A new softener/debonder helps eliminate the need for solvents and non-ionic surfactants, allowing its use as a base for blends with other softeners

New Additive Improves Softness With Low Environmental Impact

By **CRAIG POFFENBERGER, PH.D.**

New chemical processing aids for papermaking must achieve the proper balance of cost and performance benefits while also satisfying the increasingly stringent regulatory requirements and restrictions for yielding the lowest possible environmental impact. The difficulty of this challenge is well illustrated in the ongoing development of softener/debonders, additives essential to the manufacture of premium-grade products ranging from tissue and towel grades to napkins and adult care products.

For these products, the needs of consumers are straightforward: the more softness and absorbency, the better. However, several requirements must be satisfied to provide the best, most practical softener/debonder.

A softener/debonder that is 100% actives, all-liquid, low-odor, FDA-compliant, and thermally stable may encourage formulators, tissue producers, and converters to take advantage of it. This article describes the specific characteristics of such a softener/debonder made by Goldschmidt Chemical Corp., a wholly owned subsidiary of Degussa Corp.

The new product's characteristics eliminate the need for solvents and non-ionic surfactants, reducing environmental impacts and allowing its use as a base for blends with other softeners, with mineral or vegetable oils often used in Yankee release aids, and with Yankee surface modifiers, among others.

The Necessity of FDA Compliance

Additives certified to be FDA-compliant for food contact are considered standard by papermakers for all grades of tissue or

FIGURE 1.

The chemical structure of the new additive is a diethyl-sulfate di-oleyl imidazolinium quaternary.

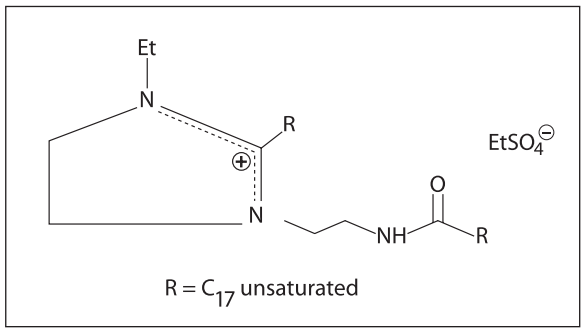
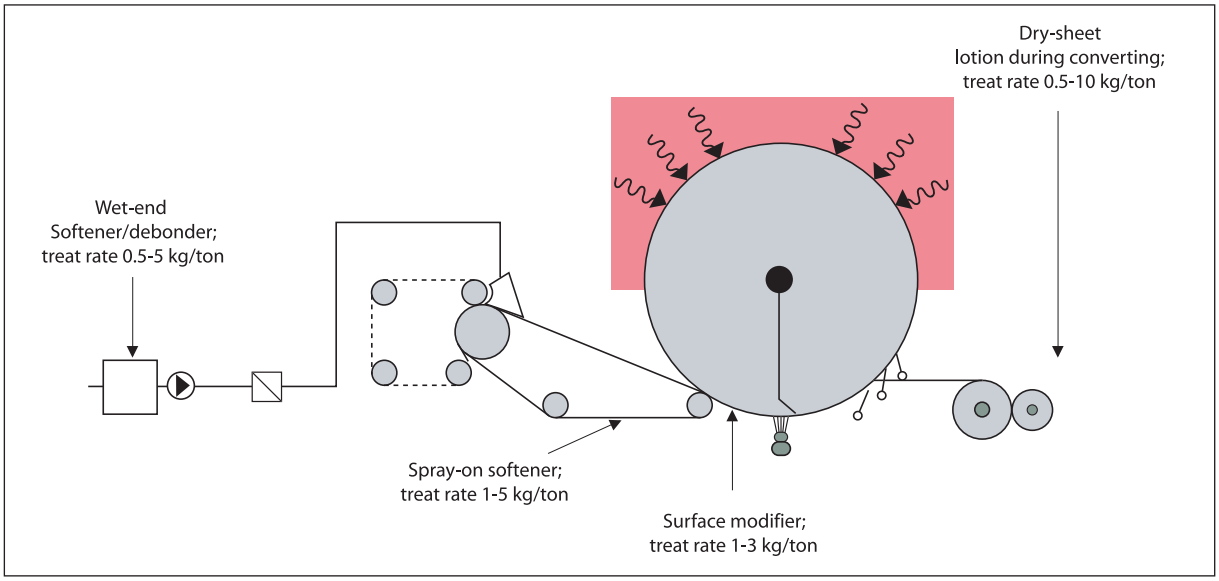


FIGURE 2.

