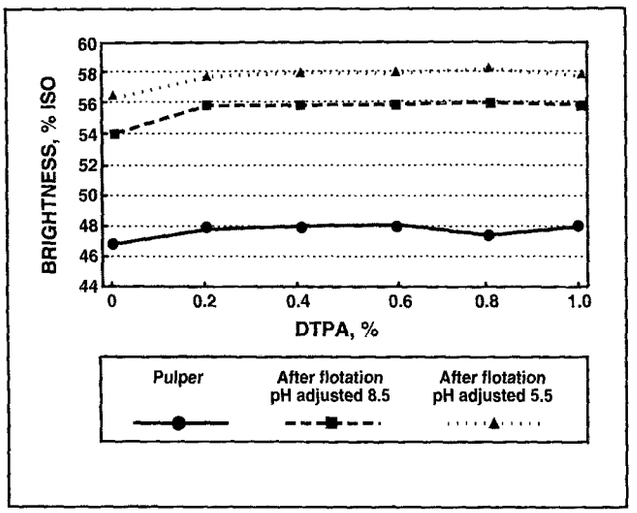
Some deinking mills have found that their metals content is low enough to preclude the use of a chelant. **Figure 10** shows the possible addition points for a chelant.

Figure 11 shows the results obtained from increasing amounts of DTPA in a 70:30 ONP/OMG furnish. The furnish in this example is an Eastern Canadian ONP source and required 0.2% DTPA on o.d. fiber to achieve a gain of 1 brightness point after pulping and 2 brightness points after flotation. In this example, adding more than 0.2% DTPA did not raise the brightness.

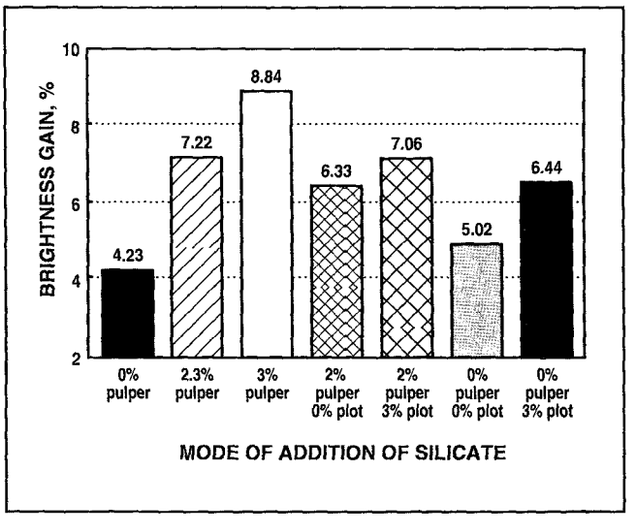
It is worth mentioning that chelants like DTPA and EDTA have been banned in some countries, for example, Sweden and Norway, when the effluent stream discharges into a water system because of the disruptive effects of the chemicals on aquatic life. The United States and Canada allow free use of chelants.

Magnesium sulfate, commonly known as epsom salts, has also been found to be an effective chelating agent *(22–24)* in virgin pulps, but is rarely used in deinking applications. It is believed that magnesium works by halting the peroxide decomposition reaction rather than deactivating the metal ions. It has been shown that magnesium will not work in the presence of iron and copper and will catalyze peroxide decomposition in the presence of manganese *(22)*. A recent paper *(24)* reported a synergistic effect between high doses of epsom salts and DTPA, but effective recovery of the peroxide residual is necessary to make this cost effective. It has been reported that magnesium sulfate works in conjunction with sodium silicate to inactivate metal ions *(15)*. The maximum stabilization effect

