Technology Offer

Nanocapsule suitable for non-invasive simultaneous oxygen content and temperature sensing in a living object

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Background

Simultaneous sensing of oxygen content and temperature within a living object is crucial to monitor its biochemical reactions and to evaluate its health condition. Non-invasive sensors used for this purpose feature optical read-out. These sensors detect changes in phosphorescence (decay time or emission intensity) of a phosphorescent compound and the delayed fluorescence intensity of a fluorescent compound induced by an increase of temperature and/or oxygen. Unfortunately, the temperature and oxygen responses are interconnected and therefore influence each other and falsify the measured data. The fluorescence and phosphorescence properties of the sensing materials as well as their interactions with oxygen are strongly affected by the temperature variations. Moreover, the sensing induced formation of the highly reactive singlet oxygen in these systems not only affects but also harms the organism.

Technology

We offer a new approach for the non-invasive intracellular measurement of the temperature and oxygen content within a join measurement procedure. In contrast to other optical read-out based sensor materials, our sensing capsule includes two sensitizer compounds (or singlet oxygen generators), one emitter compound (fluorescence emitter) and a matrix that contains singlet oxygen scavenging compound (Fig. 1).

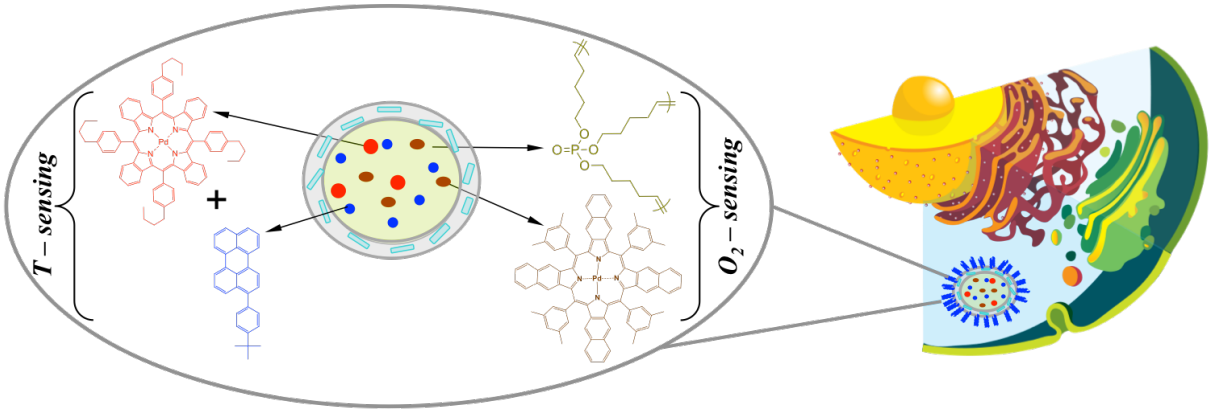

Fig. 1: Sketch of the sensing capsule and its sensing compounds and its implementation inside a living cell.

The two sensitizer and the emitter compound are chosen and combined in a specially way that their triplet energy bands are adjusted for different excitation and emission frequencies. The first sensitizer is completely energetically decoupled from the second sensitizer and the emitter in the way that their mutual non-emissive energy transfers is forbidden.

The corresponding energetic schemes and the sensing performance of this capsule are demonstrated in the Fig. 2.

