Fiber Production Technologies Oriented Toward Environmental Sustainability

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The fiber and textile industry is often cited as the second-largest contributor to global carbon emissions. Approximately 50% of the carbon emissions in this industry arise from the dyeing and finishing process (36%) and the fiber production process (15%). Meanwhile, polyester (PET, poly(ethylene terephthalate)) accounts for ~80% of global man-made fibers (88% of synthetic fibers), mainly because of its excellent properties and low cost. Therefore, even incremental improvements in PET fiber technologies can have a substantial impact on environmental sustainability. This presentation introduces recent technologies aimed at improving the environmental performance and sustainability of synthetic fibers, with particular emphasis on polyester fibers.

Dye-free coloration has been achieved by introducing interference colors from a nanoscale alternating layered structure in the fiber cross-section. Decolorization is a major issue in textile recycling. However, in the material recycling of these fibers, decolorization is not necessarily required because the colors automatically disappear upon melting. A significant reduction in energy consumption is also expected by simultaneously developing fiber structure and performing dyeing at room temperature using an infusion process during the drawing of PET UDY (undrawn yarn). When undrawn PET fibers are drawn in ethanol, fiber structure development and dyeing can be achieved simultaneously at room temperature. This process is based on the concept of “infusion”, i.e., penetration of the solvent into the fiber during drawing. Utilization of infusion is expected to substantially reduce carbon emissions.

From a materials perspective, two routes are promising for reducing carbon emissions: (i) partially or fully bio-based PET and (ii) a fully bio-based polyester with a chemical structure similar to PET.

The production of high-performance PET fibers is another important topic, because higher performance can reduce material usage and energy consumption. A new concept for producing high-strength polyester fibers, developed through national research projects in Japan and Korea, will be introduced. Fiber-reinforced composites enable efficient utilization of material strength. From a recycling viewpoint, thermoplastic monomaterial fiber-reinforced composites have attracted increasing attention. This presentation introduces a concept for producing a PET resin/PET fiber composite by leveraging differences in fiber structure development behavior in a high-speed bicomponent spinning process.

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