UV sensor for continuous monitoring of BTEX compounds in groundwater

Rachel GONZALEZ [1,2*], Benoît HEINRICHS [2], Sophie PIRARD [1]

[1]Haute école Libre Mosanne – Centre de Recherches des Instituts Groupés, 27 Quai du Condroz - Angleur – Belgium.
[2]University of Liège – Department of Chemical Engineering - Nanomaterials, Catalysis, Electrochemistry, 11-13 Allée du 6 Août- Sart-Tilman – Belgium.

*(r.gonzalez@uliege.be)

Keywords: *BTEX compounds, optical fiber, evanescent wave spectroscopy, PDMS, adsorption.*

Benzene, toluene, ethylbenzene, and xylene (BTEX) are highly toxic compounds. Analytical methods such as GC-FID are currently used to measure their concentrations in groundwater [1]. Although very sensitive, these methods are expensive, time-consuming, and based on a periodical sampling of water. Optical fiber sensors based on evanescent wave absorption spectroscopy could be a real-time in-situ low-cost alternative to quantify BTEX in water.

Optical fibers are made of three layers: (1) an external protective layer, (2) a fluorine-doped silica glass cladding, and (3) a pure silica core. Light can be transmitted along the optical fiber by total internal reflection. However, at the cladding-core interface, evanescent waves propagate in the normal direction and decrease exponentially with the distance beyond the core surface [2]. By removing the cladding layer, the evanescent waves can interact directly with the surrounding medium. Thus, if a cladding-free optical fiber is immersed in a medium which contains analytes that absorb light, a decrease of the signal transmitted along the fiber may be detected.

The aim of the present work is to develop an optical fiber sensor using evanescent wave spectroscopy absorption in the UV wavelength range to measure BTEX concentrations in groundwater in a monitoring mode. The sensitivity of the sensor is expected to be less than 1 ppm. To reach this goal, a polydimethylsiloxane layer is deposited on the core surface of the cladding-free optical fibers by dip-coating. This material has a great affinity with BTEX compounds which adsorb on its surface [3]. The coating concentrates BTEX near the core surface and allows a sensitivity increase of the sensor.

Last experiments show promising results as a signal loss was detected for a solution of 1 ppm of ethylbenzene. In addition, a first calibration curve has been drafted from 1 ppm to 16 ppm and a linear dependency between the signal loss and the concentration of ethylbenzene was observed. The study of the sensor repeatability and the enhancement of its sensitivity are in progress.

References :

[1] Silva, L., Panteleitchouk, A., Freitas, A., Rocha-Santos, T., & Duarte, A. (2009). Microscale optical fibre sensor for BTEX monitoring in landfill leachate. *Analytical Methods*, *1*(2), 100. doi: 10.1039/b9ay00077a

[2] Messica, A., Greenstein, A., & Katzir, A. (1996). Theory of fiber-optic, evanescent-wave spectroscopy and sensors. *Applied Optics*, *35*(13), 2274. doi: 10.1364/ao.35.002274

[3] Chao, K., Wang, V., Yang, H., & Wang, C. (2011). Estimation of effective diffusion coefficients for benzene and toluene in PDMS for direct solid phase microextraction. *Polymer Testing*, *30*(5), 501-508. doi: 10.1016/j.polymertesting.2011.04.004

Acknowledgements:

The authors are grateful to the Walloon Region for the funding of the project (Win2Wal) and to the project partners (Be-Sens, GEOLYS and GEO3) for their advice and expertise.

Figure 1: *Cladding-free optical fiber (up) and polydimethylsiloxane coated optical fiber (down).*

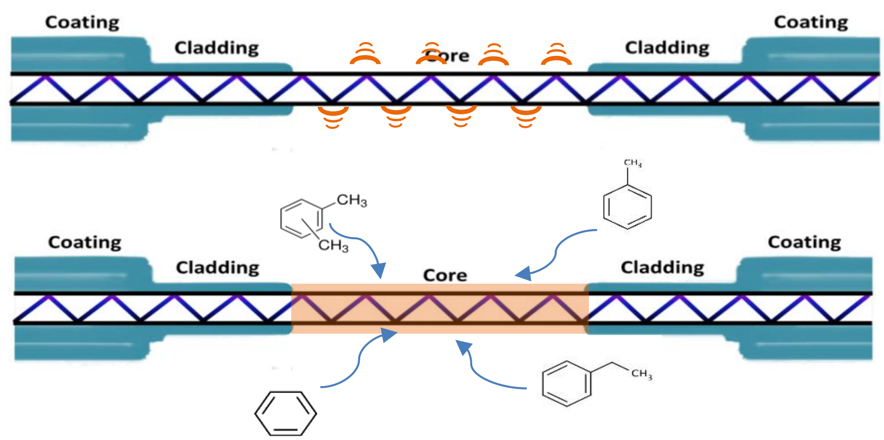

Figure 2*: Successive additions of ethylbenzene in water. Each drop of the signal occurs when the pollutant is injected. The concentration of ethylbenzene in the cell test after each injection is given in the graph (bellow each plateau).*