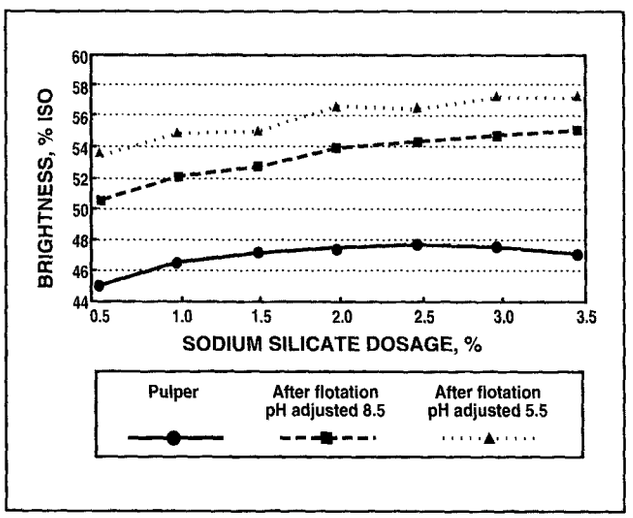
11. Role of DTPA in pulper *(4)*. Conditions: 70:30 ONP/OMG, 2.5% sodium silicate, 1% hydrogen peroxide, 1.5% NaOH (exit pH 10.2), 0.8% fatty acid soap.



12. Effect of silicate during flotation deinking *(27)*



13. Role of sodium silicate, 0% DTPA in pulper *(4)*. Conditions: 70:30 ONP/OMG, 1.5% NaOH (exit pH 10.2), hydrogen peroxide, 0.8% fatty acid soap.



requires magnesium or calcium ions in a concentration of 50 ppm, which is usually supplied by normal mill operations. This can be seen in Eqs. 3 and 4.

$$Na_2SiO_3 + MgSO_4 \text{ ----> } MgSiO_3 + Na_2SO_4 \quad (3)$$

colloidal dispersion

$$MgSiO_3 + Mn^{++} \text{ ----> } MgSiO_3\text{--}Mn^{++} \quad (4)$$

inactive complex

However, as described earlier, the purpose of adding peroxide to the pulper is not to bleach but to balance the formation and destruction of chromophores. This means that the use of magnesium sulfate may not be applicable for deinking applications and so does not warrent the use.

Sodium silicate

Sodium silicate (Na_3SiO_3), or water glass (a literal translation from the German term for silicate), is commonly used in deinking mills as a 41.6° Baume solution of sodium metasilicate which contains roughly equal amounts of SiO_2 and Na_2O. This gives a degree of alkalinity corresponding to approximately 11% NaOH. The silicate component is actually a blend of many complex polymeric silicate anions. Silicate is believed to function by forming a colloidal structure with the heavy metal ions, but the specific action has not yet been determined *(25–28)*. As mentioned above, silicate is often referred to as a peroxide stabilizer. This is a misnomer as the silicate stabilizes the environment within which the peroxide works, not the peroxide itself. Ali *et al. (27)* and Ferguson *(4)* have reported that silicate aids in deinking through an ink dispersant action or by preventing the ink from redepositing on the fiber surface. The anti-redeposition effect is what made silicate popular in laundry soaps. The dirt or soil was emulsified and prevented from sticking back on the clean wash *(13)*. Ali and co-workers continue with the observation that in the presence of peroxide, only half of the silicate's function is to deactivate metal ions. **Figure 12** shows the work done by Ali in demonstrating the effect of silicate beyond stabilization.

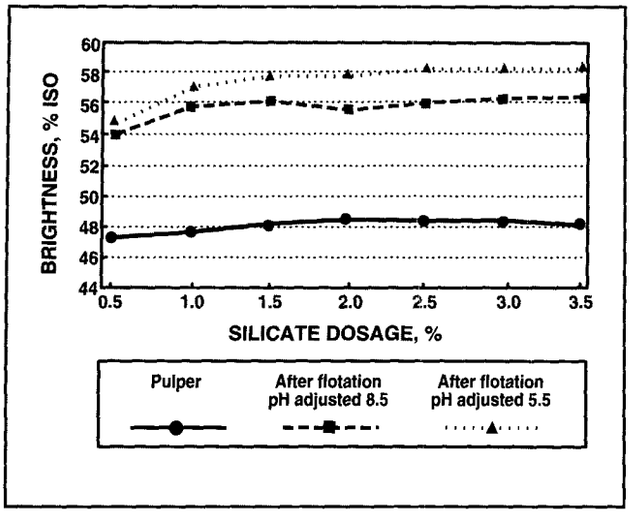
The sodium silicate solution is a source of alkalinity, derived from free hydroxyl groups, as well as a pH buffering agent which operates around pH 11.3 *(21)*. The source of the alkalinity can be noted from Eq. 5 which shows the reaction of silicate with water:

