Engineering Native Hawaiian Plant–Derived Biosurfactant Formulations for Wildfire Suppression

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Wildfire suppression agents commonly rely on synthetic surfactants that pose environmental persistence and runoff concerns, particularly in island ecosystems. This study evaluates the feasibility of biosurfactant formulations derived from native Hawaiian plant species, ‘Anapanapa (Colubrina asiatica), A‘e (Xylosma hawaiensis), and ‘Awapuhi (Zingiber zerumbet), as environmentally compatible alternatives for fire suppression. Dried and crushed leaves were extracted using food-grade hydroalcoholic solvents and optimized through ultrasonic-assisted extraction (UAE), with a 70/30 ethanol–water ratio producing the highest yield and stability. Formulations were evaluated using foam stability testing, volumetric expansion, and ignition and re-ignition suppression trials conducted with a local fire department. ‘Anapanapa extracts demonstrated the greatest foam persistence and most consistent fire knockdown performance. UAE-derived extracts outperformed soak-only controls, showing improved suppression efficiency and reduced re-ignition. Thin-layer chromatography revealed distinct phytochemical profiles across species and extraction methods, supporting formulation-based performance differences. Environmental compatibility was assessed through post-application soil pH analysis, showing minimal deviation from baseline. Results indicate that plant-derived biosurfactant formulations, particularly those optimized via ultrasonic extraction, can achieve performance comparable to commercial suppressants while reducing environmental impact. This work highlights the potential of locally sourced, biodegradable materials for sustainable wildfire response while supporting native restoration and reducing invasive fire-prone species.

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