Ultrafast transient absorption spectroscopy: principles and applications

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The study of photophysical and photochemical processes crosses the interest of many fields of research in physics, chemistry and biology. In particular, the photophysical and photochemical reactions, after light absorption by a photosynthetic pigment-protein complex, are among the fastest events in biology, taking place on timescales ranging from tens of femtoseconds to a few nanoseconds. Among the experimental approaches developed for this purpose, the advent of ultrafast transient absorption spectroscopy has become a powerful and widely used technique.[1,2]

Focusing on the process of photosynthesis, it relies upon the efficient absorption and conversion of the radiant energy from the Sun. Chlorophylls and carotenoids are the main players in the process. Photosynthetic pigments are typically arranged in a highly organized fashion to constitute antennas and reaction centers, supramolecular devices where light harvesting and charge separation take place. The very early steps in the photosynthetic process take place after the absorption of a photon by an antenna system, which harvests light and eventually delivers it to the reaction center. In order to compete with internal conversion, intersystem crossing, and fluorescence, which inevitably lead to energy loss, the energy and electron transfer processes that fix the excited-state energy in photosynthesis must be extremely fast. In order to investigate these events, ultrafast techniques down to a sub-100 fs resolution must be used. In this way, energy migration within the system as well as the formation of new chemical species such as charge-separated states can be tracked in real time. This can be achieved by making use of ultrafast transient absorption spectroscopy.

The basic principles of this notable technique, instrumentation, and some recent applications to photosynthetic systems[3] will be described.

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