Reconfigurable Optical Waveguide Multi-Analyte System for River Water Pollution Monitoring

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Research on fluorescence-based integrated optical immunoassay multisensing systems has gained growing interest in the last ten years because these sensors offer high sensitivity and good specificity, can simultaneously detect multiple analytes in a single measurement and are fast, robust and cost-effective [1-5]. Therefore they have the potential to replace conventional chromatographic techniques as the monitoring systems for the rapid assessment of pollution in water. These highly multiplexed analytical systems are also in demand in other fields such as clinical diagnostics and forensic science. This research work presents advances in multi-analyte integrated optical fluorescence-based sensors, their integration into a novel, reconfigurable, multi-bio-sensing system and their use in detecting organic pollutants in river water.

A fibre-pigtailed sensor chip consisting of a channel waveguide circuit which distributes evanescent excitation light to 32 separate sensing patches on the chip surface, as described previously [1] and shown in Fig 1, is used. Surface immunochemical techniques were used to sensitise individual patches to a specific analyte and a microfluidic system is used to automatically handle the sample injection over the sensor surface. Software controls the laser, fluidics, data acquisition and processing of the fluorescence signals. In our previous work [1-3] a fibre-coupled photodiode detection array monitored the 32 separate fluorescence signals, using 32 separate detectors and filters. In the work described here, to improve system flexibility for expansion in the number of analytes, to lower detection limit and to reduce cost for multi-analyte systems, we have realised an improved system configuration, in which the multiple filters and photodetectors are replaced by a single filter and CCD array, as shown in Fig 2.

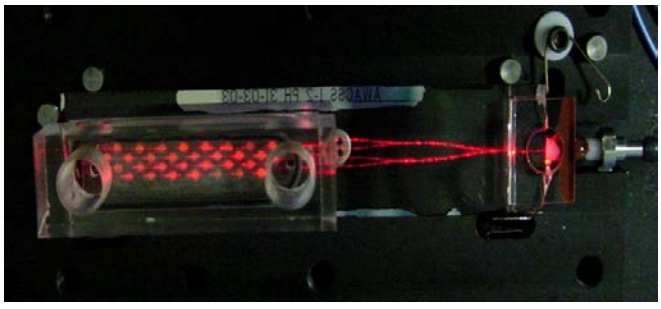

Fig. 1 Multianalyte sensor chip with flow cell attached [1]

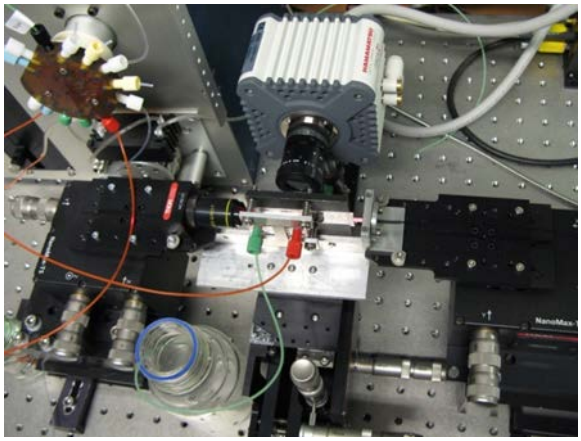

Fig 2 CCD-based detection system

The photodetector-based sensing system was characterised for a single analyte, estrone, and a limit of detection (LOD) below 1 ng/L in water was achieved [1]. It was then applied to atrazine, bisphenol A, estrone, isoproturon, sulphamethizole, and propanil and LODs below 20 ng/L were achieved for all six analytes [2,3]. Now, a direct experimental and theoretical comparison between the fibre-based and CCD-based systems has been carried out, and the CCD system shows a limit of detection about one order of magnitude better than the fibre array collection system.

We have demonstrated a simplified instrument prototype for use with integrated optical fluoroimmunoassay chips where the detection limit has been improved and flexibility to use redesigned chips with more analytes or for a different application has been introduced. It is expected that this approach will find widespread application in environmental monitoring and in clinical diagnostics.

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