Lower-cost, lower-quality synthetic fibers entering the marketplace have posed a threat to producers vying for market share in textiles, carpeting and synthetic turf over the past several years. The increasingly competitive landscape has made it essential for companies to seek opportunities to add value and create points of differentiation.

Finding the right mix of polymer color and additives can be the key to unlocking new business opportunities, helping synthetic fiber producers enhance material properties and create improved efficiencies in the spinning process, which, in turn, adds greater value to end customers when compared to lower-cost alternatives.

Throughout this paper, we’ll detail how processing methods, color and additive solutions impact aesthetics, functionality and stabilization of synthetic fibers during production and in the field.

**Weigh Your Options**

Differentiating your fiber products from the competition’s can be accomplished in a number of ways, but it boils down to determining what you are trying to accomplish, and then working with suppliers to find the right solutions. *(Figure 1)*

<table>
<thead>
<tr>
<th>Goal</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enhancing appearance</td>
<td>Custom colors, blacks and whites, delusterants, and optical brighteners</td>
</tr>
<tr>
<td>Extending useful life</td>
<td>UVA and light stabilizers</td>
</tr>
<tr>
<td>Inhibiting the spread of germs</td>
<td>Antimicrobials</td>
</tr>
<tr>
<td>Improving processability during spinning</td>
<td>Lubricants, antioxidants and heat stabilizers</td>
</tr>
<tr>
<td>Preventing ignition or spread of flame</td>
<td>Flame retardants</td>
</tr>
<tr>
<td>Removing static charge from fabrics</td>
<td>Antistatics</td>
</tr>
<tr>
<td>Enhancing performance</td>
<td>Moisture managers, odor absorbers, fillers, reinforcement, tracers and biodegradation</td>
</tr>
</tbody>
</table>

*(Figure 1)*
Processing

After you determine what you are looking to accomplish, the next step is to examine your process and its impact on the performance of the end product.

Let’s first look at the elements that could negatively impact synthetic fiber performance. These are elements that can cause polymer degradation:

**Processing**
- Hydrolytic - exposure to water
- Thermal - temperatures that exceed reasonable process conditions

**Product Performance**
- Sunlight - exposure to ultraviolet light
- Stress - wear and use of the polymer over time
- Exposure to extreme heat
- Exposure to chemicals, particulate and gaseous contaminants

Any combination of these elements can cause issues with the integrity of synthetic fibers long term.

First, moisture must be tightly controlled to avoid degradation of the polymer. Many polymers used in the production of synthetic fibers are considered hydroscopic, meaning they have a tendency to absorb moisture from the air. During processing, this is especially important to remember because moisture can break polymer chains in a process called hydrolysis, causing a drop in solution viscosity (IV, RV), and thereby weakening the polymer and causing the melt to be more fluid.

Second, temperatures must be closely monitored lot to lot to ensure the consistency and performance/weatherability of the product. Processing temperatures that are too high will degrade components, generate free radicals and open the door for radiation absorption when exposed to sunlight.

Given the potential implications that moisture and temperature can have on the end product, you should not only look at your own process, but the conditions the end products are exposed to.
Solution Dyeing

Beyond processing considerations, there are thousands of possibilities when it comes to designer colors, but choosing the right one with the right performance characteristics is as much a science as it is an art. For example, outdoor fabrics for awnings would require different attributes than the lining of a fleece jacket. And the team logo on a turf playing field would have different needs than the athletic shoes running on it.

There are two primary methods for dyeing polyester fibers: post dyeing and solution dyeing.

Post dyeing, the traditional method, refers to post dyeing of polyester fiber or fabric in aqueous media at elevated temperatures, typically around 130 C, and pressure. Thus, post dyeing is a two-step process—spinning of natural/white fiber and subsequent dyeing. Post dyeing uses large quantities of water and requires effluent treatment to address the dye discharge.

Solution dyeing, also referred to as dope dyeing or spin dyeing, is a one-step process in which the color masterbatch is added to the polymer melt during the extrusion phase of the fiber manufacturing process. Since colorants are dispersed into the polymer during extrusion, the color is locked into the fiber; it is colored throughout, providing superior color consistency. (Figure 2)

With the solution dyeing approach, fiber spinning and coloring is achieved in one step without the use of water, thereby reducing its environmental footprint. Because of its many benefits, solution dyeing is the recommended approach. (Figure 3)
Color-Enhancing Solutions

Solution dyeing provides superior color and endurance, and when it comes to the color quality of the end product, gloss, scattering, light sources, surroundings and temperature all impact appearance. To further achieve the look you are after, the following color and additives might also be considered.

