PHOTOCHEMISTRY

Adieu to photobleaching

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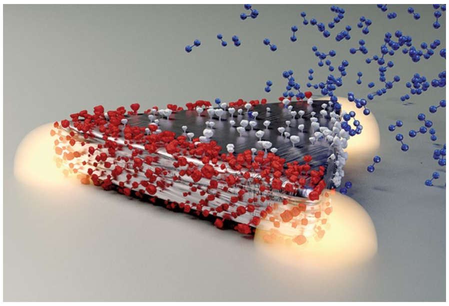

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Under intense illumination, most organic dyes tend to degrade. This photobleaching is the result of a reaction between the dye in a long-lived photoexcited state, such as a triplet state, and molecules in the environment, such as molecular oxygen. In functional devices, photobleaching is therefore considered detrimental for long-term operations. Now, Munkhbat et al. have reported a system in which the rate of photobleaching can be substantially reduced.

The researchers study the photochemistry of a J-aggregate in the vicinity of a plasmonic nanoantenna. The plasmonic mode and the molecular exciton form a hybrid light–matter state (polariton) that modifies the photochemistry of the dye molecules. In particular, the polariton is characterized by two new energy levels that split the excited singlet state of the dye. The lower polariton state has lower energy than the triplet state of the dye. Therefore, on irradiation of this coupled system, the probability of populating the reactive triplet state is greatly reduced. The researchers show in particular that by selectively irradiating the lower polaritonic band, the photo-oxidation rate of their dye can be decreased by 100-fold. *AM*

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NANOELECTRONICS

Thermal release

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For decades, thermal management has been a serious engineering hurdle in the design of electronic devices and circuits. A rapid reduction in transistor size has expanded the excess heat issue into the nanoscale, calling for the development of new materials for efficient heat dissipation. Now, building on recent theoretical predictions, Sang Kang and co-workers experimentally obtain a defect-free single-crystal boron arsenide (BAs) exhibiting a thermal conductivity on par with the best known heat conductors.

The performed structural analysis reveals the single-crystalline nature and zinc-blende face-centred cubic crystal structure of the synthesized BAs. The researches then use ultrafast optical pump–probe spectroscopy to study the heat transport properties of BAs, and compare their findings with similar measurements performed on diamond and cubic boron nitride samples. The measurements confirm ballistic transport in all studied samples including the BAs crystals, which show a thermal conductivity of 1,300 W mK^{-1} at room temperature, the second highest value among all known bulk materials. According to the report, the efficient heat conduction of the crystals stems from the enhanced phonon mean free path enabled by the unique BAs phonon band structure. *OB*

https://doi.org/10.1038/s41565-018-0241-9

AFM-IR

Probe protein conformation

ACS Nano http://doi.org/csbc (2018)

The chemical and structural characterization of single protein aggregates is crucial to understand the protein folding/misfolding processes in living organisms. The photothermal-induced resonance (PTIR) technique, also known as AFM-IR, has been demonstrated to be powerful in accessing protein conformation. However, its application in liquid environments remains challenging due to the strong infrared (IR) adsorption of water and the interference of fluid drag on cantilever oscillation. Now, Centrone from NIST and co-workers report PTIR spectra with high signal-to-noise ratio in water, which enables them to identify the chemical and structural state of single fibrillar aggregates.

The researchers first validate the acquisition of PTIR data in water or air on gold plasmonic resonators coated with a 200-nm-thick PMMA layer. The nanoscale confinement near the resonators gaps results in surface-enhanced IR adsorption, leading to IR spectra and maps in water and air with comparable resolution and signal-to-noise ratio. They subsequently test the viability of this technique on the characterization of single protein aggregate conformation. D_2O is used instead of H_2O to avoid the spectral overlap with amide. Diphenylalanine (FF), the core recognition module of the Alzheimer's β-amyloid peptide, and its derivative Boc-FF are chosen as model systems. FF and Boc-FF can form morphologically similar fibrillar aggregates in water. Using the present PTIR approach, the differences in fibril secondary and quaternary structural properties are revealed by their different IR fingerprints. *WS*

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QUANTUM TECHNOLOGY

Three qubits in one

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The number of entangled qubits determines, to first order, the power of a quantum computer. Hence, increasing this number is a key challenge in the field of quantum technology. Photons are special qubits in that they possess several independent properties such as polarization, position or orbital angular momentum. These degrees of freedom can all be employed to encode quantum information. The number of accessible qubits can thus be increased beyond the number of particles by a so-called hyperentanglement — the simultaneous entanglement of multiple photons and multiple degrees of freedom. Yet, this has not been achieved for more than two degrees of freedom. Wang et al. now show that they can entangle three degrees of freedom of six photons, providing control over an 18-qubit ensemble.

The researchers employ the paths, the polarization and the orbital angular momentum as independent qubits. By means of a complex optical set-up including beam splitters and 30 single-photon interferometers, they coherently control and entangle the three independent properties of all six photons. 48 single-photon detectors then discern between the 218 possible outcome combinations. The measured state fidelity of 0.7 demonstrates the entanglement of all 18 qubits and the potential of this approach to extend the power of optical quantum information processing. *BH*

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