

Market opportunities with superabsorbent fibers

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By offering performance advantages over powders, superabsorbent fibers show potential in a broad range of product applications.

Superabsorbent fibers offer a new range of product flexibility, both to manufacturers currently using fluffed pulp for absorbent products and to roll goods manufacturers who handle other fibers.

Superabsorbent fibers can be blended directly with pulp to dramatically enhance absorbent properties, or they can be blended with other fibers for processing to fabric form. This latter process yields unique fabrics which can be used in a variety of new product applications, including laminations.

Superabsorbent fibers are relatively new to the superabsorbent polymers market, which was launched in the 1970s when the U.S. Department of Agriculture developed superabsorbent starch compounds. In recent years, the demand for superabsorbent fibers has grown as the result of increasing knowledge about the product and the inability to adapt powders to some fiber-based processes.

The superabsorbent fibers segment of the market will experience dramatic growth during the next two years as fabric and personal absorbent products manufacturers develop their understanding of processing these fibers and learn to tailor composites to achieve unique properties in specific end-use products.

General characteristics

The superabsorbent fiber described in this paper was created from a unique polymer using proprietary technology. It is available in a variety of deniers. The entire cross-section of each fiber is superabsorbent.

Superabsorbent fibers absorb many times their weight in liquid and can retain much of it under pressure. The absorbent capacity of these fibers varies by the fiber grade and the specific liquids (e.g., water, body fluids) to be absorbed. Typically, a superabsorbent fiber absorbs 45-55 times its weight of 0.9% saline solution (equivalent to urine), and about 200-300 times its weight of water.

Other properties of these fibers, using 0.9% saline solution, are illustrated in **Tables I and II**.

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The fiber changes structure during the absorption process, forming a gel. As with all superabsorbent materials, liquid can be removed and the absorption cycle repeated, although this is not economical in most circumstances. Therefore, most applications using superabsorbent fibers will be for disposable products.

Processing characteristics

Superabsorbent fibers are not intended to be structural components of a product for two reasons. First of all, when dry, they are not as strong as most other fibers of similar denier. Furthermore, the fiber changes its structure to a gel after absorption. Their tensile strength is in the 1 g/denier range, which is more than sufficient strength to process the fibers into suitable materials.

A concern for many operations is the effect of humidity or moisture on superabsorbent materials. Our experience has shown that the fibers must be processed between 45% RH and 70% RH. However, superabsorbent fibers do have virtually limitless shelf life if stored in sealed plastic bags or under conditions where humidity is under 70%.

In blending, finished products require only a small percentage of superabsorbent fibers to achieve desired absorbency, because the fibers absorb a large amount of water for their weight. Blending can also provide good strength properties and improve economics. Processing is accomplished on standard opening and blending equipment.

Superabsorbent fibers are not melt spun and cannot be used alone as melt-bondable fibers. However, they can be bonded by blending with fusible fibers prior to the bonding process. Fabrics have been made by needle punching, calendering, melt bonding, weaving, and stitch bonding in pilot plant operations.

Direct use as tow or staple

Superabsorbent fiber can be part of the pulp process. In diapers and incontinence products, for example, superabsorbent fiber can be fed, along with the pulp, directly into the hammermill to achieve a homogenous blend. This supply system can be added without elaborate feed equipment and its related capital outlay.

Metering is achieved by feeding a continuous fiber

bundle (tow) at a set speed. The grams of superabsorbent fiber per foot of fiber tow are specified to add the required grams in the end product. Accuracy in metering and reduced material losses result in uniform pads and significant cost improvements.

Fiber performance vs. powder performance

When compared with superabsorbent powders, superabsorbent fibers provide the following performance advantages:

- No migration
- Accurate dosing
- Intimate blending
- High speed of absorption
- Possibility for versatility in range of structures
- Minimal loss of void area
- Possibility for loadings greater than 50%
- Minimal capital expenditure to adopt technology.

Within a composite, fibers are inherently more effective because of their complementary structure. They also outperform superabsorbent powders in handling. Powders can be difficult to adhere in position; they migrate, dust, and abrade in processing. While new technology is improving powder handling, fibers will continue to provide better performance through use of tow or nonwoven fabric as a means for very accurate dosing into the end product.

The versatility of superabsorbent fibers provides an opportunity to use superabsorbents where they never before could be used. This versatility also offers performance advantages in existing markets, as previously noted.

Product opportunities

Product design is no longer limited or hindered by constraints imposed by superabsorbent powders. For example, a lightweight (20 g/m²), physically stable superabsorbent fabric structure is now possible. Absorbent structures can be thinner without superabsorbency loss or migration. Unlike powders, which are introduced into pulp cores and held in place by binder or tissue layers, superabsorbent fibers require no such binders or barriers. This could lead to superthin cores that require minimal, if any, fluff pulp.