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de

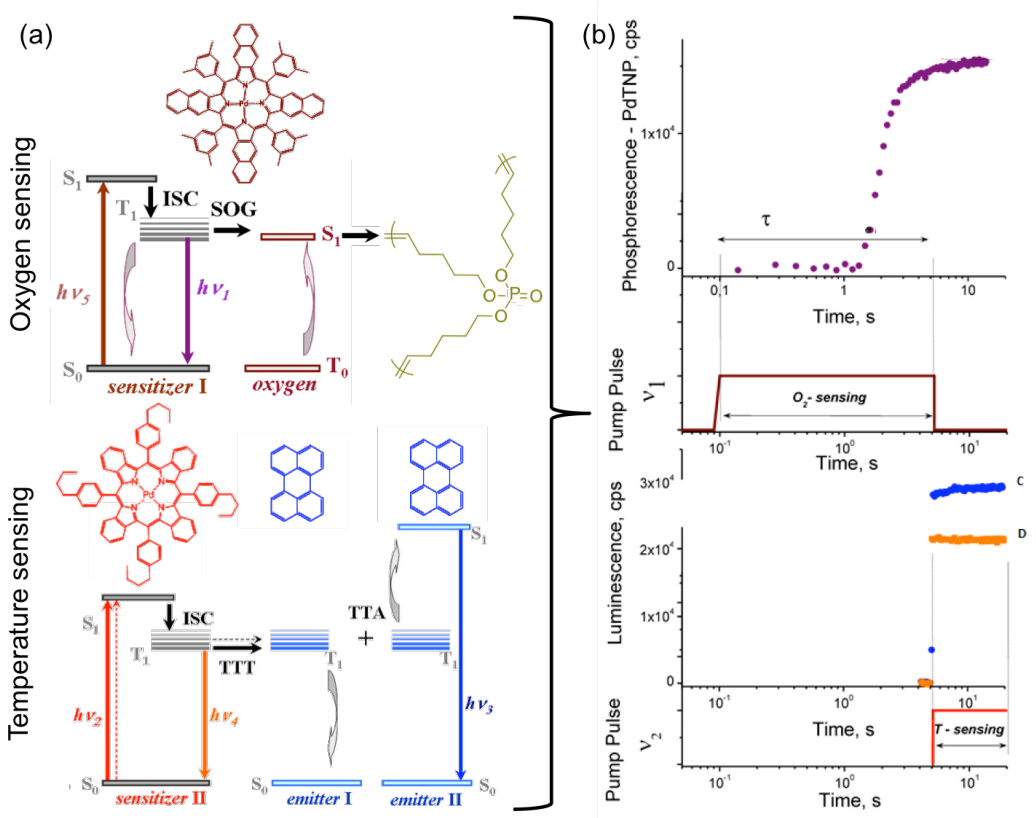

Fig. 2: (a) Simplified energetic schema for the oxygen and temperature measurement with the nanocapsule including PdTNP/PdTBP /perylene/paraffin wax/di(5-hexen-1-yl) phenyl phosphate.
(b) Time sequence of the probing optical signals in the nanocapsule.
Conditions for example measurement: c(O_2)=50 ppm, T=26°C, λ_5=704 nm, λ_2=635 nm

The measurement starts with the oxygen sensing by the irradiation of the first sensitizer (λ_5=704 nm). The generated singlet oxygen is immediately captured by the phosphate based scavenging compound and the light emission $h\nu_1$ can only be detected after the complete elimination of oxygen within the capsule. The initial oxygen concentration can be determined based on the excitation intensity and the delay of phosphorescence τ.

By the irradiation of the second sensitizer (λ_2=635 nm) in the now oxygen free capsule core, the energetically optimized annihilation couple sensitizer II/emitter reports the local temperature in a ratiometric-type optical response.

After the measurement, the oxygen equilibrium between the environment and the capsule core - which ratio can be adjusted by the design of the capsule shell - is reached within a time range of about 10 seconds.

Advantages

- Non-invasive, reliable determination of oxygen content and temperature within a living object with a single sensor
- Total measurement time around 600 ms (excitation intensity 1.5 Wcm^{-2})
- No auto-fluorescence or nutrition mixtures from the cell
- Elimination of the harmful singlet oxygen by its reaction inside the sensing capsule

Patent Information

EP patent application filed in March 2015.
PCT patent application filed in March 2016.

Contact

Dr. Lars Cuypers Senior Patent- & License Manager, Chemist
Phone: +49 (0)89 / 29 09 19 – 21
eMail: cuypers@max-planck-innovation.de

Max-Planck-Innovation GmbH
Arnulfstr. 58
80335 München
www.max-planck-innovation.de