Bottom-up modular engineering of porous graphene nanoarchitectures

A. Mugarza

aitor.mugarza@icn2.cat

Bottom-up nanoarchitectonics has shown remarkable capability in designing nanomaterials with atomic precision. A notable demonstration of this concept is the surface-assisted synthesis of graphene-based one-dimensional nanostructures, where structural parameters are basically designed à la carte. However, despite significant progress in synthesizing one-dimensional homostructures, advancing towards greater structural complexity presents significant challenges. For instance, the site-specific functionalization of nanoribbon edges is an effective strategy for customizing their electronic and chemical properties, yet it often encounters obstacles due to the instability of desired functional groups or dopants during the synthesis process. Another challenge arises in fabricating heterostructures, where precise control over the size and distribution of constituent components is crucial. Additionally, extending surface-assisted strategies to two-dimensional structures faces limitations, with only a few examples of long-range ordered nanoarchitectures currently available.

In this presentation, I will discuss different strategies that we have developed to address each one of these challenges. Firstly, I will introduce our method for synthesizing 2D nanoporous graphene, where the long-range order is achieved through the sequential growth and coupling of 1D building blocks [1]. Subsequently, I will focus on two modular approaches leading to more intricate nanoporous structures. The first involves molecular engineering of coupling bridges, demonstrating tunability in quantum electronic coupling and in-plane electronic anisotropy through the introduction of flexible phenyl groups [2]. The second relies on a sequential intercalation method, where the first 1D ribbon component defines a long-range ordered scaffold for the intercalated growth of a functionalized second component. This method serves a dual purpose by enabling simultaneous doping and the generation of ultranarrow lateral heterostructure superlattices [3].

In conclusion, our modular engineering approach stands out as an efficient tool for tailoring the physical and chemical functionality of carbon-based 2D nanoarchitectures.

References

[1] C. Moreno et al., Science 360 (2018) 199–203.
[2] C. Moreno et al., J. Am. Chem. Soc. 145 16 (2023), 8988–8995.
[3] M. Tenorio et al., Adv. Mater. (2022) 2110099.

Figures

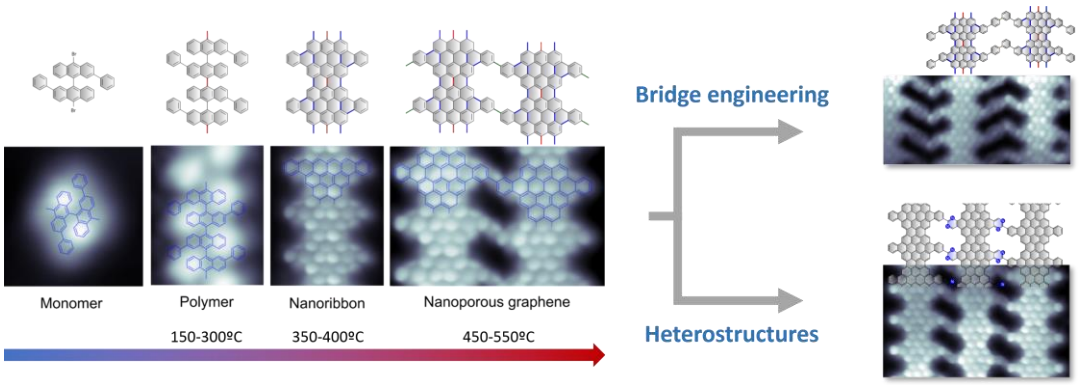

Figure 1: Illustration of the sequential method that leads to the modular engineering of porous graphene nanoarchitectures.