Laser Tuned Micro-Fluorescence in Fish Scales for Steganography and Chemical Sensing

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Environmental pollution is a major global concern, exacerbated by several issues; namely, the accumulation of fish bio-waste due to the growing population's increased consumption of fish, and textile industries producing huge quantities of effluents containing a myriad of chemicals, mostly dyes, and discharging them into water bodies. This pollution of water bodies has devastating impacts on our climate and our health. This study seeks to find new functionalities of fish scale waste with the help of a focused laser beam – steganography material and a low-cost, rapid micro-chemical detector for Rhodamine B (RhB) sensing. We approach this aim by (1) varying the power density and speed of the laser to achieve the fluorescence enhancement with minimal changes to the surface morphology of the fish scale and (2) drop-casting RhB onto the laser-treated fish scales to study the absorptivity of RhB on the fish scales. Detailed characterizations attribute both effects to the denaturation of collagen and hydroxyapatite (HAp). With delicate control, such enhancements and adsorption capabilities can be used in steganography, where the versatility of the laser patterning process allows hidden messages to be revealed under UV excitation. As a rapid micro-chemical detector for RhB molecules, the laser-treated fish scales exhibit more pronounced orange fluorescence under green excitation. The detection limit of the laser-functionalized fish scale is 10^-10 mol of RhB, whose turbidity is similar to deionized water, and results are observable within 1 minute. Applications from this study contribute towards sustainable living via a circular bioeconomy.

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