Advanced Phosphorus Heterocycles for Controlling 3D Nanomaterials

Carlos Romero-Nieto[1,2]

[1] *Instituto Regional de Investigación Científica Aplicada (IRICA), University of Castilla-La Mancha, Avenida Camilo José Cela 1, 13071, Ciudad Real, Spain*
[2] *Faculty of Pharmacy, University of Castilla-La Mancha, C/ Almansa 14, Edif- Bioincubadora Albacete, Spain*

E-mail: carlos.romeronieto@uclm.es

Modern organic chemistry has led to a rapid evolution of π-extended systems, since they are pivotal for the development of future technologies, particularly in organic electronics. Their beneficial properties for materials science stem from the efficient electronic delocalization across their π-extended framework. While carbon-based architectures dominate this field, the inclusion of phosphorus introduces unique properties that are inaccessible with an all-carbon framework. Notably, phosphorus stands out because of its pyramidal geometry, which may disrupt conventional π-stacking, and its special electronic characteristics; i.e. the possibility to reversibly interconvert from tri- to pentavalent form.[1] Within π-extended systems phosphorus exhibits a unique non-hybridization that originates a myriad of fascinating properties such as strong photoluminescence, electron-accepting capacity,[1] and a large variety of coordination reactions,[2] just to name a few. However, deepening into the chemistry of heteroatomic π-extended systems requires the development of not only suitable synthetic protocols capable of incorporating heteroatoms but also new strategies to control the 3D molecular arrangement, as it determines the materials' properties as a whole. Both aspects have recently attracted a great deal of research efforts;[3] the future of heteroatomic π-extended architectures will be certainly governed by the availability of straightforward means to control their overall molecular arrangement.

In this communication, I will discuss recent advancements in the multifaceted contributions of phosphorus heterocycles to the field, with a particular focus on their role in controlling 3D nanomaterials. I will provide an overview of synthetic methodologies for the preparation of phosphorus heterocycles, encompassing both traditional organic synthesis routes and cutting-edge approaches. Additionally, I will highlight their unique structural versatility and electronic properties, which enable precise manipulation of nanoscale architectures. Special emphasis will be placed on their potential in materials science, particularly in the design and control of 3D nanostructures for applications in organic electronics, functional materials, and bioactive systems. Emerging trends in phosphorus-based nanomaterials will also be discussed, showcasing their impact on next-generation technologies.

References

[1] a) Hindenberg, P.; Romero-Nieto, C. *Synlett* **2016**, *27*, 2293; b) Regulska, E.; Romero-Nieto, C. *Dalton Trans.* **2018**, *47*, 10344.
[2] Kollár, L.; Keglevich, G. *Chem. Rev.* **2010**, *110*, 4257.
[3] Regulska, E.; Romero-Nieto, C. *Mater. Today Chem.* **2021**, *22*, 100604.