Possible applications for the new softener/debonder during tissue manufacturing



pulp, even for grades that do not require such compliance. The primary reasons are that most paper mill water circuits are now closed-loop and broke is returned to all grades. Consequently, it is essential that the whitewater system contain only FDA-sanctioned contaminants in the event that a switch needs to be made from manufacturing products that may not require FDA compliance, such as bathroom tissues, to products that do, such as paper towels, which are often subject to indirect contact with foods.

The new cationic softener/debonder has been FDA-approved for indirect food contact (Food Contact Notification 389 for conformance to 21 CFR 176.170, components of paper and paperboard in contact with aqueous and fatty food, and 21 CFR 176.180 for components of paper and paperboard in contact with dry food).

Figure 1 shows the chemical structure of this new additive, trademarked as Varisoft 3696, a diethylsulfate di-oleyl imidazolinium quaternary. Using this new softener/debonder will enable paper mill operators to switch from manufacturing one product type to another without having to incur the added expense and time of changing chemistries. It is currently registered for use in the U.S., Canada, South America, Europe, Australia, and the People's Republic of China.

Bulk and Softness with Environmental Compliance

Today's paper mills operate under restrictive environmental regulations that affect not only the water circuit but also the emission of volatile organic compounds (VOCs). In response to these challenges, the new softener/debonder is a low-odor, moderately viscous liquid offered at 100% liquid actives. This eliminates the need to use environmentally suspect volatile solvents for liquefying and is in accordance with general paper mill requirements for liquid ingredients that are easy to handle. As a result, there are no emissions of volatile solvents to contend with.

In addition, analytical testing has demonstrated that the new softener/debonder exhibits efficiency at building both bulk softness and high absorbency without the addition of hydrophilic nonionic surfactants, thus eliminating the possibility of their accumulating in the whitewater system. Analytical testing has also confirmed that the new additive is 100% substantive to fibers, which may further minimize environmental load in the whitewater system.

Fiber Friendliness for Strength Loss

Premium-grade tissue products are often manufactured from virgin wood fibers in a blend of approximately 60-70% short fiber for softness and 30-40% long fiber for strength. For these premium products, eucalyptus is frequently used as the short fiber and northern bleached softwood kraft (NBSK) pulp is used as the strength fiber. Customer trials conducted to determine the impact of adding the new softener/debonder to such a blend showed a pronounced reduction of overall tensile strength.

