Wound Healing Monitoring System Integrating Plastic Optical Fibre Sensors

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A system was developed for the remote monitoring of pH and metalloproteinase in a wound dressing composed of biosensing plastic optical fibres and a modular electronic system.

In the frame of the Nano-Tera project TecInTex [1], a system for monitoring several biomarkers in a wound was developed. The ultimate goal is to monitor the wound healing process remotely and without intervention. It is not only necessary to develop sensors compatible with the dressing format to be in contact with the wound but also to develop the electronic system that will have to be close to the patient and even be worn. The electronic system comprises an interface to the sensors, processes the signals to obtain relevant information, records the data that will be examined later and also sends the most relevant information to the physician in charge of the patient by a wireless link. A modular system was designed: it is composed of plastic optical fibre sensors, a sensor interface board that is adapted to the nature of the sensors and a main board comprising the microprocessor, memory and communication interfaces.

After a skin injury, the wound healing process takes place and follows successive main phases: inflammation, proliferation and remodelling. During these wound healing phases, different biological processes occur and can be monitored by measuring the concentration of relevant biomarkers. This project focuses on two biomarkers: pH for inflammation status and matrix metalloproteinase (MMP) for the proliferation status. Therefore two types of fibres were developed for the biomarkers monitoring [2]. Biosensing optical fibres measure optical changes within a sensing layer chemically grafted around the fibre core. A light source and a detector are placed at both extremities of the fibres to detect the changes in absorption induced by the sensitive layer.

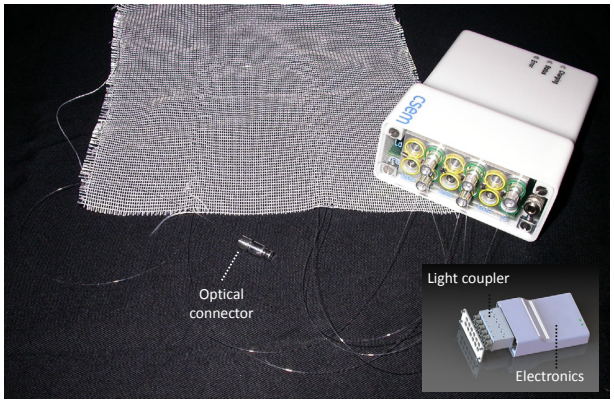

Figure 1: Wound healing monitoring system

The electronic system was developed to control 6 optical fibres simultaneously. The sensor interface board consists of an optical duplexer to inject two different wavelengths in the fibre and a photodiode to receive the transmitted signal through the fibre. At one wavelength, the absorption changes with pH or MMP concentration, the other is used as a reference. The main board controls the illumination and the measurement of the intensity of light at the output of the optical fibre. The microprocessor allows more flexibility in the type of illumination sequences that are adapted to each application. The measurement of the photodiode voltage is done by the analogue chain. For each wavelength and for no illumination (dark), a sample and hold circuit captures the voltage of the photodiode. The data are then processed in real time in the microcontroller to obtain the pH value and the protease activity.

Communication with a remote computer is done via USB or via Bluetooth (BT) to either control the device or stream the data. In addition, to guarantee the integrity of the data when neither USB nor BT communication is available, all data are saved locally on a SD Card. The system is powered by a Li-Polymer battery which is automatically recharged with the help of the USB link. Electronic components were packaged in the box shown on Figure 1.

A user interface was developed in JAVA to operate the system from a remote computer. It communicates through Bluetooth and allows streaming the data in real time and starting or stopping the recording on the SD card. While data is streamed, it is displayed and recorded on the remote computer for further analysis. It is also possible to send the calibration values for each fibre. An example of the data recorded on three pH sensitive fibres is presented on Figure 2.

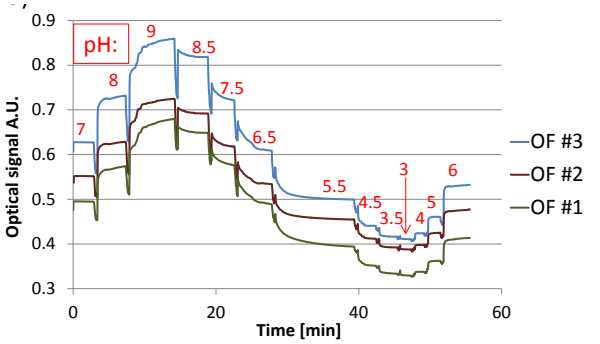

Figure 2: Simultaneous measurement of different pH sensitive fibres

Because of the increasing health care cost and the ageing of the population, remote nursing of patients will become increasingly popular. In this perspective, a modular system for wound healing monitoring was developed. It allows easy adaptation to different sensors. After successful development for the measurement of pH and MMP, it is now being adapted for measurement of sensors integrated in underwear for a paraplegic in order to prevent the apparition of pressure ulcers.

This work was done in the frame of the Nano-Tera program and CSEM thanks them for their support.

[1] www.nano-tera.ch/projects/69.ph

[2] B. Schyrr, E. Scolan, R. Afshar, S. Pasche, G. Voirin, “Optical Fibre Functionalization for Measurement of pH and Matrix Metalloproteinases (MMPs) in Wound Dressing”, this report page 52