"Jumping Dye": Single-molecule Four-colour FRET

To control light on the nano scale, scientists require new kinds of optical devices to function as wires and switches. The energy transfer between single dye molecules, for instance, could function as a sort of wire. There is already an example in nature for such a transfer mode: during the process of photosynthesis, light energy is transported between single molecules within the light harvesting complexes.

**Professor Philip Tinnefeld** (until fall 2010 at LMU Munich, now at TU Braunschweig, Germany) and his team applied this mechanism to conduct light from one fluorescent dye molecule to another. The principle is called [FRET](https://en.wikipedia.org/wiki/Fluorescence_resonance_energy_transfer) for **Fluorescence Resonance Energy Transfer**. For their light control experiments the biophysicists worked with dye molecules with absorption maxima respectively in the blue, green, red and infrared wavelength ranges. The results have been published in the journal *JACS*.

Such an interaction between molecules - for example in artificial optical switches - is only feasible if they are located no more than five nanometers apart. To enable this, the scientists utilized a tiny pinboard built from the biomolecule DNA. They first connected each dye molecule to a short artificial DNA strand. These loaded segments, together with about 200 more short DNA strands, act like staples, supporting one single very long DNA strand to fold into a two- or even threedimensional structure. This structure is pre-defined in such a way that, after the folding, the dye molecules face outward from this DNA pinboard or "DNA carpet" in optimal position with respect to each other. The DNA pinboard typically has a size of less than 100 nm x 100 nm. The customized use of this molecular self-organization and self-folding technique is called "DNA origami", based on the Japanese art of folding paper.

In the experiment, the biophysicists first excite the blue "input dye" using the corresponding light wavelength. The excited molecule in turn transfers parts of the excitation energy in the form of fluorescent radiation via FRET to another adjacent dye molecule.

Now we come to the key aspect of the DNA pinboard system: the green "jumping dye". For, depending on its position, this molecule directs the light energy either towards the red or towards the infrared output dye. The color of the output signal shows which route was selected.
With their novel approach Philip Tinnefeld's team of scientists has for the first time combined the use of DNA as supporting material with **single-molecule four-color spectroscopy**. This combination makes it possible to visually represent the switching of energy-transfer pathways. The DNA origami constructs provide numerous binding sites for other molecules, and therefore can be regarded as a molecular pinboard or "nano-board".

The four-color spectroscopy technique with alternating laser excitation can also provide detailed information on objects at the nanoscale, both in terms of their structure and their interactions. In addition, the novel technique is well suited for high-sensitivity analyses. For this purpose the scientists can adapt the system so that it can use light signals to detect the binding of a single molecule of a requested substance.

**Original publication:**

http://www.uni-muenchen.de

http://www.nano-initiative-munich.de