From Waste to Interface: Tuning Amino Acid Surfactants Derived from Used Cooking Oils

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The environmental fee of conventional, non-biodegradable petrochemical surfactants has accelerated the demand for renewable, biobased alternatives. Consequently, the upcycling of used cooking oil (UCO) has emerged as a highly effective circular economy strategy[1]. Taking advantage of the versatile chemical structure of UCO-derived triacylglycerides (**1**), it is possible to design and synthesize high-value, sustainable surfactants.
Building on our previous work in biobased surfactant synthesis, we report a peptide-inspired, sustainable strategy to generate a library of amino acid-based surfactants from UCO. Using amino acids as natural, versatile building blocks, the surfactant charge can be tuned, yielding anionic, cationic, or amphoteric compounds depending on the reaction conditions[2]. This approach leads to surfactants with a smaller carbon footprint and enhanced properties.
Fatty acids from UCO triacylglycerides (**1**) were activated with *N* -hydroxysuccinimide (NHS) to increase their reactivity. Using both chemical and enzymatic methods, we successfully carried out the amidation between NHS esters and a variety of amino acid methyl hydrochlorides (**2**), yielding the surfactants (**3**). The physicochemical performance of the synthesized surfactants was evaluated in aqueous solutions using standard methods. Essentially, we observed that varying the amino acid headgroup significantly dictated colloidal behavior. Tensiometry and dynamic light scattering (DLS) analysis demonstrated that these biobased derivatives exhibit exceptionally low critical micelle concentrations (0.01 – 0.20 mM) and tunable self-assembly, forming either pure vesicles or mixed micelle-vesicle systems depending on side-chain polarity. Furthermore, the surfactants displayed excellent colloidal stability ($|\zeta|$ > 60 mV) and remarkable emulsifying capacity, sustaining emulsions above 60 – 70% for up to seven days. Beyond their physical interfacial properties, the cationic arginine derivative (**3j**) exhibited significant antibacterial activity against *S. aureus* and *E. coli* , presenting significantly low minimum inhibitory concentrations (4 μg/mL and 31 μg/mL, respectively). These findings establish a framework for upcycling UCO into tunable surfactants, correlating molecular architecture with macroscopic interfacial properties.

Keywords:
waste valorization; circular economy; amino acid-based surfactants; self-assembly; emulsification properties

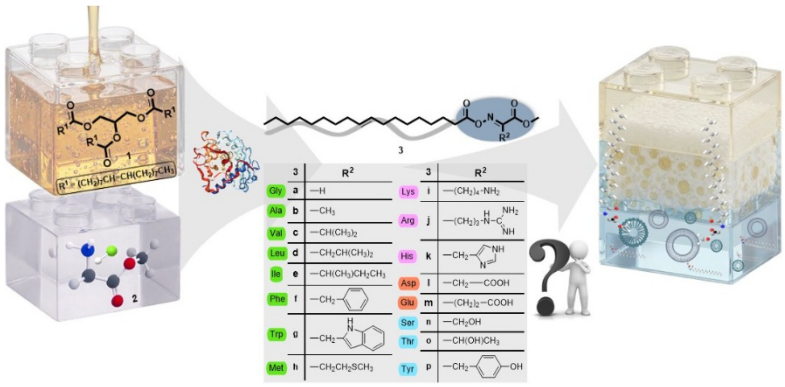

Figure 1: Synthesis of a diverse library of amino acid surfactants from used cooking oil (UCO) triacylglycerides, illustrating the study into how the amino acid side chain (R2) directs surface activity and self-assembly behavior.

References:

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