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Tailoring Multifunctional Materials through Chemical Design and Structural Control

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Aula Gismondi

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Tailoring Multifunctional Materials through Chemical Design and Structural Control

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Recent advances in synthetic organic chemistry and materials science have enabled the development of functional organic materials whose properties can be rationally engineered through molecular design and structural control. However, the preparation of highly pure materials, the expansion of their chemical functionality, and the precise control of long-range structural order remain challenging. In this talk, these aspects will be discussed through two representative case studies: Carbon Dots (CDs) and Covalent Organic Frameworks (COFs).

CDs are photoluminescent carbon nanoparticles synthesized from small organic molecules through solvothermal methods. Despite the simplicity and accessibility of their preparation, the properties often reported for novel CDs can arise from molecular impurities that are not removed during purification. In our recent work, we introduced advanced characterization protocols to reveal these inconsistencies and establish new quality standards for the field.[1] Building on this expertise, we expanded this synthetic methodology to access novel chiral CDs, which were successfully employed as catalytic platforms for organic transformations by exploiting both the core and surface functionalities of the nanoparticles.[2]

In parallel, COFs provide an ideal platform to investigate how structural order impacts material properties. COFs are crystalline porous polymers that are typically obtained as polycrystalline materials. Our recent efforts have enabled the development of synthetic methodologies for the growth of single-crystalline imine-based COFs.[3,4] Access to highly ordered materials enabled us to elucidate how crystallinity influences their properties and performance in targeted applications.

[1] B. Bartolomei, A. Bogo, F. Amato, G. Ragazzon, M. Prato, *Angew. Chem. Int. Ed.* **2022**, *61*, e202200038.
[2] B. Bartolomei, V. Corti, M. Prato, *Angew. Chem. Int. Ed.* **2023**, *62*, e202305460.
[3] A. Natraj, W. Ji, J. Xin, I. Castano, D. W. Burke, A. M. Evans, M. J. Strauss, M. Ateia, L. S. Hamachi, N. C. Gianneschi, Z. A. Alothman, J. Sun, K. Yusuf, W. R. Dichtel, *J. Am. Chem. Soc.* **2022**, *144*, 19813−19824.
[4] A. Natraj, I. R. Landman, C. E. Pelkowski, D. W. Burke, S. Kewalramani, W. R. Dichtel, *J. Am. Chem. Soc.* **2024**, *146*, 16775–16786.

Short bio

Beatrice Bartolomei is a Marie Skłodowska-Curie Global Postdoctoral Fellow at the Max Planck Institute for Solid State Research in the group of Prof. Bettina V. Lotsch, in collaboration with Prof. William Dichtel at Northwestern University. Her current research focuses on covalent organic frameworks, working on the development of synthetic methodologies to achieve highly crystalline materials with new chiral and catalytic features. She received her PhD in Nanotechnology in 2024 from the University of Trieste, under the supervision of Prof. Maurizio Prato. During her doctoral studies, she worked on carbon dots, developing expertise in their synthesis and applications. As part of her doctoral training, she also carried out a visiting research period at the University of Michigan in the group of Prof. Nicholas A. Kotov, where she studied aspects related to chirality in nano- and microstructures.