Study of Luminol Electrochemiluminescence with a Planar Optical Waveguide for Peroxide Sensor Application.

J. Kremeskötter#, R. Wilson#, D.J. Schiffrin#, B.J. Luff*, and J.S. Wilkinson*

Department of Chemistry, Liverpool University, L69 3BX, UK
Tel.: #44 51 794 3552, Fax: #44 51 794 3588
* Optoelectronics Research Centre, Southampton, UK
Tel.: #44 703 59 2792, Fax: #44 703 59 3149

The work presented in this paper is aiming at the development of a highly sensitive, specific, cheap and widely applicable new sensor based on the combination of optical and electrochemical techniques.

The new device described here is a planar optical waveguide coated with an indium tin oxide (ITO) film and is shown in Fig. 1. The ITO is electrically conductive and serves as an optically transparent electrode.

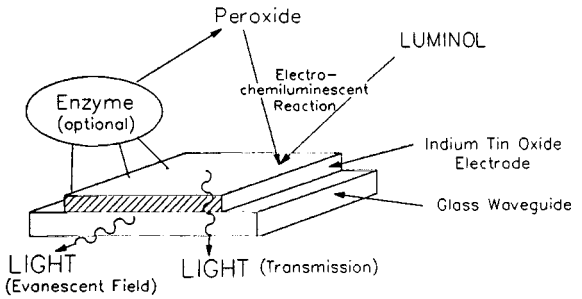

Fig. 1 Schematic diagram of the planar optical waveguide device for ECL-sensor application.

The purpose of the ITO is to act as the working electrode in a standard three electrode setup to trigger electrochemiluminescence (ECL). The waveguide is used to collect photons due to ECL, which are generated very close to the electrode surface, because only those generated within the range of the evanescent field of the waveguide can couple in it.[1] By measuring the incoupled light intensity the concentration of a component linked to the ECL reaction can be detected.

The luminol/peroxide ECL reaction was used in this study. Both reactants can be used in connection with biological systems which make the device very versatile and highly specific. Peroxide can be generated by a large number of enzymes (peroxidases), while luminol can be used as a label for proteins and immuno-chemical systems.[2] Light detection can be performed at the level of single photon counting and therefore offers high sensitivity.

ECL occurs if the product of the electrochemical oxidation of luminol reacts with peroxide to form an electronically exited state that emits light upon relaxation. When only luminol and peroxide are present in aqueous buffered solution in an electrochemical cell and no electrode reaction takes place (E = 0 V *versus* SCE), the rate of luminol oxidation by peroxide is very low and therefore the amount of light generated is very low. If the electrode potential is switched to a value where luminol is partially oxidized (E ≥ 0.7 V *versus* SCE), the electrode product reacts very quickly with peroxide to generate light.

In addition to the analytically valuable information of light intensity generated, the light transient resulting from a double potential step experiment contains kinetic information for both the electrochemical step as well as for the successive diffusion and chemical steps in the reaction layer. The comparison of transients due to short range waveguide-evanescent field coupling as shown in Fig. 2 and those obtained by measuring light over the full depth of the diffusion layer in Fig. 3 can be used to obtain such information.

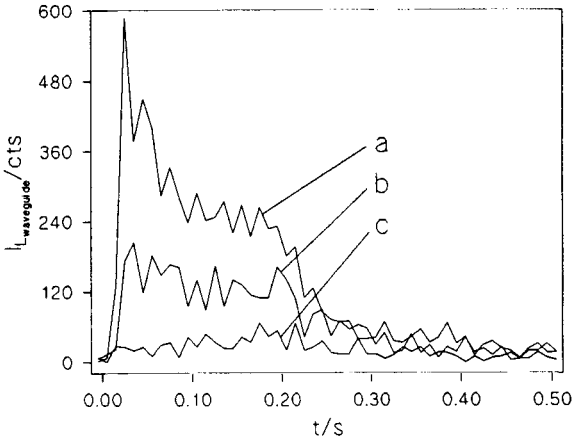

Fig. 2 ECL transient for a 0.2 s potential pulse due to evanescent field coupling. 0.1 M NaCl, 0.1 M sodium phosphate buffer, pH 8.0, 50 μM Luminol, 1 μM Peroxide, pulse potential (V *versus* SCE): a=1.6; b=1.4, c=1.2.

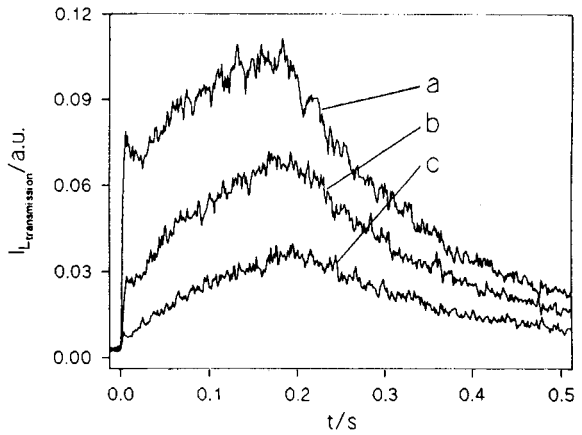

Fig. 3 ECL transient measured in transmission through the waveguide. See Fig. 2 for details.

By varying the pH, the amplitude and length of the potential pulse as well as the concentration of the reactants the reaction mechanism can be analysed and compared to transients calculated by finite differences-based computer simulation,[3] based on reaction and diffusion models.

References

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2. M.A. DeLuca and W.D. McElroy (Eds.), *Methods in Enzymology*, Vol. 133.
3. D. Britz, *Digital Simulation in Electrochemistry*, 2nd Ed., Springer Verlag 1988.