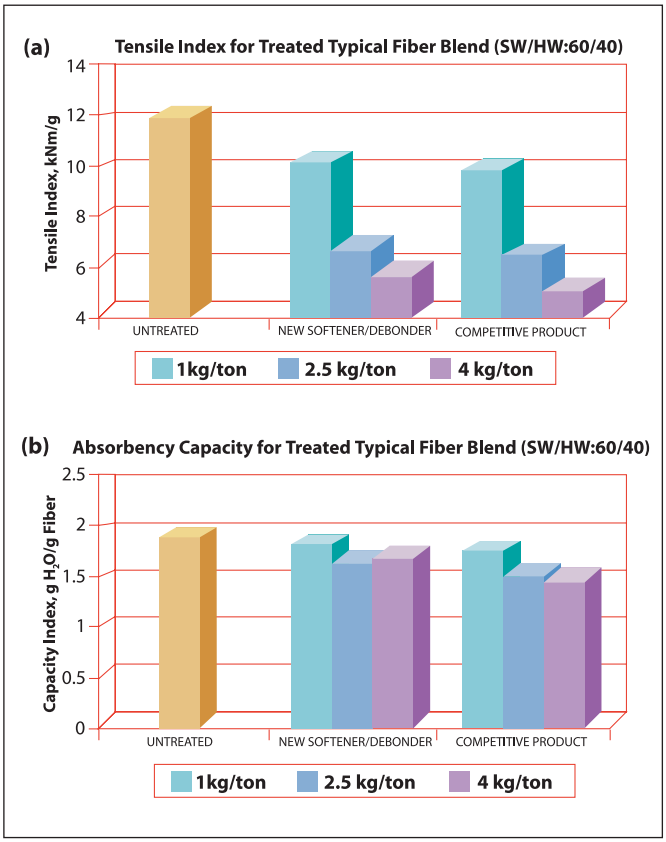
As shown in Figure 2, addition at the wet end of a tissue manufacturing operation disrupted (debonded) the inter-fiber hydrogen bonding. Figure 2 also illustrates several other possible applications for the new softener/debonder during a tissue-manufacturing operation.

The presence of NBSK fiber made this loss of strength manageable, since it also resulted in a concomitant increase in sheet softness through an increase in bulkiness. This combination of eucalyptus fibers, bulk softness, and surface softness (softness one feels when dragging fingers over a sheet surface) looks promising for creating a premium-quality paper tissue sheet and towel.

Figures 3a and b represent the results of customer trials conducted to determine the bulk softness enhancement (indirectly determined by loss of tensile) and absorbency capacity

FIGURES 3a-b.

(a) Bulk softness enhancement, which is the inverse of tensile reduction and (b) absorbency capacity of treated tissue handsheets



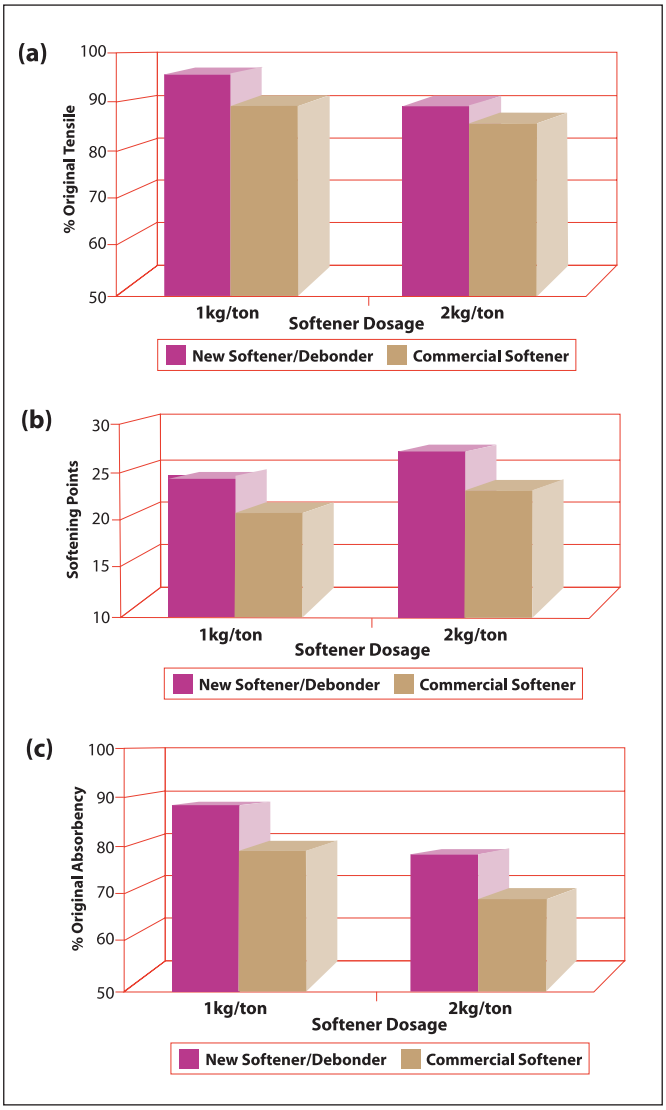
of tissue hand sheets treated with the new softener/debonder and with an industry standard softener (typically blended with liquefying solvents and non-ionic surfactants).

