ADVANCED ADHESIVES REPORT

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Your corrugating adhesives newsletter from Harper/Love Adhesives Corporation

Wet-strength resins: cost vs. quality

Shaving costs with inferior resins is false economy

by John Kohl

The benefits of wet-strength resins are well-known; virtually all box plants use them sometime; some run them continuously. Their use is a given for boxes that will carry produce, meats, or similar products—and wise for any box that could be exposed to a wet or humid environment anywhere in its travel from plant to consumer.

Less well-understood is the fact that wet-strength resins are not all created equal, and that how they are used makes all the difference in the quality and integrity of the final box. These are important issues; boxes that fail can ruin shipments, waste money, and lose customers.

The evolution of modern wet-strength resins

The level of water resistance needed from a corrugating adhesive varies depending on the box application and the performance requirements of the customer. The resins used to provide wet strength have evolved greatly in the past 50 years. Originally, plants used a resorcinol-formaldehyde product that was difficult to prepare and had run speed limitations. Various urea-formaldehyde and melamine-formaldehyde blends were developed that had to be used with acid pH starch adhesive. This caused running limitations due to a high gelatinization temperature and unstable viscosity. In 1950 the use of ketone-formaldehyde resins was introduced to the corrugating industry and has since become the most widely used waterproofing additive.

Currently available ketone-formaldehyde or ketone-aldehyde resins, although all are derived from the same basic chemistry, differ significantly depending on the manufacturer. All these resins are thermosetting. They develop wet strength in the same manner, by mixing with the starch and hardening (gelling) in the glue line with the heat of the corrugator. However, they vary in the ratios of key raw materials from which they are formulated. They also vary in the crucial characteristics of percent solids content, percent of free formaldehyde present, the length of time to gelatinize, and reactivity with the starch adhesive. All these characteristics are important in a resin so that it will provide the best water resistance and overall value to a box plant and its customers.

This pineapple operation is a perfect example of the need for boxes with superior wet strength.The product is moist, and packaged in a hot humid environment. Box failure in shipment or storage would be catastrophic.

Percent solids: no place to cut corners

The total solids content in a wet-strength resin can vary from 38 percent to 65 percent, without the user even being aware of what they are getting. Low solids create adhesives that don't perform well, and you can't solve the problem by simply adding more resin to achieve the target of approximately 50 pounds of solids per 660-gallon batch. This sounds easy enough, but when you add more than 100 total pounds of resin to a 660-gallon batch of adhesive, the viscosity increases dramatically from what is called resin shock. This thick, stringy adhesive is hard to pump and causes problems with pickup and transfer, reducing board quality.

Reducing residual formaldehyde

Another important issue in considering wet-strength resins is the residual, or unreacted, formaldehyde remaining in the product. In 1987 OSHA published its Final Rule on occupational exposure to formaldehyde, and revised it again

Next page, please

in 1992. The rule states that the maximum average exposure to a worker is 0.75 ppm over an 8-hour period.

This ruling, coupled with the requirements of box plants' Air Quality Permits, has forced all resin manufacturers to reduce the amount of free formaldehyde in their products. However, different methods of reducing, cross linking, or scavenging residual formaldehyde, produce varying end results. Some formaldehyde reduction methods dramatically reduce the overall ability of the resin to perform at its best. Some methods can actually create an adhesive bond that *attracts* moisture, defeating the purpose of a wet-strength adhesive.

Don't compromise on gel time

The gel time for ketone resins is also affected by the type and amount of raw materials used in manufacturing. The gel time is crucial to a corrugating adhesive since it is directly proportional to the ultimate amount of wet strength it can develop. Desirable resins have a short, finite gel time that will deliver higher levels of water resistance. Resins that don't completely gel in a short period of time normally don't develop the same degree of water resistance. Some of the current undesirable resins on the market have very long gel times, with virtually no end point.

