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Acrylic Fiber

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Report Abstract
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Acrylic Fiber

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INTRODUCTION

Acrylic fiber is a widely used commodity to produce fiber filaments and fabric. Acrylic fiber (or polyacrylonitrile fiber) is usually defined as a polymeric material which contains at least 85 percent by weight of acrylonitrile monomer. The main comonomers employed are neutral esters, such as methyl acrylate and vinyl acetate. The comonomers improve solubility of the polymer in solvent, improve fiber flexibility and morphology. Often, a small percent of an ionogenic comonomers such as sodium itaconate is also incorporated to increase the number of dye receptor sites in the polymer.

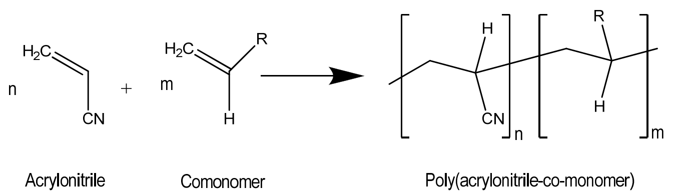
If a polymer contains large amounts of comonomer (from about 15 to 50 weight percent) and at least 35 weight percent acrylonitrile monomer, then the polymer is usually considered a modified acrylic fiber and referred to as modacrylic fiber. Modacrylic fibers often contain monomers with chlorine containing groups (such as vinylidene chloride) which confer flame retardant properties to the fiber for use in carpet applications, children's night wear and other such consumer products where resistance to flammability is of high importance.

Acrylic fiber has excellent chemical, biological, sunlight and general weatherability resistance. Acrylic fiber has high electrical resistance, and good tenacity. However, the material is attacked by strong bases. Acrylic fibers are reasonably comfortable to wear. A review of its properties clearly explains why it is widely used for outdoor applications.

Acrylic fibers compete in the market place with other synthetic fibers (such as polyester and nylon) and natural fibers (such as cotton and wool). Acrylic fiber properties are compared to other natural and synthetic commodity fibers in the PERP report.

TECHNOLOGY

The production of acrylic fiber is now more than 50 years old. The technology is mature. Acrylic fiber production from acrylonitrile and a comonomer may be schematically summarized as below.



Oftentimes, a ternary polymer is produced which incorporates a monomer capable of forming ions (such as sulfonate) that enhances the dyeing capacity of the fiber.

The production process involves polymerization, spinning and treatment. The two principal polymerization processes employed commercially are suspension and solution polymerization.

Solution Polymerization

This process is carried out in a homogenous medium by dissolving the raw materials in a solvent. In solution polymerization, a spinning solution (called dope) is prepared directly from the polymer solution that forms. This results in lower energy costs and a smaller plant production complex since less preparatory units are required. However, it is much more difficult to obtain a high molecular weight polymer (because of interaction between the polymer chain and the solvent as the reaction is occurring) and there are impurities retained in the solvent that must be removed or at the very least, minimized.

Suspension Polymerization (i.e., Aqueous Dispersion, Precipitation or Slurry Polymerization)

Suspension polymerization is the process used to produce most of the acrylic fiber in the world. The polymer chain production from monomer/comonomer does not take place in solvent, but in demineralized water (where the polymer is insoluble). This polymerization reaction is easy to control. However, investment cost is higher as the complex will be larger as it involves extra steps compared with solution polymerization, such as isolating the polymer once it is formed, drying it, grinding the resulting pellets into powder, and re-dissolving in solvent to prepare a solution suitable for subsequent spinning.

Spinning

A viscous solution of polymer in solvent (dope solution) is prepared and auxiliary chemicals (such as thermal stabilizers) added as required. In the solution process, this dope solution is prepared directly, requiring only adjustment to get a suitably viscous content and addition of auxiliary chemicals as required.

In either case, the resulting solution of polymer in solvent is continuously mixed. The solution has to be as viscous as possible to lower solvent recovery costs that would be incurred downstream if it were too dilute and also to facilitate the extrusion process which leads to long filaments of fiber.

Both wet, dry, and air gap spinning are employed in commercial process operations. The terms wet and dry refer to the way in which solvent is removed to leave behind fiber filament.

Acrylic fiber decomposes before it melts, which makes melt spinning a particularly challenging task which has not been economically achieved to date.

Post-Spinning Treatment

The fiber filament product from the spinning unit is then subjected to a series of treatments to wash out solvent from the polymer, get it thoroughly dry, and confer it with desirable mechanical properties by stretching, crimping, application of finish oil, (dyeing when required).