As the results in Figure 3a show, enhancement of bulk softness was similar for each additive. However, as shown in Figure 3b, the absorbency of the hand sheet tissue treated with the new softener/debonder was higher than that of the hand sheet treated with the industry standard softener.

Overall, the trial results demonstrate that the new softener/debonder could be used to produce a highly absorbent paper tissue or towel that features premium-grade softness. Also, since the new additive has virtually no odor, no malodors would be imparted to the sheet. In addition, FDA compliance would be maintained, and the environmental load for the mill would not be increased with VOCs or accumulations of process solvents and non-ionic surfactants. Further, due to the 100% substantivity of the new additive on virgin fibers, none of it would be lost to the whitewater system.

FIGURES 4a-c.

(a) Comparisons of original tensile strength retention; (b) Tabulated "handfeel" results from six panelists (5 = best, 1 = worst); (c) Original absorbency capacity of 90% bagasse/10% NBSK handsheets treated at two softener dosages



Low-Cost Fibers, Biofuels, and Functional Tissue

Where virgin fibers are unavailable or prohibitively expensive, other options need to be considered. One less expensive option growing in popularity is bagasse, a fiber recovered from sugar cane processing. Bagasse may have potential because it is a renewable resource, but more would have to be produced, especially for application in North America. This might occur if sugar cane is seen as a biofuel given the trend in oil and natural gas prices.

Although not used as a fiber source in North America, tissue is now produced from bagasse in four Kimberly-Clark mills in Mexico. Elsewhere, it is used in tissue in South Africa, China, and Japan. Its renewability and recoverability should enable bagasse to grow as a fiber source, but tissue produced from bagasse/softwood fiber blends is best described as functional, not premium-grade.

Bagasse is easy to pulp and bleach, though typically not refined and of low strength. Consequently, for the manufacture of tissue, bagasse is often blended with 10-40% softwood to enhance its strength. For customer trials conducted to improve the surface feel of bagasse-based tissue, hand sheets were prepared from 90% bagasse/10% NBSK fiber blends and treated with a range of softeners. The amount of NBSK was kept low to compensate for the chemical cost of the softeners. Screening studies eliminated several candidates.

Results presented for the new softener/debonder in Figures 4a through c show that the sheet strength was substantially maintained at dosages up to 2 kg/ton. In addition, the hand feel was excellent and increased with dosage. Also, the absorbency was considered very acceptable.

Although the new softener/debonder is free of solvents and non-ionic surfactants, it has been demonstrated to improve hand feel without significant loss of tensile strength. In addition to the economic benefit of upgrading low-cost fibers, machine efficiency and uptime are not reduced and less broke is recycled due to a weakened sheet. Moreover, sustained sheet strength helps keep housekeeping issues such as the collection of lint and dust to a minimum.

These trials were conducted by wet-end addition to the fiber blend before sheet formation. However, as Figure 2 illustrates, it would be simple to spray the new softener/debonder

onto a sheet by means of easily prepared aqueous dispersions. Should foam formation become an issue because of surfactant build-up from other sources, FDA-compliant organomodified siloxanes could be added to manage the foam and, possibly, build fiber lubricity.

Additional Softener/Debonder Applications

Many essential products made by papermakers require FDA-compliant softeners in their manufacture. The new softener/debonder was also tested for effectiveness in other applications, including:

Debonding Fluff Pulp: Fluff pulp, which is used in the manufacture of feminine hygiene and adult care products, among other paper-based products, needs to be debonded with FDA-compliant softeners to lower de-fiberization energy, as the fatty alkyl groups provide a lubrication effect. Customer trials pitted the new softener/debonder against an industry standard softener.

