Optimizing Biofoams for Multi-Phase Pollutant Capture/Remediation in Fresh and Marine Environments

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Water pollution remains a significant issue for aquatic ecosystems, as most available absorbents for remediation are either non-biodegradable or toxic to aquatic life. The main goal of this project was to develop three biodegradable foams capable of tackling multiple water pollution aspects simultaneously: F1 (alginate spirulina), F2 (potato- starch chitosan), and hybrid-multilayer F3 combining both to test the synthesis of both properties. Their performance was evaluated for microplastic, oil, and dye removal in freshwater and simulated seawater. F3 performed the best across all tests. In freshwater tests, it removed 72.3 ± 0.6 % microplastics, absorbed 5.87 ± 0.01 g oil/g foam, and removed 72.0 ± 1.0 % dye, significantly outperforming F1 and F2, (ANOVA, $p < 0.001$) which averaged 57.8% and 48.2% microplastic removal, 4.70 and 3.69 g oil/g foam, and 59.0% and 45.0% dye removal, respectively. In saltwater, F3 had the highest microplastic (66.5 ± 0.7 %) and dye (64.0 ± 1.0 %) removal. Oil absorption increased to 6.06 ± 0.04 g oil/g foam for F3 ($p < 0.05$), which was most likely the result of stronger hydrophobic interactions. Dye adsorption reached maximum uptake in 90 minutes. F3 retained 94.7 % oil absorption capacity after three cycles. Environmental safety tests showed no significant toxicity: Daphnia survival (96.7 %, $p = 0.45$) and lettuce germination (94.9 %, $p = 0.25$). The foam biodegraded with 60.3 ± 0.5 % mass loss in 40 days. Reusability testing showed that F3 was able to retain 91.1% of its initial oil capacity after 3 cycles. These findings show that the hybrid biofoam design effectively combines multiple strengths, yielding a biodegradable, reusable, and safe biofoam for multipollutant capture in both freshwater and marine environments.

Awards Won:

NC State College of Engineering: Alternates (not read aloud)