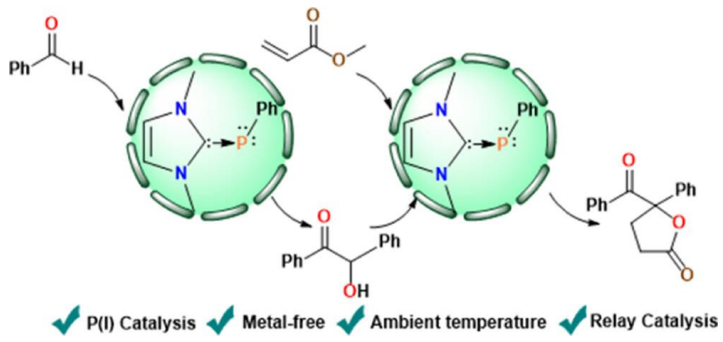
Main group elements as alternatives to transition metals

Over the years, catalysis has been predominantly driven by transition metals, but now it is time for main group elements to gradually take over the role of transition metals as viable alternatives in catalytic processes. Their abundance, reduced toxicity, lower cost, and unique reactivity make them promising candidates to replace transition metals in many applications.

But, achieving this significant milestone requires replicating one of the most critical attributes of transition metals; their ability to undergo redox switching. This unique property enables transition metals to facilitate complex chemical transformations, making their replacement both a challenging and exciting goal. Unlocking the redox potential of the main group elements could pave the way for a new era of sustainable and efficient catalysis. The primary challenge lies in the ability of the main group species to return to the low-valent state following oxidative addition, a process that remains an uphill battle.

In this direction, we recently achieved a significant breakthrough by developing a unique reactivity driven by highly reactive low-valent phosphorus (I). This approach enabled the synthesis of γ-butyrolactones, wherein we observed a facile switching between the P(I) and P(III) oxidation states under ambient reaction conditions. In this work, we successfully utilized the nucleophilic phosphorus (I) center for the dual catalytic activation of aldehydes and acrylates, leading to the formation of γ-butyrolactones.

Based on these results, we believe this represents a significant step forward toward the goal of using the main group species as the new transition metals in catalysis.



Ref: **Sreejyothi P**., N. Gautam, S. Maji, K. Bhattacharyya and **S. K. Mandal**, *J. Am. Chem. Soc.,* 2024, **146,** 16743–16752.