Title: Structure-effect mechanism of polyimide fibers: role of carrier in disperse dyeing and process optimization

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Abastact: Polyimide fibers exhibit excellent thermal stability and mechanical strength, but their crystalline structure and smooth surface pose challenges for dyeing with dispersed dyes, necessitating carriers to enhance dye uptake. This study explores the efficacy of phenyl glycol ether (PPA) as a carrier in the dispersed dyeing of polyimide fibers. After evaluating multiple carriers, PPA emerged as the most effective, improving both dye solubility and fiber penetration. The swelling effect induced by PPA increased dye accessibility to the fiber's interior, resulting in uniform and vibrant coloration. The impact of PPA on the fibers' physicochemical properties, such as thermal stability, spectral characteristics, morphology, and crystallinity, was also investigated. These changes were assessed to determine how PPA enhances dyeing without compromising fiber integrity. After treatment with 40 g/L PPA, the fiber swelling depth reached 86.11 nm, while leaving the core structure intact. Optimization of the dyeing process under these conditions resulted in a 17.5% increase in dye uptake compared to untreated fibers. These findings highlight PPA's potential to significantly improve dyeing performance and color fastness in polyimide fibers, offering a robust solution for industrial applications.

Keywords: Polyimide fibers · Carrier dyeing · Structure-effect mechanism · Process optimization · Color properties

https://link.springer.com/article/10.1007/s11696-026-04815-4