A new method to measure photosynthetic activity in algal mixtures reveals allelopathy between diatoms and dinoflagellates

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Despite the central role of phytoplankton in the Ocean-atmosphere exchanges, our understanding of the forces shaping the dynamics and structure of phytoplankton communities remains limited. One of the major parameters contributing to the ecological structure is allelopathy, i.e. the direct inhibition of the metabolism of competitors thanks to secondary metabolites. Photosynthesis is an ideal probe to study allelopathy between marine microalgae because it is one of its main targets. However, any approach based on photosynthesis remains hampered by a major methodological constraint: the lack of a reliable method allowing the extraction of the contributions and photosynthetic physiologies of the several microalgae comprising a mixture.

We developed an innovative approach based on a physical phenomenon, the electro-chromic shift (ECS) of photosynthetic pigments, when subjected to the electric field generated across the thylakoid by photosynthesis. This innovative method allows a full dissection of the photosynthetic activities of each microalga in mixtures, here a dinoflagellate/diatom assemblage. Indeed, electro-chromic spectra of diatoms and dinoflagellates show different signatures, permitting the extraction of the photosynthetic responses of each species in an assembly. Moreover, all complexes involved in photosynthesis contribute to the generation of the electric field (photosystems, cytochrome b6f) or to its consumption (ATP synthase); this allows a complete deciphering of the photosynthetic function in the two microalgae.

With this method, we observed that the photosynthetic activities of the diatoms *Thalassiosira pseudonana* or *Phaeodactylum tricornutum* are inhibited by 80% when mixed with the dinoflagellate *Amphidinium carterae*. In the laboratory, we studied the mechanism of the inhibition of the diatom's photosynthesis, and how this interaction depends on the physiological state of the two species and growth conditions (light, temperature and nutrients). The annual event of diatoms and dinoflagellates bloom in the estuary of the Penzé (Roscoff, France) gave us the opportunity to demonstrate that the ECS-method can provide us with the specific photosynthetic activities of diatoms and dinoflagellates *in situ*. This new method is therefore a powerful tool for studying *in situ* and in real time the cellular mechanisms that are key determinants of the structuration of the phytoplankton community in the ocean.