FEBRUARY 2009

ADVANCED ADHESIVES REPORT

Your corrugating newsletter from Harper/Love Adhesives Corporation

Exploring alternatives to corn

With concerns about cost and supply, should we look to other plant sources for starch?

by Rex Woodville-Price

Corrugating managers often ask our tech reps about alternatives to cornstarch for producing corrugating adhesive. Their motivation is usually concern about cost or supply. (Recently, production of fuel-grade ethanol diverted some US corn production away from industrial starch applications, which also pushed prices to unprecedented levels. This caused a short-term supply issue that is currently stabilized.)

There are alternatives to corn, and they are more or less attractive, depending on where in the world you operate. In the US, corn still beats them all. Let's review why.

The alternatives

Wheat: Wheat starch has been used extensively in Canada, since wheat grows better than corn in that climate. Often considered a serious alternative to corn, wheat has a lower natural gel point and requires less caustic soda in the adhesive formulation. Because wheat is more sensitive to caustic soda and temperature than corn, the finished adhesive will often experience swelling and viscosity instability in storage, particularly over long periods of time. Wheat gives the adhesive desirable rheological properties often described as a creamy feel and is more often used as the carrier starch than the base slurry.

Banana: Unripe (green) bananas have a fairly high starch content. In the past, banana companies experimented with the production and use of banana starch in their corrugating operations with varying degrees of success. The starch they produced often exhibited problems with viscosity stability. It is possible that some of the fiber remaining in the starch swells as it hydrates and contributes to the problem.

Potato: Potato starch is used in Europe because it is abundantly available locally. Potato has a naturally low gel temperature and varying granule size, which can result in viscosity instability in storage. Being a tuber, it has a lot of water for its starch content.

Tapioca, mandioca or cassava: These are used in Brazil and parts of Asia. As tubers, these starches have high water content and a fairly low amount of starch.

Pea: Pea starch is used in Italy and other parts of Europe. Total volume of production is low. The starch contains a substantial amount of protein, which is not readily removed. This can cause problems with foaming and bacterial degradation.

Milo/sorghum and rice: As grains, these also contain starch and have seen limited use as corrugating adhesive at one time or another.

The issues

Granule size uniformity: Starches that have granules of varying sizes will exhibit changing behavior over time (swelling or viscosity swings). As a sphere gets smaller, the ratio between surface area and volume increases. This is why smaller starch granules take less time to be affected by the free caustic soda in the formula than the larger ones. One of the limitations of most alternative starches is that they are made up of many different size granules. (Corn by contrast, has a very uniform granule size.)

One way to combat this is to make smaller batches and reduce storage time. Storing the adhesive at lower temperature, a practice common in Europe, also helps delay swelling.

Supply and cost: Most of these alternative starches (or the raw materials they are made from) are usually valuable as a food source, which generally brings a better selling price. The quantity produced is also limited so a lower supply tends to increase prices.

Natural gel temperature: Corn has a comparatively higher natural gel temperature than alternative starches. This allows more caustic soda to be used in the formula.

This is good. Much of the recycled paper produced today generally contains large amounts of starch sizing, which can make them harder to bond. Caustic soda functions as a wetting agent. Alternative starches with less caustic soda in their formulation may require an additional wetting agent or penetrant to be used.

And the winner is—

All things considered, cornstarch remains the best choice for making corrugating adhesive. It has several advantages.

- It has uniform particle size, which contributes to stability in storage.
- Its naturally high gel temperature allows it to be tailored to a wide range of operating conditions through the addition of caustic soda.
- It is customarily produced with 10 percent to 12 percent moisture and is easily blown (fluidized with air), facilitating use of bulk storage devices such as silos.