$$Na_2SiO_3 + H_2O \text{ <-----> } 2Na^+ + OH^- + HSiO_3 \quad (5)$$

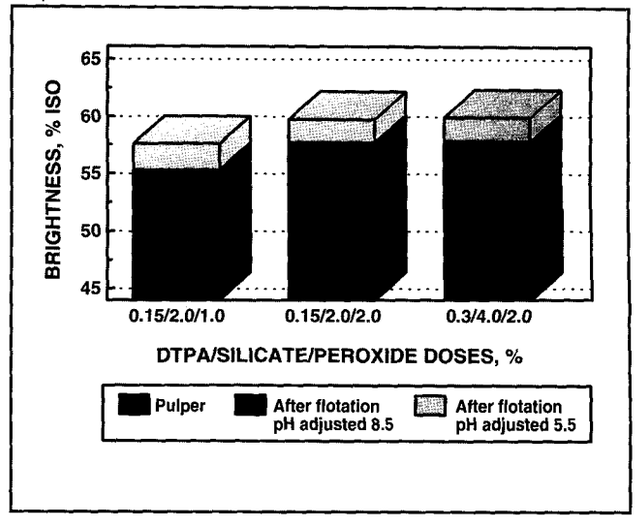
The fact that silicate is a source of alkalinity, and will affect the pH, must be kept in mind when adjusting the pulper chemistry. Increasing the silicate will increase the pH, and this may call for a reduction in the sodium hydroxide addition rate.

Figure 13 shows the effect of increasing silicate level on a 70:30 ONP/OMG furnish, with no chelant, and holding the pH constant by adjusting the level of caustic soda to give a pulper

14. Role of sodium silicate, 0.4 % DTPA in pulper *(4)*. Conditions: 70:30 ONP/OMG, 1.5% NaOH (exit pH 10.2), hydrogen peroxide, 0.8% fatty acid soap.



15. Relationship between DTPA, silicate, and peroxide *(4)*. Conditions: 70:30 ONP/OMG, 1.5% NaOH (exit pH 10.2), 0.8% fatty acid soap.



pH of 10.2. The brightness of the pulper increases as the amount of silicate is increased. If the distance between the pulper brightness and the post-flotation brightness curves is examined, the dispersant effect of silicate can be readily observed. The distance between the two curves becomes greater as the silicate helps to disperse the ink. The higher the dose of the silicate, the higher the post-flotation brightness. A repetition of the work was carried out with the addition of 0.4% DTPA to the pulper. It can be seen in **Fig. 14** that the presence of the chelant increased the pulper brightness and, therefore, the post-flotation brightness. The dispersant effect of the silicate can still be observed.

