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TecInTex RTD 2009

FNSNF

Smart system for advanced wound management

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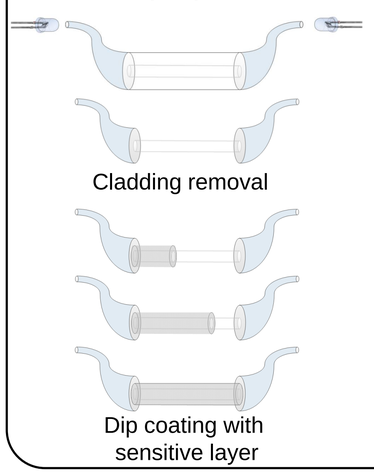
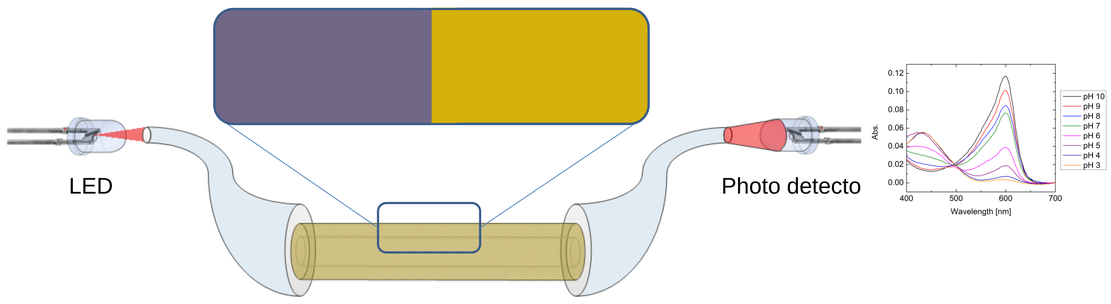
One of the TecInTex ideas was to develop biosensing optical fibers with the adapted electronic device for monitoring parameters on the skin before or after the formation of ulcers. The development of smart wound dressings for real-time supervision of wounds in ambulatory care is important for the early detection of tissue transformation indicative of wound pathologies (chronic wounds, infection, …), and assessment of the wound healing process and the response to treatments. A portable electronic device for monitoring the signals of several fibers was developed together with optical fibers sensitive to pH and the activity of matrix metalloproteinases (MMP), two relevant parameters for wound care management

System principle

Biosensing optical fibers

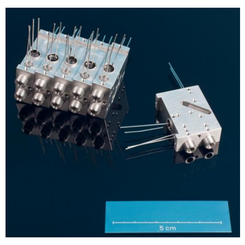
Fiber preparation



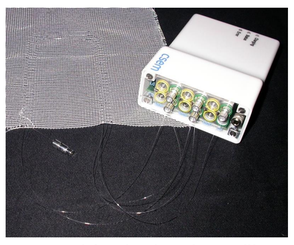


Plastic optical fibers were modified: a part of the cladding is removed and replaced by a sensitive colored coating. When it reacts with the target species the coating changes color. When light is coupled in the fiber, the color of the coating affect the transmitted spectrum

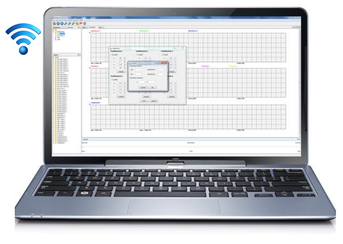
System



Optical duplexer



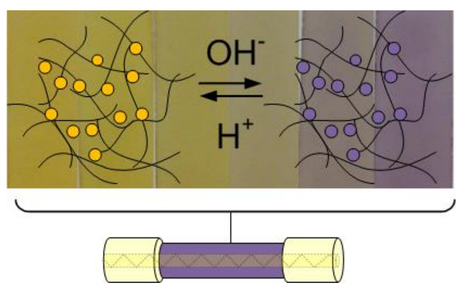
Portable device for 6 fibers with wireless communication



An optical duplexer is used to couple two wavelengths in the fiber (reference and measurement signals). An autonomous portable electronic system is able to process the signal of 6 fibers in parallel, record them or transmit them wirelessly to a computer

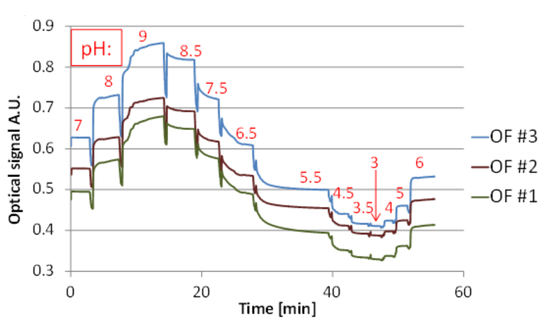
pH

Sensing layer

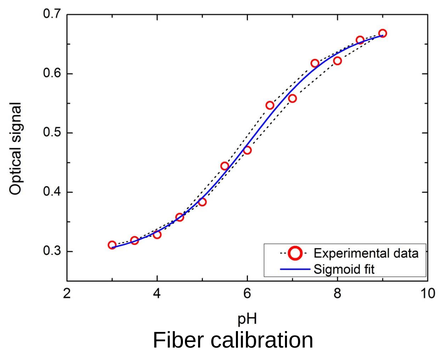


The sensitive coating is made with a dye-doped ORganically Modified Silica (ORMOSIL) films that provides high dye entrapment efficiency (Bromophenol Blue)

