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New Optical Sensing Materials for Application in Marine Research

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Optical chemosensors are versatile analytical tools which find application in numerous fields of science and technology. They proved to be a promising alternative to electrochemical methods and are applied increasingly often in marine research. However, not all state-of-the- art optical chemosensors are suitable for these demanding applications since they do not fully fulfil the requirements of high luminescence brightness, high chemical- and photochemical stability or their spectral properties are not adequate. Therefore, development of new advanced sensing materials is still of utmost importance.
Here we present a set of novel optical sensing materials recently developed in the Institute of Analytical Chemistry and Food Chemistry which are optimized for marine applications. Particularly, we present new NIR indicators and sensors for oxygen and pH which feature high brightness and low level of autofluorescence. The oxygen sensors rely on highly photostable metal complexes of benzoporphyrins and azabenzoporphyrins and enable several important applications such as simultaneous monitoring of oxygen and chlorophyll or ultra-fast oxygen monitoring (Eddy correlation). We also developed ulta-sensitive oxygen optodes which enable monitoring in nM range and are primary designed for investigation of oxygen minimum zones. The dynamic range of our new NIR pH indicators based on aza-BODIPY dyes is optimized for the marine environment. A highly sensitive NIR luminescent phosphor (chromium(III) doped yttrium aluminium borate) can be used for non-invasive temperature measurements. Notably, the oxygen, pH sensors and temperature sensors are fully compatible with the commercially available fiber-optic readers (Firesting from PyroScience). An optical CO_2 sensor for marine applications employs novel diketopyrrolopyrrol indicators and enables ratiometric imaging using a CCD camera. Oxygen, pH and temperature sensors suitable for lifetime and ratiometric imaging of analytes distribution are also realized.
To enable versatility of applications we also obtained a range of nano- and microparticles suitable for intra- and extracellular imaging of the above analytes. Bright ratiometric 2-photon-excitable probes were also developed. Magnetic microparticles are demonstrated to be very promising tools for imaging of oxygen, temperature and other parameters in biofilms, corals etc. since they combine the sensing function with the possibility of external manipulation.