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Development of photosynthetic protocells for low-cost production of solar fuels

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The increase in global energy demand and the climate change crisis is causing a progressive increase in global warming and deoxygenation of our atmosphere.[1] Therefore, it is of paramount importance to develop new technologies to simultaneously (i) reduce the global amount of CO_2 in our atmosphere, (ii) produce eco-sustainable fuels, and (iii) reoxygenate our planet.
In the past decade, micro-compartmentalized systems called "protocells" have been developed to study complex biological phenomena such as enzymatic metabolism, chemical signaling or photosynthesis under simple and controllable experimental conditions.[2,3] Recently, Prof. Gobbo, in collaboration with the University of Bristol (UK) and the University of Padua (Italy), has synthesized catalytic protocells capable of decomposing H_2O_2 into oxygen and water starting from poly(diallyldimethylammonium chloride) (PDDA) and a mixture of polyoxometalates: sodium phosphotungstate (PTA) and a synthetic catalyst called "Ru_4POM".[4] The research team has then demonstrated that the same catalytic protocells are capable of utilizing sunlight to oxidize water to protons and O_2 (**Figure 1**) when dispersed in a solution of $Ru(bpy)_3Cl_2$ (a photosensitizer) and $Na_2S_2O_8$ (a sacrificial electron acceptor).

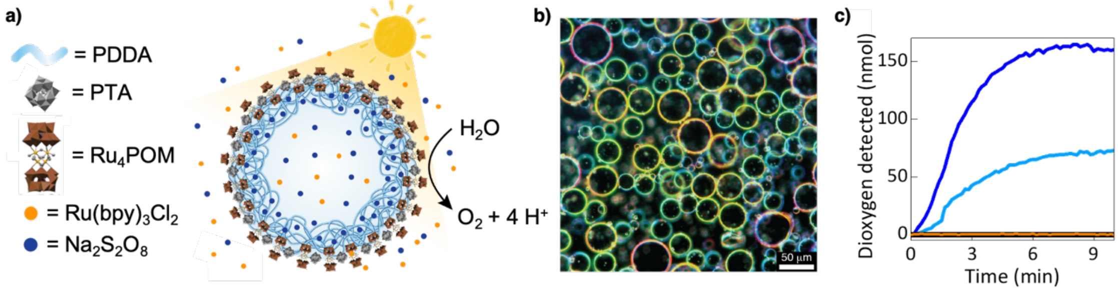

Figure 1: a) Schematic representation of a photo-catalytic protocell and its reactivity. **b)** Darkfield microscopy image of a population of protocells structured like described in **(a)**. **c)** Graph showing the time-dependent production of O_2 for: a sample of photocatalytic protocells (dark blue plot); a sample of photocatalytic protocells that have been utilized a second time (light blue plot); control experiments carried out in the absence of light (black plot) or in the absence of the Ru_4POM catalyst (orange plot). *Non-published preliminary results*.

The project, financed by the EU project PLANKT-ON, starts from these important preliminary results and aims to develop the first photosynthetic protocells capable of utilizing sunlight, water and CO_2 to autonomously and continuously synthesize O_2 and fuels at low costs. The student will develop these preliminary results into groundbreaking research following their interests and attitudes with the support of a higly dynamic and international research group.
Through this multidisciplinary project, the student will develop skills in synthetic chemistry, polymer chemistry, soft materials chemistry, photocatalysis and biochemistry. The protocells that will be developed and their reactivity will be characterized *via* advanced spectroscopic (NMR, UV-vis and fluorescence) and microscopy (brightfield, darkfield, fluorescence, and electron) methods. The student will join a dynamic and highly interdisciplinary research group with important ties with the University of Bristol (UK), the University of Western Ontario (Canada), and the CEA Institute of Grenoble (France), where a period abroad could be organized.

References:
[1] J. Huang *et al. Sci. Bull.* **2018**, *18*, 1180-1186. [2] P. Gobbo* *et al. Front. Mol. Biosci.*, **2021**, *8*, 804717. [3] C. Xu, *et al. Mater. Today* **2016**, *19*, 516-532. [4] P. Gobbo, M. Bonchio, S. Mann, S. *et al.* Nat. Commun. **2020**, *11*, 41. [5] M. Bonchio, M. Prato, *et al. Nat. Chem.* **2019**, *11*, 146-153.