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## Recent advances in radical phosphorylation

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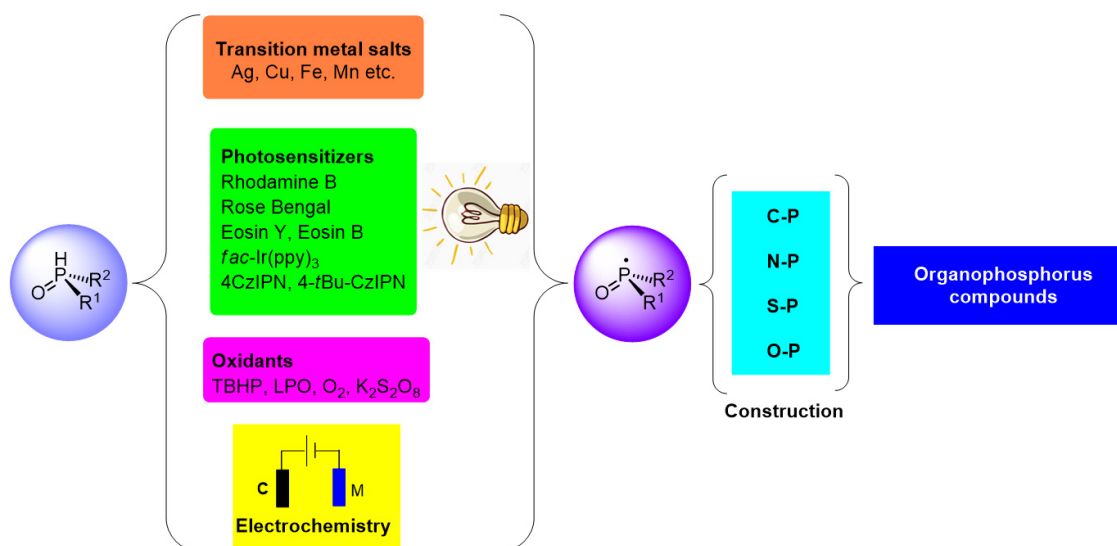
As an important class of chemical molecules, organophosphorus compounds play an irreplaceable role in human industry and life<sup>[1-3]</sup>. Therefore, the construction of phosphorus-containing compounds has attracted significant attention from organic chemists. In recent years, there have been advances made beyond the traditional C-P bond formation strategy such as the Arbuzov reaction, Hirao reaction, Friedel-Crafts-type reaction of  $\text{PCl}_3$  with aromatic compounds, and the reactions of organometallic reagents with electrophilic phosphorus species<sup>[4,5]</sup>; the construction of X-P (X=C, N, O, or S) bonds with P-centered radicals has created a new avenue for the construction of organophosphorus compounds [Figure 1]<sup>[6-11]</sup>. In the latest issue of *Chemical Synthesis*, Liu *et al.*<sup>[12]</sup> reviewed the recent advances in transition metal-catalyzed, photocatalyzed, and electrocatalyzed C-P, N-P, S-P, and O-P bond formation based on P-centered radicals in the past five years, and some earlier pioneering works were also discussed.

In the review, Liu *et al.*<sup>[12]</sup> first briefly introduced the geometries of P-centered radicals and general methods for generating P-centered radicals and also exhibited some common structures of photocatalysts used in phosphorylation reactions. Subsequently, the authors described in detail the radical functionalization of alkenes based on P-centered radicals with different strategies including visible light photoredox-catalyzed reactions and transition metal-catalyzed reactions. In the visible light photoredox-catalyzed reactions, in addition to traditional metal photosensitizers, some organic dyes like Eosin Y can also promote this kind of reaction as well. This summary could play a certain guiding role in the subsequent reaction design. Additionally, a series of P-centered radicals-based difunctionalization of alkenes were also discussed in the section.



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**Figure 1.** Strategies for constructing organophosphorus compounds by generating P-centered radicals.

Liu *et al.*<sup>[12]</sup> then summarized the radical phosphorylation of alkynes. In addition, the authors also focused on the discussion of difunctionalized phosphorylation of alkynes. Furthermore,  $\pi$ -conjugated phosphine molecules have become vitally important in the blooming area of organic light-emitting diodes and photovoltaic cells. The radical cascade cyclization phosphorylation of alkynes has also been well developed and was included in this review. Moreover, arylphenylisonitriles, which contain a  $C\equiv N$   $\pi$ -bond and have good radical acceptor properties, were also compatible with radical phosphorylation though visible light-induced cascade reaction.

Liu *et al.*<sup>[12]</sup> continued to introduce the cross-coupling phosphorylation reactions of (pseudo) halides via transition-metal and photoredox dual catalysis. Moreover, decarboxylative or denitro phosphorylation and dehydrogenative C-H phosphorylations were also discussed in the review.

In the final section of their review, Liu *et al.*<sup>[12]</sup> summarized several other types of radical phosphorylation such as  $C(sp^3)$ -P bond formation via C-C and P-H bond cleavages and Atherton-Todd-type reaction. Notably, electrochemical oxidative phosphorylation with hydrogen evolution was also discussed.

In summary, Liu *et al.*<sup>[12]</sup> provided readers with an overview of transition metal-mediated and photoredox-catalyzed radical phosphorylation reactions. At the same time, the review also introduced the method of electrochemical phosphorylation to synthesize organophosphorus compounds. The authors summarized the latest advances on phosphorylation reaction over the past five years. Furthermore, on the basis of this review, the authors put forward their own views on phosphorylation and prospects for the future. This information provided valuable insights and guidelines for the design of such reactions.

## DECLARATIONS

### Authors' contributions

Prepared the manuscript: Niu Y, Yang SD

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Not applicable.

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**Conflicts of interest**

Both authors declared that there are no conflicts of interest.

**Ethical approval and consent to participate**

Not applicable.

**Consent for publication**

Not applicable.

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