

Experimental design and analysis of synergistic effects of ultrasonication and process parameters for optimization of Lycra and Tricot fabrics dyeing process

U.P.R. Madhuhansi, U.L.L. Manujitha, and M. Rathnayake[#]

Department of Chemical and Process Engineering, University of Moratuwa,
Sri Lanka.

[#]mrathnayake@uom.lk

Ultrasonication emerges as a promising technique to utilize in the dyeing processes in textile industries to minimize energy consumption. The efficacy of ultrasonication in the dyeing process has been demonstrated in this research, particularly in Lycra and Tricot fabrics, where achieving optimal temperature and contact time conditions can result in reduced energy consumption, cost-effectiveness, and improved product dyeing quality. The factorial experimental design and analysis technique was utilized to experimentally evaluate the synergistic effects of the major process parameters. The product dyeing quality was chosen as the dependent variable and was quantitatively determined by a specific spectrophotometer. Through a comprehensive ANOVA study on the experimental results, it has been scientifically demonstrated that ultrasonication, combined with contact time and temperature of the dyeing bath, significantly impacts the ultimate product dyeing quality. Based on the findings, it is imperative to establish that optimal dyeing results for the intertwined Lycra and Tricot fabrics can be achieved by employing ultrasonication at temperatures ranging from 60°C to 70°C, with contact times exceeding 45 minutes in comparison to the conventional dyeing process carried out at 98°C and 1 hour respectively. These findings highlight the efficacy of ultrasonication in enhancing the dyeing process for both Lycra and Tricot. Ultrasonication demonstrated a substantial improvement over previous results obtained without ultrasonication, resulting in a noteworthy reduction of 39% in operating temperature and 25% in contact time. This underlines the synergistic effects of ultrasonication and process parameters, wherein ultrasonication acts as a catalyst, enhancing dye penetration and fixation within the fabric structure. The integration of ultrasonication in the dyeing process offers significant advantages, including reduced energy consumption, improved process efficiency, and enhanced fabric quality, making it a promising technique for achieving sustainable dyeing goals.

Keywords: Ultrasonication, dyeing, nylon, process optimization, sustainable