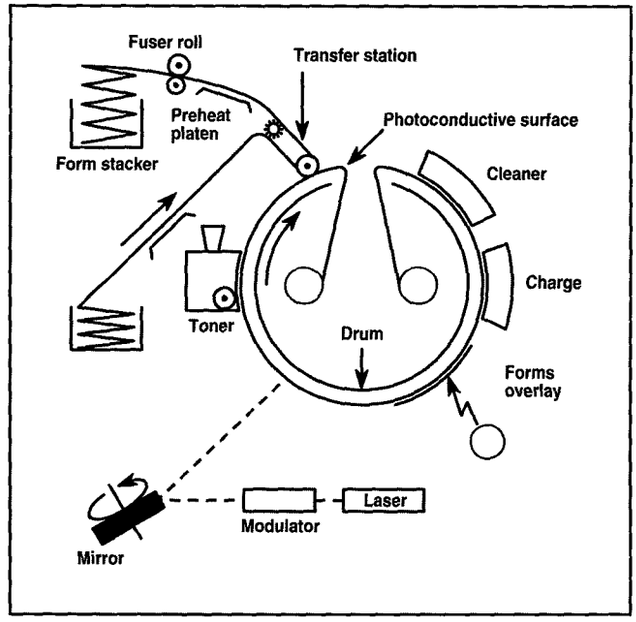
Figure 15 shows a bar graph for the brightness results from increasing peroxide while holding the DTPA and silicate constant, then increasing the DTPA and silicate while holding the peroxide constant. The pulper brightness was slightly increased by doubling the peroxide dose, and the post-flotation brightness was increased by three units. These modest increases demonstrate the point that attempting to bleach in the pulper is not an efficient use of the peroxide. When the peroxide was held constant and the DTPA and silicate were both doubled, the brightness from the pulper or after flotation did not change. Figure 15 helps to illustrate that finding the correct balance of these chemicals is important, not only for performance, but for cost purposes as well.

Silicates are under attack as being undesirable additives due to problems such as scaling and fouling of equipment, wires, and felts; coating of fibers; harshness in paper; difficult handling in cold weather; and high-temperature breakdown to silica causing fouling on refiner-type disperger plates *(29)*. Several approaches have been suggested to remove silica, the most common being replacement with a polymeric stabilizer. There is little published data available on the performance of silicate replacements in a deinking plant.

Agglomerating chemicals

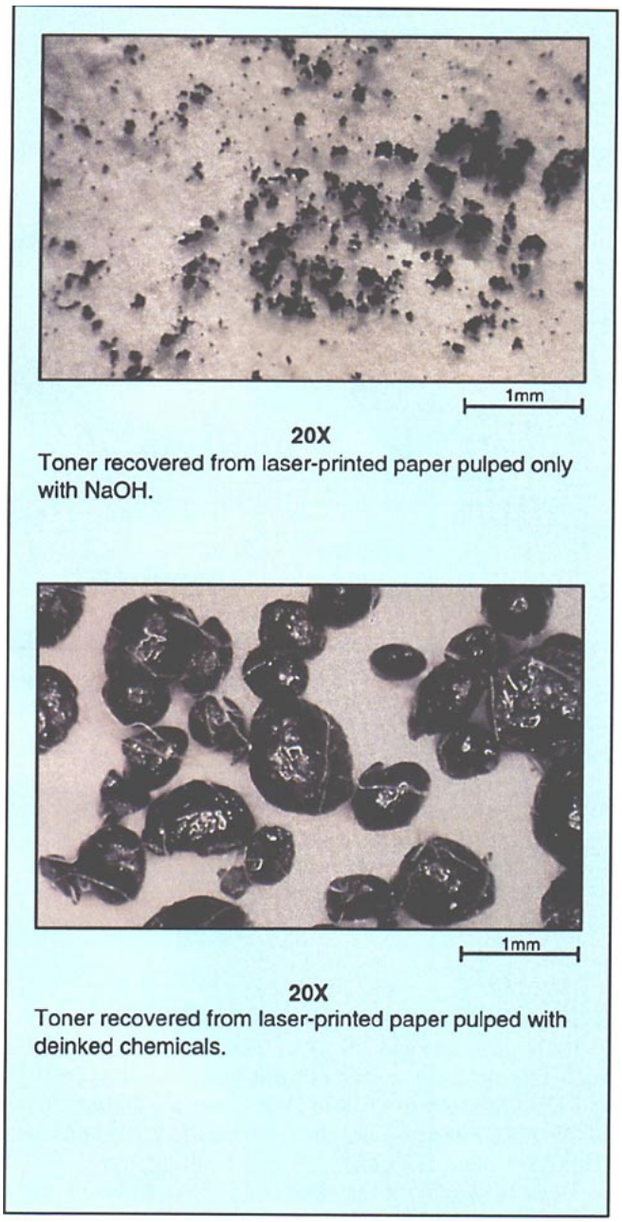
Agglomerating chemicals are relatively new on the market and