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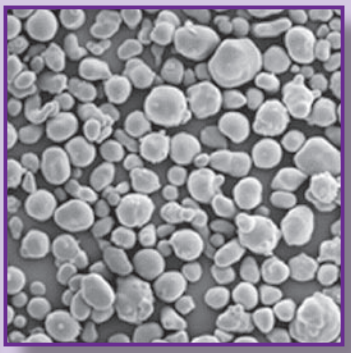
- Corn wins on supply and cost: corn is grown extensively in the US and has a high yield per acre compared to most other starch bearing crops. This helps keep its cost competitive. The two largest users of industrial cornstarch are corrugating and papermaking. Papermaking uses a much higher-priced modified starch than the cheaper pearl (raw) starch used for corrugating. Also, there is a synthetic alternative for sizing paper. Theoretically, as prices increased, starch would become too expensive for papermaking before corrugating. This could potentially free up some supply and act as a buffer for further price increases. At the present time there is no synthetic alternative to starch based corrugating adhesive that is economically viable.

These are all compelling reasons why cornstarch is still the preferred choice for corrugating adhesive and continues to be the best value.



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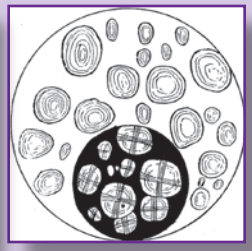
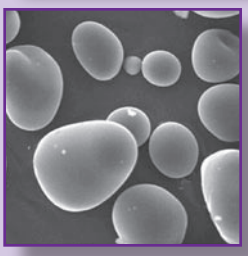
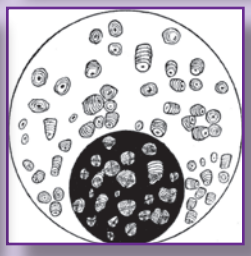


Wheat



Potato



Tapioca

Maximizing starch corrugating adhesive

How to get consistent performance and value from your adhesive system

by John Kohl

Corrugating as we know it has been around for more than 100 years. During that time there has been constant evolution in corrugating equipment, enabling the production of higher quality board and higher production speeds. It is now common for a modern corrugated box plant with a high-speed corrugator to produce board at speeds over 1000 linear feet per minute (300 meters per minute). Many of these plants produce in excess of 1.4 billion square feet per year—more than twice the volume of plants considered modern and high speed just 15 years ago.

Along with this evolution in corrugating equipment there has been an evolution in starch adhesive. The first corrugators used a paste that had only a 15 percent solids content, made from cooking starches and flour in water. With so much water to be removed from the combined board, running speeds were very slow. By 1920 the industry had changed to silicate of soda, with much higher solids content and therefore higher run speeds. It had cleanup issues. Then in the 1930s Jordan Bauer, of the Stein Hall Company, developed the Stein Hall process still used today in the majority of box plants.

The Stein Hall adhesive uses a small portion of cooked starch, called the carrier starch, to suspend and carry the uncooked starch through the pipes to the pans and the glue line. The Stein Hall adhesive also uses caustic soda (sodium hydroxide) to help cook the carrier portion, and borax to increase tack and cohesiveness. These three raw materials, and water, are the main ingredients for all corrugating adhesives. Their consistency will affect the quality, stability, and running qualities of the finished adhesive.

Use raw materials of consistently high quality

The first step in maximizing your adhesive should be to track the quality of the raw materials used in the adhesive. Plants should ask their adhesive raw materials suppliers to provide them with a certificate of analysis (COA) for each component, and record the properties to identify any changes that will affect the finished adhesive. This is most important for the starch used in the adhesive since starch is a natural material and will have variations in moisture content and natural gel point.

Equipment considerations

The type of starch-mixing equipment is the next area to address in adhesive performance. For older single- and two-tank mixers, that have motors of less than 20 horsepower for agitation, there can be limitations in viscosity stability and solids content of the finished adhesive. When using these older mixers, a plant will need to balance the finished viscosity, solids content, batch size, and viscosity on the corrugator. This can be achieved by accurately controlling the amount of starch cooked in the carrier portion of the adhesive. The amount of carrier starch used in an adhesive determines the finished viscosity, and by decreasing the amount of carrier starch slightly (about 5 percent), the solids

content of the finished batch can be increased 1 percent to 3 percent without an increase in viscosity.

Newer high-shear mixing equipment provides greater flexibility in adhesive formulations. The higher horsepower and higher rpm allows for higher solids formulations without high viscosity or a drastic drop in viscosity over time.

