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Cover Profile

Mix-&-Read Determination of Mercury(II) at Trace Levels with Hybrid Mesoporous Silica Materials Incorporating Fluorescent Probes by a Simple Mix-&-Load Technique

Dedicated to Dr. Norbert Jakubowski on the occasion of his 65th birthday

The group of Dr. Knut Rurack

BAM
Bundesanstalt für Materialforschung und -prüfung

Invited for this month's cover picture is the group of Dr. Knut Rurack at the Department of Analytical Chemistry; Reference Materials at the Bundesanstalt für Materialforschung und -prüfung (BAM) in Berlin (Germany). The cover picture shows how differences in color and fluorescence on a test strip can be easily read out with a mobile device. Two reference spots frame the sensitive spot that indicates the presence of trace amounts of Hg^{II} below the threshold in a natural water sample. This dipstick contains a hybrid material that combines boron-dipyrromethene (BODIPY) probes sterically loaded into specifically tailored mesoporous silica particles, allowing for ultrasensitive Hg^{II} detection through enhanced fluorescence in a few seconds. The applicability in real water samples and fish extracts are also studied. Read the full text of their Full Paper at 10.1002/open.201800277.

What are the key features of your research?

Our research is devoted to the development of simple analytical tools and assays for use outside of the laboratory, including chemical sensors, dipstick tests, microfluidic setups, robust laser-spectroscopic as well as mass and ion mobility spectrometric devices for the sensitive and selective detection of a wide variety of target species, including hazardous substances. Most of our chemical sensing systems utilize micro- or nanoparticles and thin films as vehicles for the indication of (bio)-chemistry, which can be sterically or covalently anchored to these scaffolds. Besides optical changes as the main mode of interrogation of our chemical sensors, we recently started with the integration of electrochemical detection. The main goal of our research is to combine fundamental science and embedding/interfacing knowledge with application-driven needs to develop advanced detection strategies that allow for simple, reliable, and robust analytical devices that can be used on-line, at-site, or in the field.

What prompted you to investigate this topic/problem?

The growing awareness of the population for food and water safety prompted us to develop simple and cheap tests for the selective detection of contaminants such as Hg^{II}, operating at the relevant trace levels set by legislative bodies in a reliable manner. As is well known, mercury is a bioaccumulating and highly toxic heavy metal that causes serious human health problems even at low concentrations. Disposable strip-based tests are one of the most appealing formats for everyday analytics, simplifying their use in random inspections or suspicious cases.

What was the biggest challenge (on the way to the results presented in this paper)?

BODIPY dyes, like the one used here as a molecular probe, became very popular in fluorescent indicator applications in recent decades because of their favorable spectroscopic properties. However, they usually require certain amounts of organic co-solvents to unfold these properties; in neat water, most are aggregated and show only weak fluorescence. The high popularity in academic research is, thus, not reflected in (commercial) applications of BODIPY probes directly in realistic samples. To overcome these problems, we decided to sterically embed the probes into mesoporous silica particles with tailored inner and/or outer surface. The biggest challenge was materials chemistry-related design, that is, the choice of a suitable chemical functionalization of the material's surface, an optimum pore size and particle diameter, as well as the amount of dye to be loaded into the host particles to avoid its aggregation yet proper fluorescence turn-on response of the analyte directly in water samples.

What future opportunities do you see (in the light of the results presented in this paper)?

Considering that our simple mix-&-read test strip assay is very appealing for the direct determination of trace amounts of mercury in real water and taking into account that a vast number of small-molecule probes for a large number of analytes that only operate in organic solvents have been reported in the literature over the last four decades, we think that reconsideration of promising examples of those probe molecules by incorporating them into suitably tailored nanomaterials according to our present approach might result in other potent indicator materials for comparatively simple analytical applications in real samples.