16. Fused-toner (laser) printing *(30)*



are used for deinking fused-toner papers such as laser and xerox print found in office waste. An important part of understanding the approach that is taken to deinking these papers is to understand how the ink is applied to the paper. Shrinath and co-workers *(30)* and Quick and Hodgson *(31)*, give an excellent overview of this process. Shrinath *et al.* give the following description of the process: "The common xerographic process is an indirect printing method. A latent image is formed on a charged photoconductive surface and transferred to paper. The charged surface receives light reflected off the document to be copied. The light reflected off the nonprinted areas causes the surface charge to dissipate, while the dark image areas retain their charge. The surface is then exposed to toner par-

17. Fused-toner deinking by agglomeration chemistry (Courtesy: PPG Corp.)



ticles of opposite charge, which adhere to the charged areas, forming a visible image. Finally, the image is transferred to paper. The toner particles are the 'ink' in this case. They consist of colored pigments, such as carbon black, in a thermoplastic resin binder. Generally, toner particles are dry, sometimes containing a small percentage of zinc stearate as a dry lubricant. Liquid toners are suspensions of toner particles in an insulating liquid. Resins or oils can be added as charge-control agents. In either case, the ink is fused to the paper surface by heating it." A schematic diagram for the fused-toner laser printer is shown in **Fig. 16.**

It is the ink-fusing action of the copier or laser printer that upon repulping results in large, flat plate-like structures that are too large to be removed by washing or flotation, and too small to be removed by the cleaners and screens. The approach that several chemical companies have taken is to chemically modify the surface of the toner flakes such that agglomeration will occur. The substantially larger particles will then be removed by slotted pressure screens and forward centrifugal cleaners. These products are usually added directly to the pulper with the dilution water. The amount to be added varies by supplier.

One example is the PPG Sansink two-component system. In this system the fused-toner particles are chemically modified so that the flakes are attracted to one another and grow into large spherical particles, as shown in **Fig. 17.** Additional chemicals are present in the formulation that will disperse the more conventional inks, for example, ledger and computer printout (CPO) inks. The agglomeration approach usually requires temperatures in the 60–70°C range and long mixing times of 45–60 min to ensure good particle–particle contact for agglomeration to occur. Darlington published one of the first papers outlining this process *(32)*. In this paper, the mechanism of action is described as being a surfactant blend which is used to reduce the repulsive forces between particles and lower the glass transition (temperature at which a resin beings to flow), such that at 60°C the toner particles become soft and tacky and stick together. The softened particles become spherical shaped. Other chemical components act as collectors to promote rapid growth of the agglomerates. When the temperature in the pulper is reduced to below 50°C, the ink agglomerates become hard and rigid.

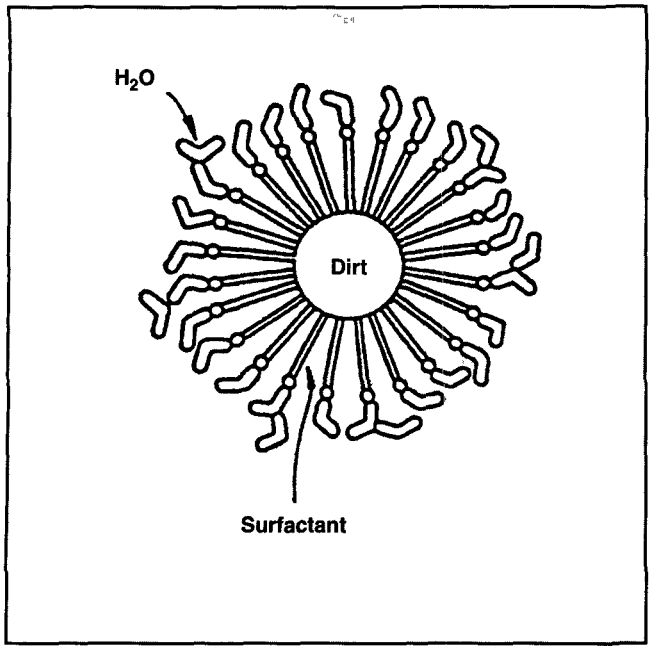
There is some controversy within the field regarding single-component versus dual-component chemistries and the role that the agglomerate density plays. Forward cleaners rely on density differences between contaminants and pulp fibers, as well as size, to help remove unwanted particles. As for all new chemistries, it is prudent to test several of the products now commercially available to see which suits the deinking process and furnish the best.

