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New strength additive for tissue offers much promise

A strength boosting additive based on hemicelluloses, derived from renewable agricultural products, can benefit tissue makers in numerous ways, claims Cargill.

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Hemicellulose is perhaps not the first word that enters a tissue maker's mind when he or she thinks of the strength properties of the sheet. This, however, might be about to change as development work done by Cargill Incorporated, the US-based food and agricultural corporation, may help these organic compounds get more attention in the tissue business.
Hemicellulose (hemi means half in Greek) is not a single well-defined chemical compound but instead a class of compounds called matrix polysaccharides. These are basically all the polysaccharide components, other than cellulose, in the cell wall of plants.
Cellulose, the building block of papermaking fibers, is a polymeric carbohydrate consisting of 1,000 - 3,000 or more glucose units in a linear chain structure (Fig. 1) that gives the fibers great tensile strength. Hemicelluloses are, on the other hand, highly-branched, non-linear polysaccharides (Fig. 2) that are found between the cellulose fibers in plant material. So cellulose is straight, strong and long, while hemicellulose is branched, weaker and shorter.

WELL DOCUMENTED POSITIVE EFFECTS. It has been known by paper scientists for decades that hemicellulose has a positive impact on cellulose fibers, with research studies clearly documenting the improved hydration rates, higher strength properties and enhanced fiber-to-fiber bonding.
What's new, says Bill Boyden, General Manager for Cargill's HemiForce® enhanced fiber additives, is the patented process that Cargill has come up with for manufacturing the hemicellulose product and delivering it to the paper furnish in a highly usable form. The new product, called HemiForce®, is a cake-like material at about 25% solids which can easily be added to pulp stock, both primary and secondary fibers, to improve strength properties of the tissue sheet.

RENEWABLE BIOMASS FOR REDUCED C FOOTPRINT. The raw material for HemiForce® comes from renewable agricultural seed-based fibers such as those found in corn, soy, oat and other grain kernels. Fiber in the outer covering of the seed, called the pericarp, is rich in hemicellulose. Being made from renewable biomass means it has a lower carbon footprint than other strength additives based on fossil fuel derived synthetic chemicals.
Boyden, who joined Cargill in 2006 after 20 years in the pulp and paper manufacturing business, says the company initiated research in the late 1990s into the possibility of using hemicellulose as a paper strength enhancer. This was part of a general effort within the group to identify value-added applications for biomass material. Cargill generates lots of biomass from its food processing operations and wanted to see what chemical or physical properties of its fibers might be beneficial in commercial applications.
After initially identifying hemicellulose as a potential strength enhancer for paper, the development team went through a formal stage-gate process for taking a new product from idea to launch. With positive feedback at each step, Cargill started commercial production of HemiForce® at its plant in Cedar Rapids, Iowa, USA, in early 2009 and is currently focusing on the North American market.

HYDROGEN BONDING IS THE KEY. Hydrogen bonding is the mechanism responsible for the strengthening effect of hemicellulose, which is able to achieve numerous low level attractions between hydrogen and oxygen atoms. Thus the

hemicellulose acts as a flexible yet strong network that could be envisioned as a type of spider web to help hold the cellulose fibers together.
Tissue is obviously a tough sheet to run on a paper machine, since it is often so light and porous that fiber to fiber bonding is limited, compared to heavier paper webs. Historically, low sheet strength is a key factor which can lead to production losses due to breaks on the wet web, during creping, reeling and converting operations. It also gives lower quality of the finished product, where strength is of paramount importance. Additionally, as more tissue makers use recycled fibers to reduce their fiber costs, the resulting lower strength of the sheet is further impacting their operations and products.
Cargill says that the strength improving effects of HemiForce® can be used in a whole range of ways, depending on the needs of the mill. These might include:
- increased secondary fiber content or using lower quality furnish;
- reduced softwood fiber usage;
- increased machine speed;
- reduction or elimination of refining and associated energy;
- lower basis weight;
- decreased percentage of crepe at the Yankee dryer;
- increased bulk at a higher freeness level;
- improved sheet stretch;
- reduced dusting during creping, reeling and converting operations.

SOFTNESS RETAINED. When the lignins are minimized and the hemicellulose/cellulose combination in fibers is maximized, the fibers become more flexible and the paper sheet also gains softness. So in addition to imparting strength to the sheet, they also help retain softness.
The product is said to be easy to use and add to the process simply by mixing and blending it in. Boyden comments that it is best applied to stock at about 3-5% consistency and is not shear sensitive, so it can be added both before or after high-shear pumps.

MARGIN ENHANCER. The net financial impact of the use of HemiForce® has been verified at up to $8 per ton or more for tissue producers (Table 1). As far as what the product can do for tissue makers, Boyden sees it this way: "We think of HemiForce® as a 'margin-enhancing' tool that adds strength, allowing the tissue makers to use it in the way that makes most sense for their specific situation. Higher strength can mean higher line speeds and therefore overall production increase in the area of 3-5% without any capital investment. There are lots of ways you can take advantage of the improved strength such as reducing refining for energy savings, increasing recycled fiber content, or increased stretch which means lower creping ratio if that is desirable. There is a whole range of possibilities and which makes most economic sense depends on the mill situation."
"The biggest challenge," continues Boyden, "is to get tissue makers comfortable with this tool, which is new technology for the world. Of course it takes time to evaluate a new solution like HemiForce® and the papermakers want to be sure before taking big steps."
This will be an interesting story to follow as it has all the makings for success, including innovation, cost savings, quality enhancement and lower carbon footprint. Stay tuned. •