Recycling Mattress Shoddy by Enzymatic Depolymerization of PET and Cotton to Monomers for Value-Added Applications

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EXECUTIVE SUMMARY

This study explores the technical feasibility of recycling post-consumer mattress shoddy felt textile pads using enzymatic catalysis to convert its components into building block chemicals. Shoddy is commonly used as a layer to separate metal springs from foam comfort layers in mattress construction. The shoddy pad is typically a non-woven blend of cotton and polyester textile fibers. Other natural or synthetic fibers such as wool, camel hair, rayon, polypropylene, and recycled fabric scraps may also be used. Due to its variable and heterogeneous composition, attempts to mechanically recycle shoddy have been largely unsuccessful. In mattress recycling operations, almost all the recovered shoddy is simply discarded and sent to landfill. According to the Mattress Recycling Council, which sponsored this study, shoddy represents approximately 10% of non-recyclable product sent to landfill.

Compared to conventional chemical and thermal processes, enzymatic catalysis is a low energy intensive and highly selective method to recover monomers which may enable reuse in new polymers or other high value applications. Polyesters, such as polyethylene terephthalate (PET), are degradable by cutinases. Cotton, composed of cellulose, are degradable by cellulases. Due to their innate selectivity, these enzymes can be used to target specific components of mixed fiber materials.

The research team was able to demonstrate a one-pot, two-step process to separately depolymerize cotton to glucose and PET to terephthalic acid in a post-consumer shoddy pad with a 60/40 PET/cotton composition. Reactions with each component of the blend could be carried independently without undesired side reactions with the other substrate. Unfortunately, yields were rather low. Starting with cellulase, approximately 20% of the cotton was reduced to glucose. High crystalline content in the PET component was found to inhibit the cutinase depolymerization

reaction. Only 5% conversion of PET to terephthalic acid was observed. Steps to reduce crystallinity through a melt quenching procedure did not improve conversion yields.

Further work is required. It is believed that further preparation of fiber material to sizes less than 1 mm and continuous agitation of the reactor mix, done to improve fiber wetting, will improve enzyme engagement. Filtration techniques to minimize fiber loss are also expected to improve yields. Lastly, utilizing more current generations of engineered enzymes is expected to improve results.

Full report