



The Department of Chemistry Presents:

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“3-in-1” Catalysis: Redefining the role of Photocatalysts in Synthesis

Carboxylic acids are versatile chemical building blocks for synthesizing complex molecules due to their high stability, low toxicity and natural abundance in biomass. When used in conjunction with photoredox chemistry, highly reactive radical intermediates are formed from carboxylic acids upon loss of CO₂, which can be trapped to achieve a number of challenging bond formations. However, radical decarboxylations traditionally require three distinct catalytic components to i) activate the carboxylic acid through proton transfer, ii) oxidize the resulting carboxylate through electron transfer and iii) facilitate cross-coupling with the radical species generated upon decarboxylation. When you also consider these multi-catalyst strategies rely on precious metals like iridium and palladium, there is a significant need to design sustainable alternatives that are more cost effective and reduce waste streams.

To address this challenge, our group has developed a family of multifunctional quinoline-based organocatalysts that combine substrate activation, photooxidation, and radical cross-coupling within a single catalytic platform. These catalysts enable efficient decarboxylative transformations under metal-free conditions, leading to faster reaction rates, broader functional-group tolerance, and a streamlined pathway toward large-scale application.

This work establishes an underexplored mode of photocatalyst turnover in which reductive quenching is achieved through catalyst-mediated bond formation rather than conventional electron-transfer processes. We have applied this strategy to use these quinolines as single-catalyst platforms for decarboxylative protonation (C-H bond formation), decarboxylative oxidation (C=O bond formation), and the first metal-free decarboxylative alkylation to form C(sp³)-C(sp³) bonds. This work demonstrates how photocatalysts can be designed not only to initiate radical reactivity, but also to actively control bond formation, expanding their potential for synthetic transformations.

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