Novel architectures based on Carbon Dots

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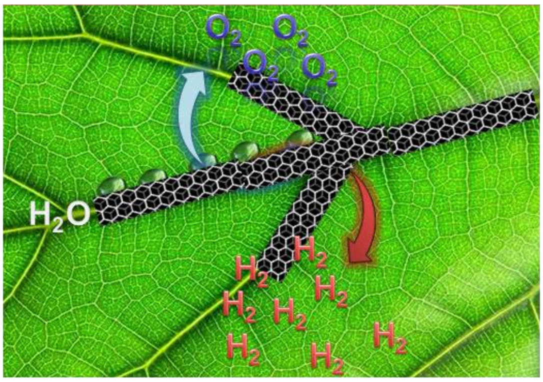
This project aims at the synthesis of hybrid nanosystems that can perform relevant redox catalytic processes. Target applications include water splitting and CO_2 reduction.

Energy- and sustainability-related research plays a major role in shaping our future. Ideally, it would be desirable to harvest clean energy, e.g. solar, and be able to valorize waste products, such as CO_2. Our group has longstanding expertise in the use of organic chemistry and carbon nanomaterials to address these societal challenges.[1] One additional possibility is given by the new materials based on carbon nanodots. In the coming years, we plan to advance the state of the art concerning water splitting and carbon dioxide reduction.



Organic chemistry for societal challenges: the functionalization of carbon nanostructures can enable light harvesting and photoredox catalysis. Examples include water splitting and CO_2 reduction.

For water splitting, we have demonstrated the feasibility of combining light-harvesting chromophores with oxygen evolution catalysts, such as polyoxometalates.[1b] The next step will be to engineer tridimensional networks that optimize charge transport and water accessibility, towards the development of an artificial "off-leaf" transposition of photosynthesis.

On the other hand, we are eager to employ carbon nanodots and other carbon nanostructures such as carbon nanohorns for the photochemical reduction of CO_2 and the electrochemical production of H_2O_2.[3] Critical for the successful outcome of these projects will be the chemical functionalization nanomaterials. Overall, the PhD student will be engaged in a variety of topics having the common underlying principle of using organic chemistry as a tool to tackle challenges central to our society.

The PhD student will design synthesize, characterize, and test the target systems. The obtained materials will be analyzed with state-of-the-art spectroscopic methods, including nuclear magnetic resonance (NMR), optical spectroscopies, atomic force and transition electron microscopies (AFM, TEM), and infrared spectroscopy (IR). Our group has also a strong track record of fruitful collaborations, that involve also the use of X-ray facilities at the synchrotron (Trieste) or CIC biomaGUNE (San Sebastian, Spain). The performances of the materials will be tested in the framework of established collaborations. On top of this, for the optimal development of collaborative projects, it is likely for PhD students to perform a research stay abroad.

Our group is a lively cluster committed to interdisciplinarity and the student will be exposed also to several aspects of carbon nanotechnology, that represent the core expertise of the group. Typically, the PhD work starts from an ongoing project. Then, the individual interests and attitudes of the student come into play and shape the development of his path into research.

References:

[1] (a) "Efficient water oxidation at carbon nanotube–polyoxometalate electrocatalytic interfaces", M. Prato, M. Bonchio *et al.*, *Nat. Chem.* **2009**, 2, 826; (b) "Hierarchical organization of perylene bisimides and polyoxometalates for photo-assisted water oxidation" M. Bonchio, M. Prato *et al.*, *Nat. Chem.* **2019**, 11, 146.

[3] (a) "Design, synthesis, and functionalization strategies of tailored carbon nanodots", F. Arcudi, L. Đorđević, M. Prato, *Acc. Chem. Res.* **2019**, 52, 2070; (b) "The Rise of Hydrogen Peroxide as the Main Product by Metal-Free Catalysis in Oxygen Reductions", M. Melchionna, P. Fornasiero, M. Prato, *Adv. Mater.* **2019**, 31, 1802920; (c) F. Arcudi, L. Đorđević, M. Prato, *Nat. Nanotechnology* **2022**, 52, 17, 112–130.