Spectroscopic and Colorimetric Analysis of Textiles Dyed With Local Invasive Plant Species and Waste-Derived Mordants

Lammers, Lucia (School: Harrison High School)

Synthetic dyes used by the fashion industry pollute aquatic ecosystems and contribute to the bioaccumulation of toxic compounds in organisms. Natural dyes are alternatives to synthetics whose colors vary in hues, values, and chromas; however, they lack adequate color fastness which can be improved by mordant application. This study aimed to determine whether extracts from the leaves and stems of invasive plant species paired with waste-derived mordants can create material efficient, cost-effective, and safe natural dyes with large color ranges. Local invasive plant species Norway Maple (Acer platanoides), Tree of Heaven (Ailanthus altissima), and Porcelain Berry (Ampelopsis brevipedunculata) were chosen, because they are abundant and accessible; removing them for dyestuff promotes biodiversity. Dyestuff from these plants were combined with waste-derived iron, aluminum, and calcium mordants made from rusted metal, recycled cans, and eggshells. Infrared (IR) spectroscopy revealed bonds formed between natural dye chromophores and aluminum ions, indicated by the evolution of IR peaks at 1570 cm-1 and 600 cm-1. This supports the capability to increase dye fixation. The Munsell Color Matching System revealed that all dye-mordant complexes produced wide color ranges. A Life Cycle Assessment determined the material efficiency, cost-effectiveness, and safety of dyeing cotton textiles with Norway Maple and different mordants. These results determined that Norway Maple paired with aluminum acetate is the most optimal dye-mordant complex due to its high chromas, cost-effectiveness, and comparative safety. These methods may aid in repurposing invasive plants and reducing the environmental impacts of textile dyes.

Awards Won:
Third Award of $1,000
United States Environmental Protection Agency: The Patrick Hurd Sustainability Award covers travel for the ISEF finalist to attend and participate in EPA's National Sustainable Design Expo