COMPACT OPTOCHEMICAL SYSTEM BASED ON PLANAR WAVEGUIDE SENSORS

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Recently some Integrated Waveguide absorbance optodes (IWAOs) have been proposed by our research group [1-3]. Such devices consists of the same chemically active membrane than conventional configurations but deposited over a microfabricated planar waveguide circuit, constructed IC technology. The optical membrane works as the selective recognition region while acts as part of the light guiding planar structure.
As guided light path is transverse to the diffusion direction of the analyte through the membrane, sensitivity is enhanced while do not compromise the response time. IWAOs are sensing platforms, which confer versatility, robustness and mass production capabilities besides high sensitivity on conventional bulk optodes.
However, for the feasible application of such sensors in field, a more compact, portable and automated system is needed as well as mass production exchangeable transducers.
In this work we report a novel compact optochemical analyser, which uses new IWAOs constructed with silicon micromachining for their easy exchangeability. The set-up includes two different light sources, one being used as a reference signal to correct any deviation due to unspecific optical interferences (Figure 1).

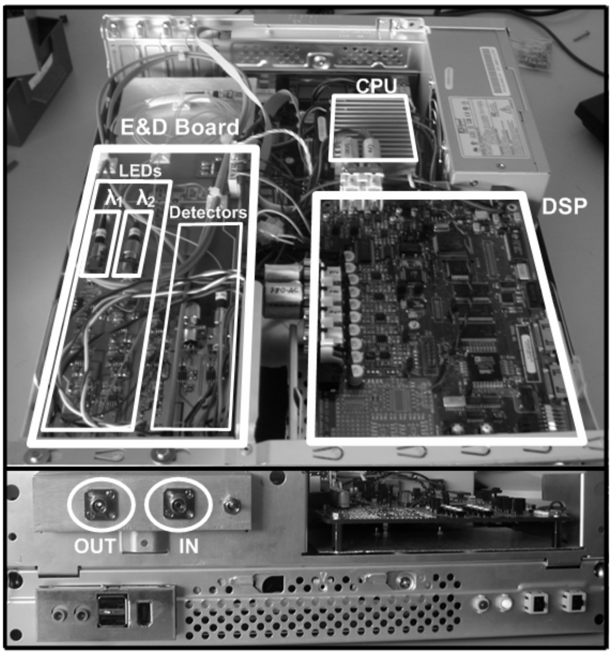

Figure 1: Photograph of the compact optochemical analyser and its main parts.

One of the innovations of the optochemical system is the use of an additional wavelength, which provides a reference signal to correct any variation in the sensing signal, which is not attributable to absorbance. Therefore, two wavelengths are injected

in the fibre, propagated through the sensor and received at the detector. Therefore, in order to separate signals, the LED sources are modulated at different frequencies f_{Ref} and f_{Abs}, and two lock-in amplifiers take the signals corresponding to each frequency meanwhile filters the other one. The lock-in amplifiers have been designed and fabricated in the research group and are included in the emission and reception electronic system, which is controlled by a PC via an RS232 line.
The advantage is that new calibrations can be avoided when measurement conditions such as optical power or refractive index variations are altered.
In order to optimise the system performance, a calcium selective IWAO has been proposed as a potential example for the determination of calcium ion in biomedical, environmental fields or industrial processes. In this way, we have developed a calcium-selective membrane combining a previously characterized ketocyanine dye with a commercially available calcium ionophore (Figure 2). The absorbance maximum of the ketocyanine dye is close to the wavelength of the working LED (780 nm), it shows a high molar absorptivity and no absorption bands at the wavelength of the reference LED is observed.

