Synthetic and natural photoswitches

DOI: 10.1039/b925378p

There can be little question that optical techniques are some of the most valuable assets in the scientific toolbox. Using light is often preferable to alternatives due to its general convenience and non-invasiveness. But increasingly researchers are finding that light does not have to be limited to a passive observer, and can play an active role in their studies too, and reach out to change matter itself. Using light to remotely or autonomously control the properties of matter is a fascinating topic that has sparked tremendous interest and numerous applications. The non-invasive character of light, in combination with its exceptional temporal and spatial resolution, makes it an ideal external stimulus with which to trigger changes in the properties of materials.

A particularly intense area of research has focused on photochromic or photoswitchable compounds, molecules that display reversible, light-induced changes in absorption. Having come a long way since its application in ophthalmic plastic lenses, nowadays photochromism has expanded into fields as diverse as catalysis, recognition, magnetism, electrochemistry, fluorescence, linear and non-linear optics. There can be little doubt that these new applications of photochromism/photoswitching are headed towards a bright future, and this themed issue of *Photochemical & Photobiological Sciences* brings readers a taste of photochromism today, where the intersection of synthetic chemistry and photochemistry meets biology and physics.

To some extent, nature itself has been leading the way in these investigations. Energy reaches the earth as light, and has to be harnessed using photochemistry in order to be useful. But the mechanisms involved are often complex, and steady progress is being made in unraveling them. A particular example here are the photoswitching reactions that lead to vision itself, and in this issue Alexiev *et al.* will provide new insight in our search to understand why we can see. Along the same lines, Heberle and coworkers provide mechanistic insight into the light-gated cation channel protein channelrhodopsin, nowadays a prominent optogenetic tool to trigger neurophysiological responses.

In some ways, the research into light-induced reactions is now coming full-circle. Where light was originally limited to the role of a passive observer, the developing field of photochromism/photoswitching allowed it to expand these confines. Now photochemistry in turn is radically changing the established views on optical microscopy, directly challenging and breaking barriers that have stood for over a century. In this issue Mizuno and coworkers report on their progress in super-resolution imaging. This paradigm shift will undoubtedly make a profound impact in the very near future.

It is now well-recognized that the key ingredient in super-resolution fluorescence microscopy is fluorophores possessing distinct and light-interconvertible states, a bright and a non-fluorescent state. This insight has spurred tremendous efforts in the development of new and better performing photochromic/photoswitching systems, as testified by numerous contributions in this issue (*e.g.* Sauer and coworkers, Mattay and coworkers, Fukaminato and coworkers, Tian and coworkers, Raymo and coworkers).

Other applications, such as sensing, require the development of tailored photochromic materials and are reported by Micheau, Branda, Abe, Tsujioka, Yokoyama and Pozzo and their respective coworkers.

The rational design of photoswitches tailored for specific applications such as phase separation, as reported by Fukumura and coworkers, or structural changes in the crystalline state, as reported by Irie and coworkers, requires a thorough understanding of the mechanistic aspects of the switching reaction and form the study object of the contributions from the groups of Miyasaka, Bourgeois and coworkers, as well as from Metivier and coworkers. Newly developed techniques (see the development of transient Brewster angle reflectometry by the group of Hobley) push the detection limits further down.

These are exciting times for photochemists and photobiologists, and with this themed issue *Photochemical & Photobiological Sciences* brings readers a taste of photochromism/photoswitching today. We are particularly excited about the work presented here, and after reading this issue, we hope you will be too.

Dario Bassani, **Johan Hofkens**, **Jean Luc Pozzo**
Guest editors