Surfactants

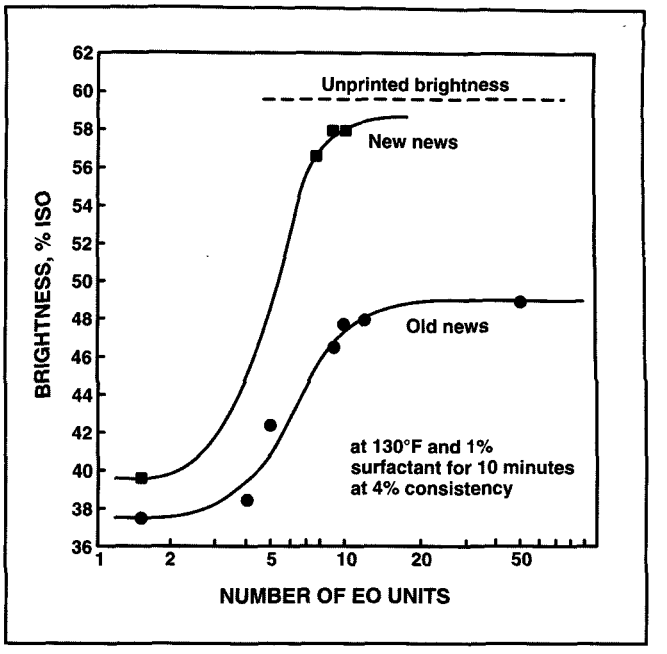
Surfactants comprise many chemical types and are used depending on their requirements. The term surfactant is derived from its function, which is to act as *surf*ace *act*ive *agents*. Surfactant use runs the range of deinking operations, tissue, news, and fine paper with the occasional unbleached kraft use thrown in. "Surfactant" is a catch-all term that covers uses like dispersants, collectors, wetting agents, displectors, anti-redeposition aids, and the like.

Surfactants that are used for deinking will have two principal components—a hydrophilic and a hydrophobic component. These terms are derived from Latin and describe whether or not that part of the molecule likes water (hydrophilic) or dislikes water (hydrophobic). When a surfactant is introduced into the pulper, or just prior to flotation, the hydrophobic end will associate with the ink, oil, and dirt while the hydrophilic end will remain in the water. The classic picture that is often given for surfactant action is the formation of "micelles," as shown in **Fig. 18.** It is difficult to know if the very dilute environment will permit formation of micelles or if some other mechanism is at work. Several interesting hypotheses have been put forward, but as yet no definitive proof exists.

18. Surfactant micelle



19. Effect of ethoxylation on the deinking of newsprint with nonylphenol ethoxylates *(34)*.



The structure of surfactants can be straight chained, branched, carrying charged groups, long or short chain, double or single bonds, etc. One method of characterizing surfactants has long been used in the paint industry and has just recently gained acceptance in the paper industry. The term is HLB value or the ratio of weight percentages of hydrophilic to hydrophobic groups in the structure. Turai and Williams *(33)* have done some of the early work on the role that HLB has on deinking efficiency. In their work, they found a relationship between the brightness from deinking news and the HLB value which is shown in **Table III.**

III. Effect of HLB value on deinking of newsprint

HLB value	*Use*	*Newsprint deink brightness*
4-6	water-in-oil emulsifier	47
7-9	wetting agent	48
8-18	oil-in-water emulsifier	49
13-15	detergency	50
15-18	solubilizing agent	51