- **Blacks and whites** can be among the most challenging colors to control batch after batch. Look for high-performance products with a high letdown ratio and proven performance against heat buildup.
- **Delusterants** help you control gloss for a richer color.
- **Optical brighteners** enable you to improve the brightness and whiteness of materials. *(Figure 4)*

![Optical Brighteners](image.png)

*Figure 4*

Optical brightener absorbs UV portion of the incident light and re-emits at higher wavelength in the blue region of the visible spectrum.
UV Stabilizers
Protecting solution-dyed color is as important as making the choice to manufacture solution-dyed products. This is particularly true for products that will be subjected to outdoor exposure. Polymers are not inherently resistant to UV light. Absorption of radiation by any component in the synthetic fiber system can cause that component to degrade over time. *(Figure 5)*

**Relative Weather Durability of Polymers**

<table>
<thead>
<tr>
<th>More Weatherable</th>
<th>PE</th>
<th>PC/ABS</th>
<th>Aromatic PU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoropolymers</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acrylics</td>
<td>PP</td>
<td>PET</td>
<td>PS</td>
</tr>
<tr>
<td>Acetal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PVC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aliphatic PU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Super weatherable for automotive exterior parts</td>
<td>UV stabilizers significantly extend outdoor use</td>
<td>UV stabilizers partially extend</td>
<td>Must be painted</td>
</tr>
</tbody>
</table>

*(Figure 5)*

Fortunately, additives can help polymers overcome this limitation. It’s a case of cause and effect. Preventing the cause (absorption of radiation) will prevent the effect (degradation of the system).

UV additives are essential ingredients in ensuring the long-term integrity of synthetic fibers, especially those with exposure to the outdoors, including synthetic turf, outdoor textiles like awnings and even indoor carpeting exposed to light through windows.

It’s important to make sure that you have the right level of UV protection in your products. So, you should put them to the test using a combination of outdoor weathering that subjects test samples to prolonged, real-world exposure to light, moisture, and fluctuating temperatures.

However, because it takes time to achieve actionable data with outdoor testing, you should also perform accelerated testing in a lab to help you predict the product’s lifespan under various climate conditions, and then make necessary adjustments to your product design.

Preferred accelerated test methods vary from application to application, so it’s important to work with your suppliers to find the right tests for your products.
Antimicrobials

Microbes are found everywhere and are most common in moist environments. They can cause illness and often leave organic residues on textiles that lead to odor and discoloration.

Bacteria thrive under warm and humid conditions, and soil and dust in materials can proliferate their growth. In addition to hygiene and odor concerns, uncontrolled bacterial growth in synthetic fibers can cause discoloration and destruction of fabrics.

Synthetic fibers with antimicrobial agents restrict or prohibit the growth of bacteria, thus reducing odor and enhancing freshness and performance. Antimicrobial functionality is achieved either by applying a topical finish or by integrating the antimicrobial agent into the fiber via melt compounding. A masterbatch introduced during the spinning process ensures that the antimicrobial additive becomes an integral part of the fiber and offers permanent antimicrobial properties.

Organic antimicrobial chemistries typically have limited thermal stability for compounding into fiber-forming resins. Silver and copper antimicrobial agents possess high thermal stability and are ideal for melt compounding and spinning. (Figure 6)

Common fiber applications for antimicrobials include:
- Performance textiles: sportswear, uniforms, intimate apparel, medical textiles, bedding, towels and automotive interiors
- Carpets
- Water and air filters
- Shower curtains and bathroom accessories

Figure 6

Americhem’s environmentally friendly silver-based antimicrobial masterbatches show excellent efficacy vs. gram positive and gram negative bacteria.
Flame Retardants

Many building codes and industry regulations require materials that do not promote the spread of smoke and flames—and if your products do not pass certain tests, you could be losing business.

Flame-retardant additives can be based on phosphorous, nitrogen and other minerals, and should be customized based on the material being used and its application. (Figure 7)

Common fiber applications that could benefit from flame-retardant additives include:
- Carpets
- Apparel
- Furnishings, including upholstery and mattresses
- Curtains and blinds
- Synthetic turf

Other Polymer Additives

There are many other types of additives that could be used to enhance the performance of polymers. Some of the most commonly used in the production of synthetic fibers include:
- Antistatic additives that provide effective protection against static generated by walking on carpet
- Fillers and reinforcement that are used to improve the physical and mechanical properties in fibers
- Additives that help polymers break down faster at the end of their useful lives

Conclusion

In the highly competitive synthetic fibers market, differentiation can be achieved by fine-tuning your processes and finding the right mix of color and additive solutions. By working with a trusted partner, you can effectively balance form and function that will add value to your operation—and your customers.

Americhem’s Product Development Services

Americhem is more than a supplier to the synthetic fiber industry—we’re a partner that can help enhance your existing products and bring new products to market faster. We become fully integrated in your processes to help improve efficiencies and overall product quality by employing our unique value-engineering approach.

Americhem’s Analytical Capabilities

There is a strong need for analytical testing in the synthetic fiber industry. Much of this testing, from quality assessment to product analysis, is done in-house by Americhem’s central analytical department. Many times, we provide solutions using decades of technical expertise and equipment in our own lab. We are also connected to many outside testing facilities that offer an even broader range of very fine analyses.

For more information on best practices in the manufacture of synthetic fibers, or to learn more about Americhem’s products and services, visit Americhem.com.