SCF Application #531

Uniform Dyeing of Polyester with Supercritical CO_2

Introduction

In the USA, the textile dyeing industry has invested more than one billion dollars in the past decade on environmental technologies designed to ensure that by-products of textile manufacturing do not pollute the environment. This investment is paralleled in other parts of the world, notably Taiwan and Korea. Initially, this effort focused on reducing the large quantities of water needed in current processes, for even the most economical use of water requires 100L/kg material.

Supercritical carbon dioxide is an alternative dyeing technology that eliminates the use of water while achieving results comparable to current dyeing processes. Supercritical CO_2 is harmless ecologically, available, non-toxic and non-explosive. When placed above the critical point (31.1°C and 73 atm) CO_2 becomes a remarkable solvent for many natural and synthetic dyes. The dye solution in the supercritical CO_2 is carried to the fiber to be dyed. Under certain conditions, the gas-like diffusion of supercritical CO_2 disperses the dye evenly into the small pores and crevices of the fiber.

This application describes a method for the use of supercritical CO_2 to dye PET packages easily and uniformly, while eliminating the expense of water treatment, waste water treatment, and the downstream processing of dyed materials.

Equipment

- ✓ Applied Separations' *Spe-ed*™ Supercritical Carbon Dioxide/Dye Pilot Plant

Materials

- ✓ Polyethylene Terepthalate (PET)
- ✓ Azo Dye – C1 Disperse Blue
- ✓ Carbon dioxide –industrial grade with dip tube

Method

The supercritical fluid dye process starts by placing PET packages in a dry state inside the vessel. CO_2 is introduced into the dye vessel and the operational pressure and temperature are achieved. The dye is dissolved in circulating CO_2 through a chamber containing dye. Dyeing is 0performed for 20-30 minutes under the optimal conditions. The depth of the shade is determined by the concentration of the dye compound in the supercritical CO_2. This can be manipulated by increasing or decreasing the density of the supercritical CO_2, (i.e. increasing or decreasing the pressure), hence the "tunability" of CO_2. In some cases, small amounts of modifier can be added to increase the solubility of the dye. At the end of the dyeing cycle the system is depressurized and excess dye is collected in a dyestuff recovery vessel.

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Dyeing Conditions

Extraction vessel:	40 Liter
Fiber:	4 PET Packages
Dye:	C.1. Disperse Blue 79
Pressure:	4200 psi
Temperature:	120ºC
CO_2 Recirculation:	5 Kgs/min
Dye time:	40 minutes

Results

Fiber from the dyed packages was woven into a "sock" and evaluated for uniformity.

Conclusion

Dyeing with supercritical CO_2 results in adulterant-free, dispersed dye compounds covering the entire color spectrum. The final dyed material does not need any further treatment, such as using water to remove unabsorbed dye. In addition, since supercritical CO_2 is a "tunable" solvent, conditions can be carried during the process to arrive at results previously unachieved.

References

Kaziunas, A. and Maxwell, R. "Optimization of Flow Conditions for the Uniform Dyeing of PET Packages with Supercritical CO_2." Presented at the AATCC Show Oct, 1999.

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