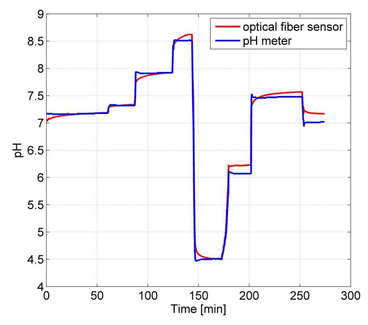
Measurements



Data acquisition



Fiber calibration



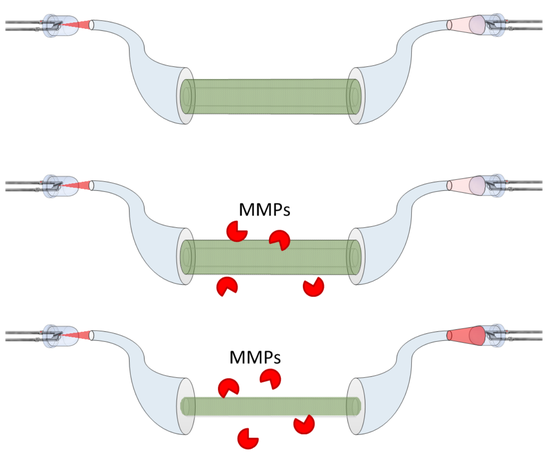
pH monitoring

The system allows to acquire the signal of up to 3 pH sensitive optical fibers. With each of them it is possible to monitor the pH in a relevant biological range and with good accuracy

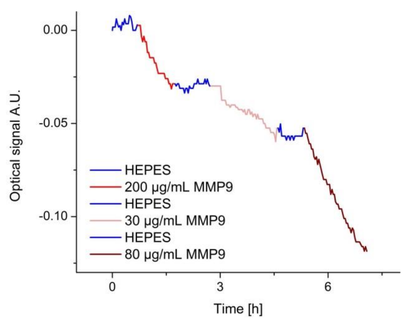
Performances	
pH Range	3-9
Accuracy	0.2
Response time	10 min
Stable in human serum	

Matrix metalloproteinases MMPs

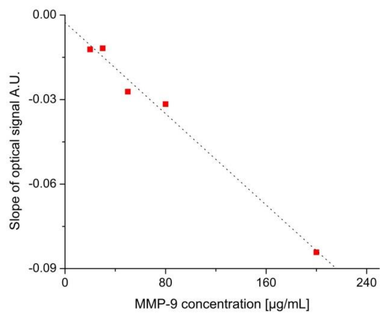
Sensing layer 1



The sensitive coating 1 is made with a stained gelatin coating. This coating can be digested by several MMPs present in wound fluid. When the coatin is degraded, its absorption decreases. By analysing the slope of the optical signal variation, it is possible to estimate the MMP concentration in the tested fluid.

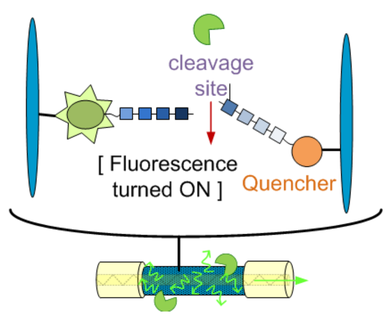


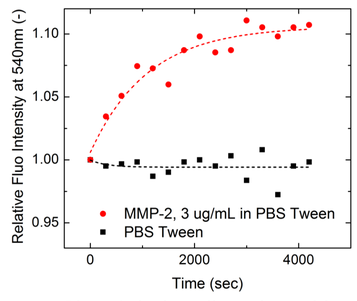
Real-time optical monitoring of enzymatic acitivity



Extracted calibration curve

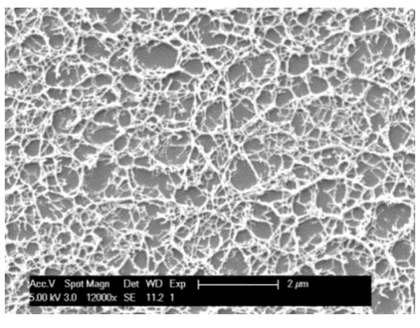
Sensing layer 2





Signal during digestion with MMP-2 at 3 µg/ml

The sensitive coating 2 is made with a nanostructured cellulose film functionalized with a fluorogenic peptide sequence. MMP-2 present in wound fluid cleaves the peptides and fluorescence signal increases. Cellulose nanoporous layer is used to increase the effective area and for surface functionalization.



SEM of cellulose porous layer

Results	
Range (layer 1)	up to 200 µg/ml
LOD (layer 1)	down to 2 µg/ml
Generic for gelatinase (sensing layer 1)	
Specific for MMP-2 (sensing layer 2)	
Stable in human serum	
Low cost (gelatin-based coating), single use	

Outlook

In order to be able to perform measurements directly on skin or in wound, special plastic optical fibers were developed in combination with a portable electronic device able to measure simultaneously up to 6 fibers. Two measurements were targeted: pH on skin and in wounds as a marker of infection and MMPs in wound fluids as a marker of non-healing (chronic) wounds. The functionality of the sensing device was demonstrated with performances relevant for the skin and wound healing monitoring application