Chemically modified carriers

For the past 40 years, one of the methods to increase performance and improve the bond has been to use a chemically modified carrier starch. By treating the starch with acids or other chemicals, the starch manufacturer reduces the viscosity of the finished adhesive, allowing 50 percent to 100 percent more carrier starch to be used. These specialty carriers were primarily used to increase the dissolved solids of an adhesive, to improve the water resistance of the finished board when using waterproofing resins. The cooked carrier has two major functions in the adhesive: One is to suspend and carry the raw starch to the glue line, and the second is to provide water holdout. This means the carrier helps hold water in the glue line so that there is sufficient water available during the raw starch gelatinization process on the corrugator. This water holdout was not an issue when corrugators had top speeds of 650 linear feet per minute (200 meters per minute). On today's high speed machines 1000+ linear feet per minute is not uncommon; with extra carrier starch holding onto the water, it is difficult to produce board dry enough to run through the slitter heads without disturbing the bond.

Product mix

To maximize your adhesive you also need to consider your product mix and the most common paper grades (basis weight) produced. If a large percentage of production is high ring crush liners, even the 35# variety, you need to increase gel point and solids, while maintaining an ideal viscosity for the corrugator. Some plants with this type of product mix and a very hot corrugator may need to increase viscosity, as well. The increase in viscosity will help increase water holdout time, giving the starch a few milliseconds more to penetrate the densified paper before gelling occurs. This increase in viscosity will also cause the glue roll to apply slightly more adhesive to the flute tips, improving the overall bond.

Stability in storage

Maintaining stability in storage is important to get the most from your adhesive. The storage tanks need a TVC system that works properly. The TVC system will maintain the starch at a constant temperature by circulating warm water through pipes in the storage tank. It will also turn on an agitator at preset intervals to mix the adhesive that contacts the heated coils. By keeping the adhesive at a constant temperature, a consistent viscosity will be maintained and prevent variations in application rate.

The adhesive in the storage tanks is also susceptible to bacterial infestation. The bacteria will attack and eat the carrier starch first, causing a drop in viscosity and a rise in gel point. The best way to prevent a bacteria problem is to use a biocide in every batch of adhesive. It is far easier to prevent bacteria growth than it is to rid a system of bacteria once they get a foothold in your starch system. For plants using fully automatic starch mixers, there are liquid biocides available that can be added automatically to the adhesive during batch preparation.

High-performance additives

Another way to improve the bond quality, adhesive stability, and corrugator speed, is to use modern performance additives. Most of these additives are liquids, which makes them easier to handle and automate in the adhesive preparation process. They are designed to increase dissolved solids without increasing water retention in the glue line. Other additives will aid in penetration of densified liners, increase drying speed, produce flatter sheets, increase water resistance and run speeds. Whatever the limitations of your corrugator, there are specialty additives that can help you overcome them.

To maximize your adhesive, you need to control the quality of raw materials, use the best mixing equipment currently available, keep temperature and viscosity consistent, formulate for current production demands and paper grades, and use the best additive technology available to enhance adhesive performance and bond speed.

Reducing starch application rates is false economy

Box plants that try to reduce adhesive application rates to extremely low levels as a way to save money are more likely to generate more waste than they save in adhesive cost. The whole purpose of maximizing corrugating adhesive is to achieve the highest return on the equipment investment with the highest possible corrugator productivity and board quality. Starch adhesive, even when it contains high-end performance enhancers, makes up less than 2 percent of the finished box cost. Paper makes up 70 percent to 75 percent of the box cost. The better the bond, the less chance of making waste.

Your starch supplier should be able to help you maximize your adhesive to achieve the best performance on the corrugator. The higher your plant's average corrugator speed, the lower the manufacturing cost per msf becomes. Along with the savings in machine cost, there also is added production time and possibly the reduction in overtime cost. For every increase of 10 linear feet per minute in average corrugator speed, an 80,000 mmsf/ month plant can produce an additional 4 msf per hour. In a three-shift operation this equates to 96 msf of additional board per day. At current selling prices over $40/msf, this is $3,800 a day and over $900,000 per year additional plant sales.

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of making
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In this issue:

- Alternatives to corn
- Maximizing adhesive performance