The results, shown in Figure 5, again confirm the hydrophilic nature of the new additive. They also highlight the benefit of reduced energy consumption during de-fiberization of the fluff pulp. Both features may prove significantly beneficial to a pulp and paper mill's profitability.

Yankee Surface Modification: As Figure 6 shows, data from thermogravimetric (TGA) analysis illustrate the new softener/debonder's stability over a wide temperature range that increased from 5° C to 300° C during a period lasting approximately 70 min, with the additive retaining 80% of its original weight at 300° C. This level of thermal stability is required for additives used for Yankee surface modification in tissue manufacturing, making the new softener/debonder a viable option for this application as well.

Broad Range of Papermaking Applications

As described, customer trials and analytical testing show the new softener/debonder to be a promising aid for a broad range of papermaking applications, including:

- Hydrophilic wet-end softener/debonder for premium tissue and paper towel kitchen rolls produced from virgin fibers
- Wet-end softener for economically improving the hand feel of tissue produced from lower-cost fibers such as bagasse
- Felt spray-on softener for tissue when used alone or in combination with organomodified siloxanes to eliminate foam and enhance tissue surface lubricity
- Formulation component with FDA-compliant organic or organomodified siloxanes for application of lotions or emollients during converting
- Thermally stable surface modifier when blended with a spray-on Yankee surface modifier
- Thermally stable emulsifier and release enhancer for paraffinic or naphthenic mineral oils or vegetable oils often used in Yankee release aids
- Hydrophilic fluff pulp debonder when formulated with absorbency aids. P&P

FIGURE 5.

De-fiberization and wicking rate for fluff pulp treated with new softener/debonder vs. the industry standard at three application dosages

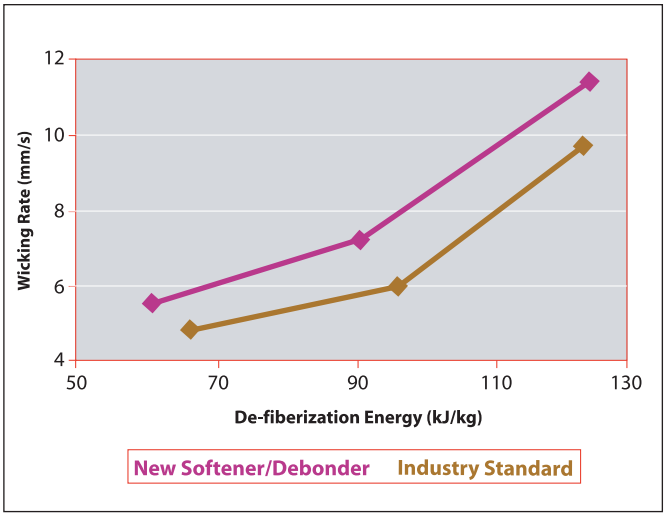
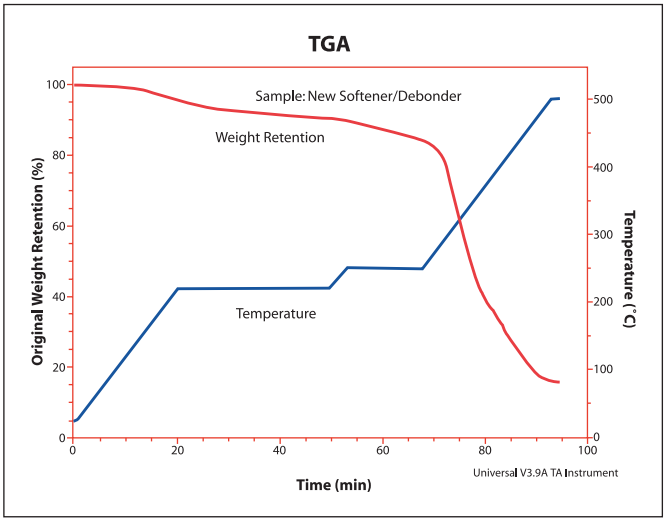


FIGURE 6.

TGA data for % original weight retention for new softener/debonder as a function of temperature over time



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