DYEING OF POLYCARBONATE IN SUPERCRITICAL CARBON DIOXIDE

Varga D., Alkin S., Gamse T.

Institute for Chemical Engineering and Environmental Technology, Graz University of Technology, Austria

Supercritical (sc.) fluid dyeing of polymers is a particular case of solute impregnation. The method offers a cost effective and environmentally friendly solution to dye different fibers and polymers. In principle, a disperse dye is dissolved in a sc. fluid and by simultaneously contacting this solution with a polymer matrix in a high pressure vessel the dye penetrates into the polymer. This batch process is mainly controlled by diffusion, where pressure, temperature, impregnation time, the amount of dye and decompression rate influences the transport. Compared to conventional processes, sc. dyeing does not produce waste water and by the use of low temperatures it is possible to work also with thermally labile dyes.

In our ongoing dyeing project, supercritical carbon dioxide ($scCO_2$) is used as sc. fluid and polycarbonate (PC) was chosen as medium. For impregnation additives, commercially available azo-dyes "disperse red 1" (DR1) and "disperse red 13" (DR13) are used. PC is impregnated in pellets and also in hot pressed films. Although the solubility of the dyes in $scCO_2$ is rather low, the high partition coefficient between the polymer and the supercritical phase drives the dye into the polymer matrix. Some experiments are also carried out in $scCO_2$-ethanol mixture, where ethanol acts as a modifier for the dyes and is completely miscible with the supercritical fluid. With ethanol the impregnation is faster than in pure $scCO_2$ atmosphere. The impregnated samples are dissolved in dichloromethane and analyzed by UV-Vis spectroscopy. To study the reaction kinetics and the dye uptake of a polymer sample, experiments were carried out in the time range from 3 to 24 hours and at pressure levels from 100 to 300 bar at a constant temperature of 40 °C. Both, carbon dioxide density and impregnation time influence the process efficiency. The higher the pressure is the better is the dyes' solubility and the swelling of PC in $scCO_2$, which results in more dye uptake of the polymer. Longer reaction times have also a positive effect to the impregnation. Decompression rate of the impregnation vessel is not critical. It was found that DR13 has more affinity to polycarbonate than DR1.

Impregnation process resulted in an entirely, equally dyed polymer with good dyeing fixation, which was analyzed by re-extraction studies of the dyed samples by an organic solvent.

Acknowledgement:
The authors want to thank the Marie Curie Initial Training Networks (ITN) for the financial support of the project "DoHip – Training Program for the Design of Resource and Energy Efficient Products by High Pressure Processes", project number PITN-GA-2012-316959