Some of the most common surfactants used in deinking are the Eo/Po copolymers (ethylene oxide/propylene oxide). The hydrophilic end (water liking) is the ethylene oxide and the hydrophobic (water hating) end is the propylene oxide end. An example of HLB value in action has been shown in work by Wood *(34)* and Suwala and Feigenbaum *(8)*. In these examples, the hydrophile is the Eo (ethylene oxide) copolymer and the hydrophobes are various structures. They have expressed the HLB value in terms of the number of Eo units, but the principle is the same. In **Fig. 19**, the effect of increasing ethoxylation (i.e., increasing water solubility) can be seen on wash deinking of newsprint. It can be seen from Fig. 19 that the deinking response is related to the number of Eo units in the chain.

Cloud point is another term used to describe a given surfactant and is a temperature-related phenomenon. When surfactants are added to give a dilute solution in water they will disperse, to some degree, into the water. Below the cloud point the surfactant molecules will be well dispersed in the water. As the temperature begins to rise, the molecules start to come more closely together and begin to associate. The aggregation or association of several surfactant molecules can be seen as a clouding or milkiness in the water. This is what is termed the cloud point. The surfactant is most effective at the temperature just below the cloud point. The cloud point will be listed as one of the properties for a surfactant and is usually given in terms of 1% or 10% solutions in water. Therefore, the choice of a surfactant for a given process must be chosen to reflect the operating temperature. **Table IV** summarizes the work done by Wood *(34)* which shows the temperature effect and cloud point on deinking efficiency.

Table IV shows that the cloud point of the surfactant has a direct impact on the performance. To get the most out of a surfactant system, the formulation is frequently a blend of many components—often 4–8 different chemicals. It is occasionally mentioned that blends of surfactants will give synergistic performance and are more effective than one single component. Again, this must be tested in the individual deinking processes.

Biodegradation of surfactants, as well as other chemicals, is becoming more of an issue as the environmental impact laws get tougher. Surfactants will find their way into the effluent stream, either directly—as in the case of dispersants—or indirectly in terms of chemical carry-over for collectors and displectors. The biodegradation question has a high profile in countries like Germany and Sweden, but has not yet become as widespread an issue in the pulp and paper industry in North

IV. Newsprint deinking temperature effects

Surfactant [a]	Temperature, °C	Temperature, °F	Brightness, % GE	Dirt count, ppm	Cloud, point [b]
Alcohol ethoxylate C12-15E9	40	105	48–49	40–45	
	50	122	49–50	40	
	70	158	52	15	74
Alcohol ethoxylate C14-15E7	40	105	49–51	20	
	50	122	48	30	
	70	158	48	20	46

[a]Conditions: 3% w consistency, 11% w surfactant based on paper, pH = 8, 30 min; reduced with hydrosulfite.

[b] = 1% solution in water

America. (The laundry detergent field has been well aware of this for many years after the phosphate issue.) Two levels of biodegradability are of concern: primary—or loss of surfactant ability—and ultimate—the conversion of the organics to their final oxidation products of carbon dioxide and water. For example, biodegradation of nonylphenol ethoxylate is causing concern. This product is an effective dispersing agent and is widely used in wash deinking operations, as well as in many surfactant blend formulations for other uses. However, nonylphenols will eventually break down in waste treatment plants to water and carbon dioxide with the liberation of harmful and toxic phenols along the way. Nonylphenol ethoxylates are being replaced by other products, for example, alcohol ethoxylates, which biodegrade more quickly and more extensively than nonylphenols.

HLB value, chain length, cloud point, etc., are all useful tools for characterizing surfactants; however, these should not be used as the primary factors determining the selection of surfactant to use. They are signposts or guides only, and several of the most promising candidates should be evaluated for their performance in the deinking process to be used. A surfactant that works well at the mill down the road from yours may not necessarily work as well in yours (or may work better) as the temperature, pH, water, furnish quality, and other consituents are different and unique to each location. □

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