Toward Safer Nail Cosmetics: A Randomized in vitro Performance Study of a Novel Natural Biologic Nail Paint

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Conventional nail paints are formulated using pigments, solvents, and plasticizers linked to adverse health and environmental concerns. As these products are repeatedly applied directly to the body, safe and sustainable alternatives are critical. This study investigates the development of biologic nail paint suitable for real-world consumption using pigmented protein and natural polymers and compared its performance to commercial nail paint. Genetically engineered non-pathogenic Escherichia coli were cultured to express fluorescent dsRED protein, which was extracted via cell lysis and desiccation. The purified protein was incorporated into nail paint base composed of pullulan, trehalose, and hydroxyethyl cellulose to produce the biologic formulation. Thirty-six artificial nails were randomly assigned to receive either biologic or commercial nail paint and were evaluated over a 7-day period under ambient conditions, water exposure, and detergent exposure. Performance was assessed through measurements of mass, thickness, gloss, spectral intensity, drying and removal times. The biologic nail paint demonstrated mass and thickness retention comparable to commercial (-6.3mg vs. -5.36mg, $p=0.65$; -0.12mm vs. -0.10mm, $p=0.25$). Gloss retention was significantly superior for the biologic formulation (-1.4GU vs. -5.5GU, $p<0.05$), and spectral intensity differences were visually imperceptible. Drying and removal times were longer for the biologic formulation (7200s vs. 106s; 157s vs. 10.4s). This study is the first to demonstrate that functional nail paint can be formulated using dsRED protein and natural polymers, attaining performance comparable to commercial nail paint in several key metrics and supporting the potential of biologic cosmetics as a sustainable alternative.

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