All wet-strength board must be allowed to cure in the stack before finishing to let the resin finish hardening. While stack-cure time can be increased to compensate somewhat for slower-acting resin formulas, most plants do not have the space, time, or operational flexibility to wait 24 hours to convert board. (See sidebar: *Stack cure time: how much is enough?*)

Use enough to do the job

Reducing the application rate of starch adhesive is another way plants have been trying to save a few dollars for years. The appeal is understandable: by keeping glue gap settings low, or using the same setting for wet-strength board as for domestic board, plants can lower adhesive cost.

In reality, the gap settings and the overall application rate need to be *increased* to produce good water-resistant board. By increasing the amount of adhesive applied, there is a shoulder formed on the flute tip to protect the pressure line (location with the least amount of starch) from water. The finished board made with a lower application rate will be less water resistant than board made with the proper amount of starch. This will cause the plant to have box failures and additional costs from customer returns.

Good adhesives: big returns from a small investment

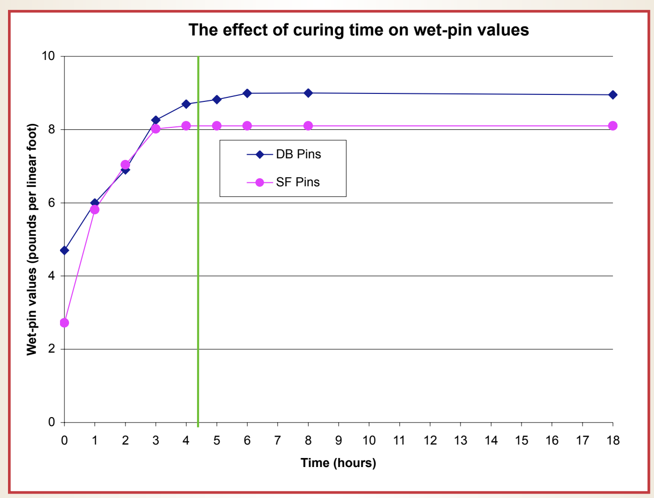
All these issues are part of the perpetual tug-of-war between cost and quality. Consider: the cost of paper alone is 85 percent of the finished box. The cost of the starch adhesive is only 1.5 percent of the box, *and the resin is only 25 percent of the adhesive cost!*

Superior wet-strength resins, such as our Aquasel™ W-150, deliver high solids, short gel times, low free formaldehyde, no resin shock, and batch-to-batch consistency. The quality and performance of the resin is the foundation of the quality and performance of the box. With so much at stake, shaving cost with inferior resins is clearly false economy. It is far better to invest in—and deliver—higher quality and enjoy the loyalty of satisfied customers.

Stack cure time: how much is enough? (And what about those fans?)

With the advent of conveyorized production and customer-driven Just In Time (JIT) requirements, there is great urgency to move board from the corrugator to finishing operations as quickly as possible. Some try to force-cool the stacked board with fans, directly off the corrugator, in order to speed things up. This practice compromises the integrity of the bond and the performance of the box in the field.

Wet-strength resins are thermosetting. They need time and heat. Even the best resins, cooled too fast, won't cure properly. Our tests show that good thermosetting resins need 4 to 5 hours before cooling to develop a hard plastic on the glue line. Cooling the stack with fans earlier than 4 or 5 hours defeats the purpose of the resin. Your board moves faster, but it no longer has a water-resistant bond.



This graph shows the results of wet-pin tests of stacked wet-strength samples at various time intervals. It is clear that cooling stacked board too soon doesn't allow the bond to develop its water-resistant potential.

Testing for wet strength

by Rex Woodville-Price

Since there are great differences among wet-strength resins in solids content, chemical make-up, and performance, it is important to evaluate the degree of water resistant performance of your board. Tests will help you establish bench marks and monitor the effects of changes in your adhesive formula.

