Dyeing of Leather with Supercritical Carbon Dioxide as Solvent

Michael Prokein[a], Sascha Gilgen[a,b], Manfred Renner[a], Eckhard Weidner[a,b]

[a] Fraunhofer UMSICHT, Osterfelder Str. 3, 46047 Oberhausen, Germany
[b] VTP, Ruhr-University Bochum, Universitätsstr. 150, 44801 Bochum

This work aims at the reduction of polluted wastewater by tanneries. Developing technologies to minimize the use of chemicals, tanning agents and dyestuff in the leather manufacturing process has the potential to reduce environmental pollution in this field.

Dyeing is an essential part of the leather production process. The first step of the conventional dyeing process takes place in an aqueous solution incorporating dyestuff into the cross-section of the collagen. In most cases, a coating containing dyestuff or pigments is applied to the leather surface in a second step. It is estimated, that more than 30 % of the dyestuff from the first step is lost with the wastewater. In the second step, the loss varies between 15 % and 40 % due to over-spraying. About 15 % is lost because the leather is cut to size after the conventional dyeing process.

The focus of the presented work is on the reduction of dyestuff and the avoidance of water and additional chemicals like acids or surfactants. Instead of water, the dyeing is performed with $scCO_2$ as solvent for the dyestuff in a technical high-pressure autoclave with a volume of 5 liters and a rotatable basket inside. The analysis of the sample material consists of rub fastness tests according to DIN EN ISO 11640 and spectroscopic color measurements to assess the resulting intensity, uniformity and reproducibility.

Carbon dioxide-based dyeing at 100 bar and 40 °C has shown uniform and intensive colorizations of the leather surface at usage of 0.1 gram of dyestuff per square feet of leather. The dyed leathers achieve the highest grades in standardized rub fastness tests. The exhaustion of dyestuff is almost 100 % leaving hardly any excess dye on the leather at the end of the process.

The dyeing process with compressed carbon dioxide as an alternative solvent has a high potential to reduce wastewater emissions, costs of chemicals, and wastewater treatment. A special feature is that standardized color-neutral leathers can be produced, which can be dyed later using this process. This allows higher flexibility to specific customer color demands.