A Good Eye for Oxygen

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(PhysOrg.com) -- We cannot live without it; yet too much of it causes damage: oxygen is a critical component of many physiological and pathological processes in living cells. Oxygen deficiency in tissues is thus related to tumor growth, retinal damage from diabetes, and rheumatoid arthritis. It is thus important to determine the oxygen content of cells and tissues, which is a challenge to scientists.

A team led by Jason McNeill at Clemson University has now developed a new technique based on dye-doped nanoparticles. As reported in the journal *Angewandte Chemie*, they are able to carry out very sensitive quantitative oxygen determinations.

Nanoparticle-based oxygen sensors typically consist of phosphorescent dyes encapsulated by a polymer or silica gel particle to shield the dye from the cellular environment. The nanoparticles also intensify the radiation of the dye. The American researchers have now developed a new nanoparticle architecture: they used a polymer with a special π-conjugated electronic structure. The electrons can thus move more-or-less freely over the entire molecule.

The researchers used this polymer to produce nanoparticles that they doped with a platinum-porphyrin complex, an oxygen-sensitive phosphorescent dye. When irradiated, the polymer very efficiently absorbs the light energy and passes it on to the dye in “energy packets”. This results in phosphorescence that is five to ten times brighter than previous nanoparticle-based oxygen sensors. In comparison to conventional oxygen sensors, the light emitted is 1000 times brighter.

The particles are highly sensitive to oxygen: in nitrogen-saturated solution, the sensors initially glow intensely red. When oxygen is introduced, the dye interacts with it, reducing the phosphorescence. The more oxygen is present, the more the phosphorescence is quenched. The researchers were thus not only able to determine the concentration-dependence of the brightness, but also the lifetime of the phosphorescence: the duration of the dye's glow is dependent on the oxygen concentration.

The new sensor is sensitive enough to detect individual particles. Because the nanoparticles are easily taken up by cells, they are ideal for the quantitative description of the local oxygen concentrations in living cells and tissues.

More information: Jason McNeill, Ratiometric Single-Nanoparticle Oxygen Sensors for Biological Imaging, *Angewandte Chemie International Edition* 2009, 48, No. 15, 2741-2745, doi: 10.1002/anie.200805894

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