There are several methods of determining how the bond will resist dissolving in the presence of water. All these methods involve placing board samples in water for a time and then subjecting the board to some sort of force.

These methods are differentiated by soak time, the direction they apply the force to the bond, and the manner in which that force is applied. In tests like 24 Hour Soak and Wet Pins, the force is applied in a line that is perpendicular to the liners. Test like the FEFCO and the MBR Wet Shear the force is applied in a direction parallel with the liners.

Wet Pins and the 24 Hour Soak are TAPPI standardized tests, so they are more common in the USA.

Here are the four most widely used wet-strength tests.

Wet Pins: TAPPI T-821

This test is the same as the common dry-pins test except that the sample is first soaked in room temperature water for one hour. A set of combs with pins appropriately spaced to fit in between the flutes is placed in the sample, which is then pulled apart in a scale that records the amount of force that it withstood.

24 Hour Soak: TAPPI T-812

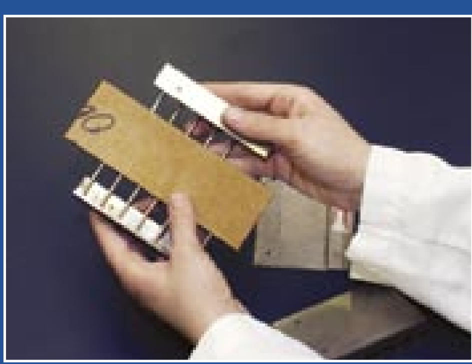
This is a popular test since it does not require any testing equipment but as such is fairly subjective. A sample of board is soaked in room temperature water for 24 hours and then pulled apart by hand. If the sample floated apart during the soaking period it fails the test. The sample is then evaluated by how much force, called suction, it takes to pull it apart. Samples that held together with a stronger bond are then evaluated for the percent of fiber tear that they generated. The best results are obtained when there is ply separation or medium decapping.

FEFCO #9

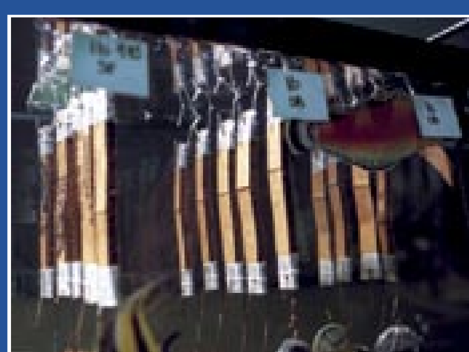
Often referred to as the fish tank test, samples are hung in a tank containing water. Weights are attached to the bottom of the sample. The samples have their liners cut through so that only the starch adhesive is supporting the weight. To pass the test the samples have to endure 72 hours without letting the weight drop.

MBR Wet Shear

This test is similar to the FEFCO test in the way that it applies a force to the sample as it is being soaked underwater and measures the amount of time to failure. The main difference between the MBR and the FEFCO is that the MBR uses a device with a bell crank to apply the force (not shown).



Lab technician prepares sample for wet-pin test, TAPPI T-821



Samples in "fish tank" test, FEFCO #9

Lab technician checks the results of 24-Hour Soak Test, TAPPI T-812

Aquaseal™ W-150 wet-strength resin

Aquaseal W-150 is our "workhorse" liquid thermosetting resin. It features less than 0.5 percent free formaldehyde and offers excellent pot life and low batch shock properties. Excellent water-resistant glue line protection. Promotes superior board quality, and efficient production.

Uses:

- Wet-strength corrugated board production
- Improve overall board quality for finishing

Operational benefits:

- Exceeds TAPPI 24-hour soak tests
- Convenient liquid form
- Safe and easy to use
- Compatible with automatic starch kitchens
- Distinctive red color provides visual assurance of use
- No resin shock to the adhesive
- Low free formaldehyde: complies with OSHA regulations

Use 100 pounds per 700-gallon batch. Available in 55-gallon drums, 275-gallon totes