Recently we have developed a new class of photochromic compounds named “diarylethenes” which undergo thermally irreversible and fatigue resistant photochromic reactions(1). When the compounds have thiophene or benzothiophene aryl groups, both isomers, initial colorless and photogenerated colored isomers, are thermally stable even at 150 °C and coloration/decoloration cycles can be repeated more than ten thousands times with keeping adequate photochromic performance.

Some diarylperfluorocyclopentenes undergo photochromism even in the single-crystalline phase. Very high photocyclization quantum yields, close to 1, and very low activation energies in the photocyclization reactions, close to zero, were found in the single-crystalline photochromism (2-6). In addition, it was found that surface morphology of the single crystal of 1,2-bis(2,4-dimethyl-5-phenyl-3-thienyl)perfluorocyclopentene reversibly changes by alternate irradiation with ultraviolet and visible light (2). Upon irradiation with ultraviolet light new steps with height of 1 (or 2 and 3) nm appeared on the (100) single-crystalline surface and valleys were formed on the (010) surface. The steps and valleys disappeared upon irradiation with visible light. The surface morphological changes could be explained by the molecular structural changes of diarylethenes regularly packed in the single crystal. The crystals can be used as photodriven nanometer-scale actuators.

One of the dreams of organic photochemists is to directly observe photochemical reactions at the single-molecule level. This was demonstrated using diarylethene derivatives linked with a fluorescent unit (7,8). Although uncontrollable fluorescence switching of single molecules, such as short-time blinking and spectral diffusion, has been extensively studied, on/off digital switching of synthetic molecules by photoirradiation in a controllable fashion has not yet been accomplished for the lack of sufficiently durable photochromic molecules. As described above diarylethenes are exceptionally fatigue resistant and have highly efficient photoreactivity. One of the fluorescent diarylethene derivatives is as follows. The open-form is
fluorescent, while the closed-form is non-fluorescent.

While in an ensemble solution system the fluorescence intensity gradually varied upon irradiation with UV and visible light, on/off digital fluorescence switching between two discrete states was observed at the single-molecule level. Both on and off times were dependent on the power of UV and visible light. The digital fluorescence switching of the single molecules is the first step to achieve the ultimate ultra-high density “Single-molecule Optical Memory”.

References