



Development of a Sustainable Plant-Based Bio-Mordant from Agriculture Waste for Enchanted Mud Dyeing of Silk Fibers

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Abstract

The textile industry requires environmentally sustainable alternatives to synthetic mordants, which generate hazardous waste and environmental concerns. This study developed an eco-friendly bio-mordant from pomegranate (*Punica granatum*) peel extract, rice husk ash alkaline solution, and local natural mud to improve mud-assisted natural dyeing of silk fibers. Six bio-mordant formulations (100:0:0, 100:0:20, 100:10:20, 100:20:20, 100:30:20, and 100:40:20 mL) were evaluated prior to dyeing with sappanwood (*Caesalpinia sappan*) extract. Color properties were measured using the CIELAB color system, while washing fastness was assessed through three washing cycles. EDS, FTIR, UV-Visible spectroscopy, and SEM were employed to characterize the materials and support the proposed dyeing mechanism. The formulation containing 100 mL mud, 30 mL pomegranate extract, and 20 mL rice husk ash solution exhibited the highest color saturation (Chroma = 8.95) and the lowest color loss (0.36%) after repeated washing. The enhanced performance is attributed to coordination interactions among tannin-derived phenolic compounds, naturally occurring metal ions in the mud, and silk fibroin, resulting in a stable dye-metal-fiber coordination network. The findings demonstrate that agricultural wastes can be transformed into an effective bio-mordant capable of improving traditional mud-assisted silk dyeing while reducing dependence on synthetic mordants and supporting sustainable textile production under the Bio-Circular-Green (BCG) Economy Model.

Keywords: Bio-mordant, Coordination complex, Mud dyeing, Silk fiber, BCG Model