Online Monitoring of Water Contaminants with an Optical Biosensor

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Water contaminants are an emerging challenge in the water management. Devices that can continuously monitor on or at site and are needed in order to guarantee a fast reaction time to incidents. CSEM's WIOS (Wavelength Interrogated Optical Sensing) system is a label-free optical biosensor and has been applied for the analysis of biologic samples. This project aims at demonstrating that it can be adopted for measuring relevant water contaminants such as atrazine in a robust, fast and reliable way. The monitoring workflow comply with automated sampling of different water matrices (e.g. lake water, seawater, treated sewage water, drinking water). The biochip can be regenerated repeatedly and forms the basis of the robust and competitive WIOS monitoring system.

There are several well-established methods to detect and quantitate contaminants (e.g. pesticides, drugs) in drinking and surface water by bioanalytical means. Most of them require a laboratory environment with a dedicated and usually bulky instrumentation as well as specifically trained personnel (e.g. mass-spectrometry, ELISA). The aim of the presented project is the development of a bioassay platform with the following characteristics:

- Reliable detection of several water contaminants, with sensitivities within the regulatory scope, and a time to result of less than 1 hour.
- A user-friendly detection platform, featuring a high degree of automation allowing robust operation and autonomy. The detection platform has to be operated by personnel not specially trained in performing bioassays.
- Cost efficiency concerning instrumentation as well as consumables.

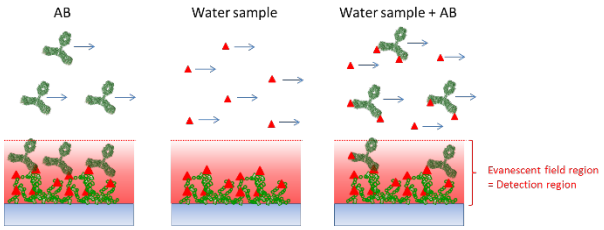

Figure 1: Schematic of the competitive ImmunoAssay on a label-free biosensor applied in this work.

The biosensing surface plays a crucial role in terms of stability, robustness and reproducibility of the system. Capture molecules (in particular small molecules) coupled to a dextran polymer (e.g. AtraDex) have been covalently bounded to the biochip surface using the OptoDex™ surface functionalization technology. The advantages are, (i) robust immobilization via multiple photobonding sites (mesh-like linking), (ii) well designable surface properties (e.g. density of capture molecules) and, (iii) suppression of non-specific binding due to the dextran basis of both, capture and cross-linker (OptoDex™) molecules.

In addition, AtraDex surfaces are very stable and a regeneration of more than 80 times is possible. These surfaces can be stored in buffer for at least 2 months and in dry state for at least one year without losing their properties. The synthesis of small molecules linked to dextran polymers seems therefore the method of choice also for other pesticides (or drugs) and water contaminants.

A competitive immunoassay (Figure 1) for the detection of atrazine has been developed and performed with the WIOS system (Figure 2). Figure 3 shows a calibration curve for the pesticide atrazine performed on the system. The sensitivity of the instrument was shown to be below 10^{-6} refractive index units for bulk refractometry and the limit of detection for the adsorption of small molecules corresponded to a surface coverage of 0.3 pg/mm^2. On the system, eight channels are available and can be measured simultaneously allowing the analyses of several contaminants including controls in parallel.

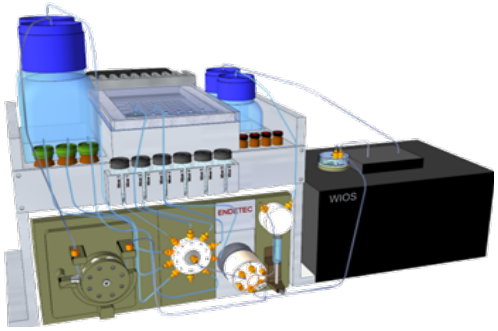

Figure 2: Schematic view of the WIOS system (right) and the automatic fluidic and sample preparation system (left).

In summary, the system allows to monitor online water contaminants with the following properties:

- Label-free sensing with WIOS
- Competitive immunoassay (antigen linked to surface)
- Multiple sensing surfaces (different characteristics)
- In-assay calibration/normalization
- Regenerative biochip (>80 times)
- Low detection limit of analyte (0.02 µg/L)
- Compensation of interfering effects

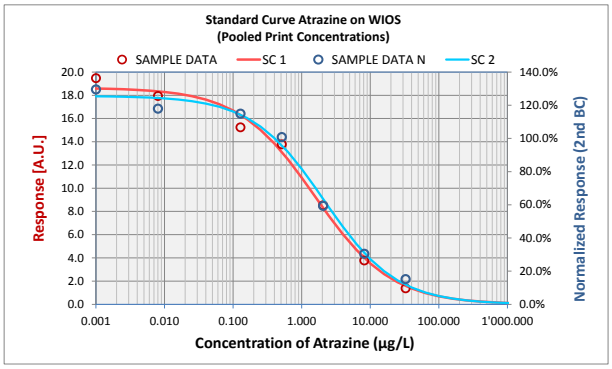

Figure 3: Fitted standard curve of atrazine measured on the WIOS system. Red fit: curve corresponds to response values without built-in calibration (in arbitrary WIOS units, left y-axis). Blue fit: calibrated with built-in calibration (in %, right y-axis) using a second response curve in the assay.