

Biological degradation of specially designed polyacrylates adapted to the enzymology of environmental microorganisms and their exemplary application in maintenance dispersions for resilient floor coverings (IGF 01IF21946N)

According to estimates by Fraunhofer UMSICHT, approximately 0.1% of the polymers produced annually in Germany are used as active or auxiliary ingredients in washing, care, and cleaning products; of these, 55 t/a enter the environment as microplastics and 23,200 t/a as dissolved, gel-like, or liquid polymers. These polymers also include polyacrylates, which make a significant contribution to the performance of washing and cleaning agents. Furthermore, polyacrylates are a main component of maintenance films, which have a positive effect on soil resistance and cleanability as well as on the service life of resilient floor coverings.

Against this background, the wfk - Cleaning Technology Institute e.V., in cooperation with the Institute of Technical Biocatalysis, TU Hamburg, conducted a research project with the aim of isolating from the environment microbial consortia capable of polyacrylate degradation and identifying enzymes or enzyme classes involved in the degradation process. To this end, microbial consortia were isolated from environmental samples that could be cultivated in media containing either a polyacrylate (e.g., PAA: polyacrylic acid, PMMA: polymethyl methacrylate) or a monomer (MMA: methyl methacrylate; HEMA: 2-hydroxyethyl methacrylate) as the sole carbon source, and were analyzed with respect to their bacterial composition. In addition, a bacterium was identified that can utilize HEMA and MMA for growth. To identify key enzymes from this organism responsible for the degradation of polyester acrylates, genome sequencing and transcriptome analysis were performed. Polyester acrylates with a cleavable ester functionality in the polymer backbone were synthesized by radical ring-opening polymerization of cyclic ketene acetals, primarily MDO (2-methylene-1,3-dioxepane), with various monomers such as MMA, styrene, HEMA, and MAA (methacrylic acid) (bulk polymerization). The synthesized copolymers had to be dispersed using a solvent-exchange method (THF to water) in order to prepare maintenance dispersions in accordance with common practical formulations. When applied to resilient floor coverings, the films exhibited comparable stability (adhesion, abrasion resistance), slip resistance (coefficient of friction), soil repellency, and barrier properties to conventional maintenance films, but were more difficult to remove during basic cleaning. No influence on the color of the floor coverings was observed. The polyester acrylates could be hydrolyzed under alkaline conditions, and enzymes (esterases) capable of cleaving the ester bonds in the polymer backbone were identified.

The research report is available on request from the wfk - Cleaning Technology Institute