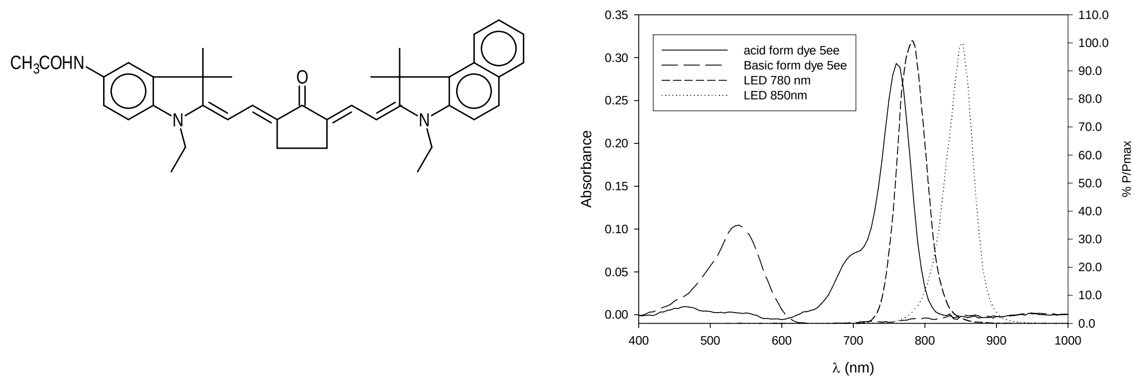

Figure 2: Chemical structure of the ketocyanine dye and localisation of the absorption bands of the dye and the emission LEDs.

Other instrumental improvement is the fabrication of the transducer and its support in order that it can be easily exchangeable. The use of silicon micromachining can assure the size of the transducer with high precision. Three main parts of the sensor can be distinguished (Figure 3): (1) the transducer based on a curved planar waveguide, where the optical sensing membrane is deposited on, (2) the V-grooved auxiliary support, where the optical fibres are fixed, and (3) the connection platform, which permits the alignment of the transducer waveguides to the optical fibres, by simply laying and clicking a new transducer.

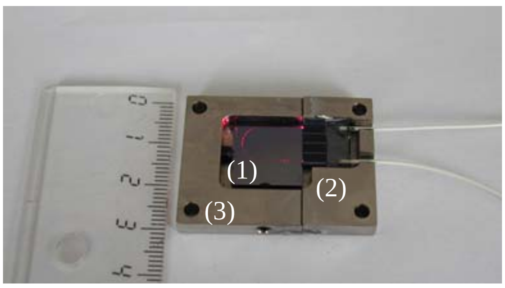

Figure 3: Photograph of the new improved IWAOs.

To demonstrate the possibilities offered by the use of the compact optochemical sensor, an IWAO has been activated with the calcium bulk optode. Optical membranes have been previously characterized with a conventional absorbance flow cell in a Flow Injection Analysis (FIA) system to perform a comparative study of the analytical response.

Although it was previously demonstrated that using the planar configuration it is possible to avoid interferences from the solution matrix, it has been noticed that the refractive index of the membrane changes while it is hydrated at the beginning of the experiments. This optical interference can be corrected using the new miniaturised analyser as the guiding properties of both wavelengths vary in the same manner due to changes of the refractive index. Figure 4 shows an example of the correction comparing the obtained direct signal with the corrected one by using the reference wavelength at 850 nm.

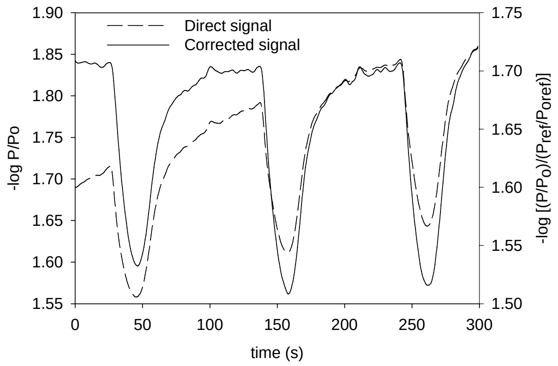

Figure 4: Recorded signals at the beginning of the membrane hydration. A sample of $1x10^{-3}$ M $CaCl_2$ is injected in triplicate at the optimised hydrodynamic parameters.

All the obtained results related to the chemical characterisation of the membrane will be presented.

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