Photosynthetic photonic crystals: photonic aspects of the ultimate light harvesting process in nature

Martin Lopez-Garcia[1], M. Jacobs[2], N. Masters[2], H.E. O'Brien[2], M.J. Cryan[3],O.-P Phrathep[2], J. Lennon[4], G. Atkinson[4], T. Lawson[5], R. Oulton[3], H.M. Whitney[2]

[1]*International Iberian Nanotechnology Lab. (INL), Av. Mestre José Veiga s/n, 4715-330, Braga, Portugal.*
[2]*School of Biological Science, Univ. of Bristol, BS81TQ, UK*
[3]*Dept. Electrical and Electronic Engineering, Univ. of Bristol, BS81TH, UK.*
[4] *School of Physics, Univ. of Bristol, BS81TL, UK.*
[5]*School of Biological Science, Univ. of Essex, CO43SQ, UK*
Contact: Martin.lopez@inl.int

From a molecular point of view photosynthesis (PS) is the ultimate light harvesting process in nature showing efficiencies not yet achievable with any synthetic chemistry approach [1]. However, one side of PS that has been seldom explored is the effect of complex photonic environments over the photochemistry of PS.

With this paper we aim to give a flavour of the potential that photosynthetic photonic systems represent for biomimetic light harvesting technologies. To illustrate this potential we will show two examples of natural photonic structures in plants and algae with different yet important roles in light management and PS.

As a first example we will discuss the presence of organelles formed by multilayers of photosynthetic tissue present in the cells of some species of the genus *Begonia* [2]. The tissue is arranged like a Bragg reflector to form a 1D photonic crystal responsible for the strong blue colour of the leaves. Interestingly our work shows that the presence of the photonic crystals can enhance the light harvesting process of the cells at wavelengths suitable for PS.

The second type of natural photonic structure we will discuss is a natural 3D photonic crystal present in the epidermal cells of the alga *Cystoseira tamariscifolia* [3]. These photonic structures are formed by ≈200 nm lipid spheres arranged in an opal-like conformation and contained in intracellular 5-10 μm diameter vesicles located next to the photosynthesis regions of the cells. We will show that these natural photonic crystals are responsible for the strong structural colour shown by this alga. More interestingly we will also demonstrate that the photonic response is dynamic. Morphological changes in the arrangement of the spheres are triggered by changes in the light environment. The nanospheres arrange in an ordered (randomized) conformation under dark (light) conditions suggesting a mechanism to tailor light propagation within the cells.

References

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Figures

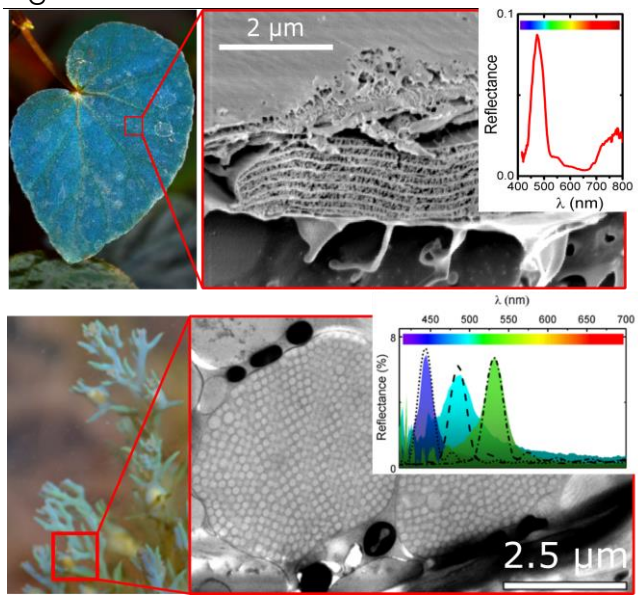

Figure 1: Specimen, micrograph and reflectance of natural photonic crystals in *Begonnia pavonina* leaf (top) and algae *Cystoseira tamariscifolia* (bottom).