Characterization of a novel dissolved CO_2 sensor for utilization in environmental monitoring and aquaculture industry

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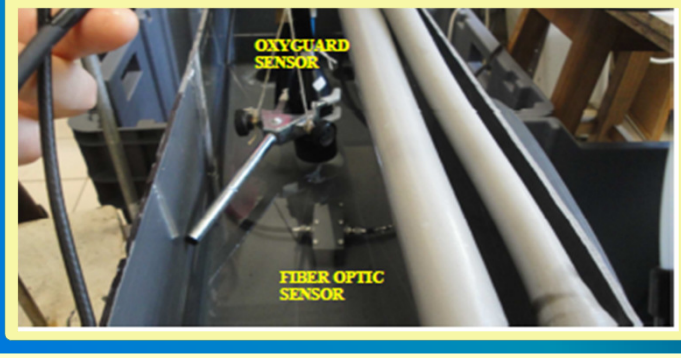
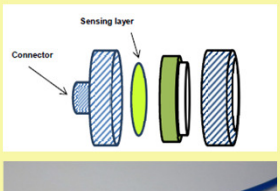
Abstract

A novel optical fiber sensor is presented for measuring dissolved CO2 for water quality monitoring applications, where the optical signal is based either on refractive index changes or on color change. A commercially available partial-pressure- NDIR sensor was used as a reference for dissolved CO2 tests with the new optical fiber sensor under development. Preliminary tests allowed verifying the suitability of the new optical sensor for accurately tracking the dissolved carbon dioxide concentration in a suitable operation range



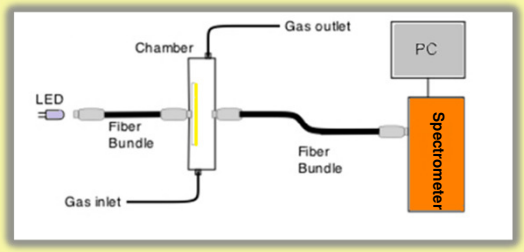


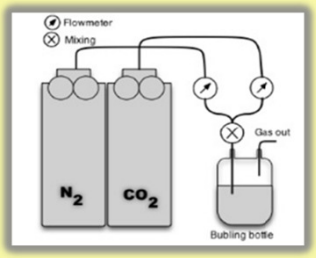
Sensor fabrication

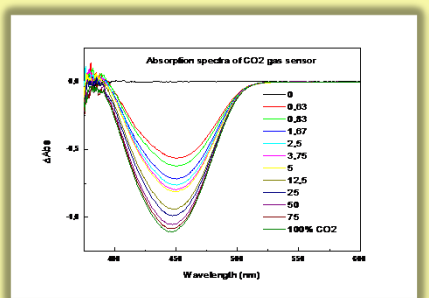
Optimized sensing layers were prepared by form 4-nitrophenol dissolved in tetrahydrofuran, Hydrogel-D4, quaternary ammonium hydroxide and polyurethane. The cocktail was spread on Mylar foil by spin-coating and allowed to dry for 2 hours. After drying a layer of silicone was spread on the membrane by using spin-coater. For dissolved CO_2 measurements, calibration sodium carbonate solutions were prepared between 0 and 50 ppm.

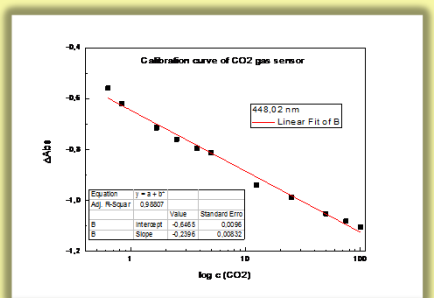
Instrumentation

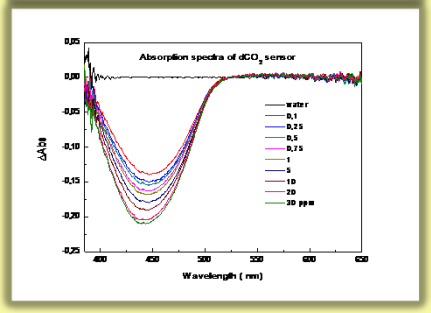
The calibration of the sensing membrane for colorimetric measurements was performed using a fiber optic CCD spectrometer, fiber optic bundles and a 430 nm violet LED. Absorption and reflection based colorimetric measurements were used for testing the sensor. The sensor film was placed into different sensing-heads inside the test chamber and connected to illumination/detection via optical fibers. To control the test chamber atmosphere, gas mixtures (N2/CO2) were prepared in a setup using precision rotameters and a bubbling system to attain nearly 100% humidity at all times during the gaseous phase measurements. The sensors were tested both in reflection and transmission configurations using optical fiber sensing heads specially designed for such purpose.

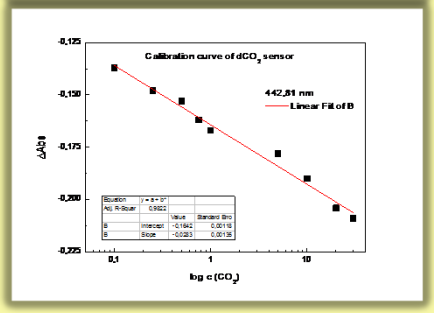








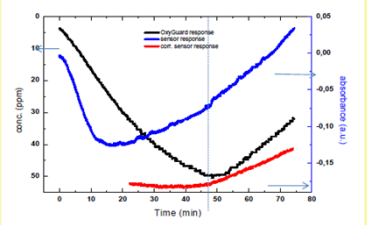




Conclusions

In this work, new sensor technology was investigated to be used as an alternative for state of the art commercial dCO2 probe for aquaculture applications, where important limitations were previously identified. A polymer based sensitive layer for carbon dioxide measurement was presented. The results show the decrease of absorbance in the presence of carbon dioxide. The response time was 120s and the resolution of 0.2% was estimated. These results show the viability of a carbon dioxide optical measurement using the phenol-based membrane with the application of colorimetric based configurations. Prototype tanks of the shallow raceway type were successfully implemented that will be used for the full characterization of the sensors in aquaculture applications,

Preliminary test results



The optical sensor response, with ratiometric detection, showed faster response time and accurate tracking of dCO2 concentration changes

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