Photosensitization of Lipid Bilayers: Observations of GUVs by Optical Microscopy

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Photosensitization is the basis of Photodynamic Therapy (PDT), a technique that can be used to treat cancer as well as to be applied in non-oncological purposes such as bacterial infections. The method relies on the administration of a sensitizer molecule that is suitable to induce the formation of singlet oxygen ($^1O_2$) when exposed to light of the appropriate wavelength. By turn, $^1O_2$ is known to promote peroxidation of unsaturated phospholipids, while no effect has been reported for saturated ones. At the molecular level, the well-known mechanism of peroxidation leads to a modification of the structural characteristics of the phospholipids including breaking of the lipid chain and formation of ketones, aldehydes, carboxylic acids, for instance. Despite extensive spectroscopic work on the chemistry of phospholipid peroxidation, little is known of the deep repercussions that such molecular modifications have on the membrane cohesion and structure at the optical length scales in the 1 – 100 μm range, where the shape, adhesiveness and fluctuations of the membrane can be continuously monitored under an optical microscopy. In the present study, we compare the photosensitizing effects of two different sensitizers on giant unilamellar vesicles (GUVs) made from DOPC (1,2-dioleoyl-sn-glycero-3-phosphocholine) phospholipids membranes. Firstly, we investigate how methylene blue (MB) dispersed in the GUVs solution affects the membrane integrity under irradiation. In this case, we show different scenarios that eventually lead to membrane photodestruction induced by MB. Secondly, we explore the effect of irradiating a porphyrin attached to a phospholipid headgroup incorporated in the GUV membrane showing that, in this case, the initially spherical GUV gained excess area, starts to fluctuate and very often expels several small buds, without membrane disruption.