LITERATURE REVIEW (TECHNOLOGY DEVELOPMENTS)

The last twenty years has seen an explosion of new applications and a new direction for acrylic fiber producers, such as developing high performance fibers for diverse uses from clothing to fuel cells. Microdenier (fibers having linear densities less than one gram per 9 000 meters of filament length) and ribbon fibers have found application in moisture wicking and thermal insulation whilst composite fibers are still finding application in innovative products.

Interesting trends include:

- "Green" technology which mainly entails use of environmentally friendly dyes and application of biotechniques to comonomers used in producing acrylic fiber along with the main acrylonitrile monomer - Section 4.1 of the PERP report.
- So called high performance fibers (used in applications where low density, good mechanical performance and heat resistance fibers are required such as in sporting applications, transport and space applications) – Sections 4.2 to 4.3 of the PERP report.
- New generation fabrics such as smart fabrics that react to conditions around them and interactive textiles – Sections 4.3 to 4.6 of the PERP report.

PROCESS ECONOMICS

Nexant has estimated costs of production for world scale, state-of-the-art, acrylic fiber plants operating via the two commercial process technologies:

- Solution polymerization with wet spinning (West Europe and China location bases)
- Suspension polymerization with wet spinning (West Europe and China location bases)

Sensitivity of the production cost to fluctuation in acrylonitrile prices and plant scale has been analyzed.

All cost tables given in this report include a breakdown of the cost of production in terms of raw materials, utilities direct and allocated fixed costs, by unit consumption and per metric ton and annually, as well as contribution of depreciation to arrive at a cost estimate (a simple nominal return on capital is also included).

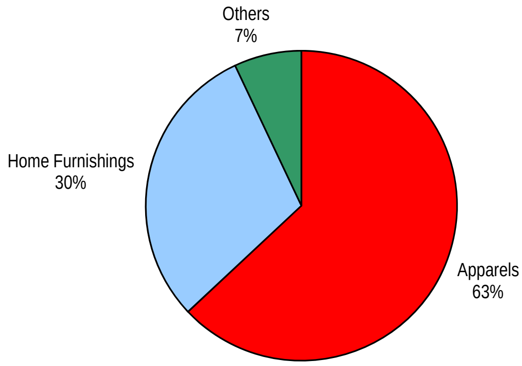
On a qualitative basis, the advantages and disadvantages of the polymerization processes suspension, solution, emulsion, bulk) and spinning processes (wet, dry, air gap, melt) for producing acrylic fiber are compared.

COMMERCIAL MARKET REVIEW

As shown in the figure below, major apparel and home furnishings applications for acrylic fiber account for 63 percent and 30 percent, respectively, of the global acrylic fibers market. These applications reflect its properties primarily as synthetic wool and, to a lesser extent, synthetic cotton. Thus, in garments it is found in sweaters, socks, fleece wear, circular knit apparel, sportswear and children's wear. In home furnishings, it is used in blankets, area rugs, upholstery, awnings, and outdoor furniture.

Partially carbonized and pre-oxidized acrylic fiber tow is used as an asbestos replacement in applications such as clutch and brake pads. Fully carbonized sub-tow (acrylic fiber precursor) is used to produce high tenacity carbon fiber.

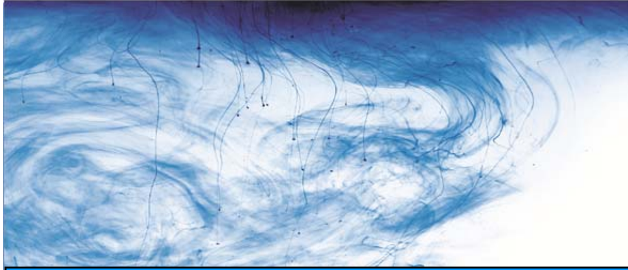
Figure 1 Global Acrylic Fiber End-Uses



Acrylic Fiber Cost of Production Tables 2 Mar 2012.xlsx\F6.1

Modacrylic fibers have low softening temperatures that allow them to be stretched, embossed and molded into special shapes. The fibers may be produced with controlled heat shrinkage capacities.

- Global acrylic fiber supply, demand and trade data are given and discussed.
- In addition, supply, demand and trade data is given and discussed according to key regions (i.e., China, Middle East, Western Europe, North America)
- A list of plants in each of the key regions above is given showing specific plant capacities, owning company, location and annual tonnage produced



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