Superabsorbent fibers can be blended with other fibers to provide strong superabsorbent fabrics with excellent handling, storage, and uniformity. These fabrics can be thick, with high absorbent capabilities internal to the structure; or thin, soft products that deliver controlled amounts of superabsorbent to specific areas. It is important in all structures to allow for swelling of the gel or the absorbency will be restricted.

Minimal blends of superabsorbent fiber with usually nonabsorbent manmade fibers can provide absorbency and improve the "hand" of the resulting fabric, creating a more natural fabric feel. Fabric properties will be determined by both the fibers used and the fabric structure.

I. Absorption characteristics

Free swell (g/g)	65
Retention @ 0.5 psi (g/g)	40
Demand absorption speed (g/g/s)	0.23
Fluid absorbed in 5 s (g/g) (tea bag test)	30

II. Physical characteristics

pH of polymer in 0.9% saline	6.0-7.0
Denier per filament	10
Maximum processing temperature	200°C

Beyond the obvious advantages in the diaper and incontinence markets, these new superabsorbent fibers offer manufacturers an opportunity to create products with properties different from anything currently available. Some of the fabric properties which can be varied by design include:

- Pore size
- Moisture
- Density
- Thickness
- Modulus
- Absorption
- Temperature resistance
- Wicking
- Wet strength
- Antistatic control.

These properties can be controlled by changing the forming process, the blending fiber, or the percentage of superabsorbent fiber.

Primary functional uses of superabsorbent fibers

Superabsorbent fibers have many potential applications. Most of these can be placed in one of the following functional categories:

1. Absorb water. This is the most obvious category. Superabsorbent fibers perform exceptionally well in absorbing large quantities of water with relatively small amounts of absorbent material. Industrial wipes and hazardous waste pickup pillows are good end-use examples.
2. Absorb and retain water. The primary end-use applications in this category are disposable diapers and adult incontinence and feminine hygiene products, where liquid must be absorbed and retained even under pressure.
3. Absorb and swell. Swelling in the presence of water is more important than absorption in this category,

where swelling blocks unwanted water flow. The inherent swelling characteristics of superabsorbent fibers and their composite wet strength make them especially well suited to applications in this category. Examples include communications cables, machinery filters, and gaskets. This category also includes medical fabrics which require fluid blockage, as well as construction fabrics.

4. Absorb and disappear. In this category, superabsorbent fibers are used during initial production. When the resulting fabric absorbs liquid, bonds break, allowing the material to decompose readily. Several applications are currently being explored.
5. Absorb and provide a barrier. Here, the fabric in the swollen state provides heat barrier properties or heat radiation barrier properties. A good applications example is fire blankets.

New market development/existing market opportunities

The initial market opportunities will be in the absorption and retention of liquids, but the unique properties which can be engineered into fabric structures will create market potential in many other areas. These include:

1. Removal of water, water vapor, or mist. The fabric or paper composites provide a method of placing superabsorbent fibers specifically or generally in or around a product. Demisting has been observed to be very effective as a result of the superabsorbent's large surface areas and high absorption speed. Product application areas include fabrics to seal out water, mist, or moisture in packaging, filters, or humidity control systems. Industrial wipes also fall into this category.
2. Liquid or solid separations. Fabrics of paper composites can be made to remove water from oil or a liquid from a solid. Product application areas include filters and medical products.

3. Controller-release geotextiles. Commercial horticulture is a major potential market for superabsorbent fibers in this category. Plants require controlled amounts of moisture and nutrients over extended periods of time. Superabsorbent fibers or fabrics can contain large volumes of water and nutrients in gel form, held for osmotic release. The fabric also acts as a soil separator or erosion control mechanism.

4. Gas permeable liquid barriers. Needle punched fabric or composite papers with superabsorbent fiber will allow gas passage when dry. When water contacts the fabric, the resultant swelling of the fiber can be designed to fill holes and stop water flow. Product application areas include protective clothing, filters, protection of communications cables, and "lightweight sandbags"—superabsorbent fibers enclosed in a fluid-permeable cover to create a dam around chemical spills.
5. Heat absorption. A saturated fabric absorbs large amounts of heat as water changes phases. Possible new product directions include emergency heat barriers, fire barriers, and supplying cooling to an area after freezing the wet fabric.

Clearly, the market opportunities for novel absorbent products using these superabsorbent fibers are many. These fibers allow many exciting new product designs never before attainable. This promises to be a fast-growing area, with some of these innovations appearing in the marketplace soon. □

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