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Abstract

Colour Catcher®: A Low-Cost Support for Developing Colorimetric Sensors for PFOA Detection †

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Abstract: In this work, we report the development of an optical sensor based on the colour variation of a silicon corrole upon interaction with specific emerging pollutants belonging to the PFAS family in water samples. The solid support on which the receptor is deposited consists of Colour Catcher® paper strips. An optical portable platform composed of low-cost electronic devices, such as an LED as a light source and a webcam as a detector, was developed to digitalize the strip colour changes during the measurements. This instrument is able to perform in situ analysis of water sources to determine the perfluoroalkyl substance (PFASs) content. Data analysis using the hue parameter allowed for the calculation, with great sensitivity, of the PFOA concentration depending on colour changes.

Keywords: colorimetric sensor; porphyrinoids; emerging pollutants; PFAS; PFOA

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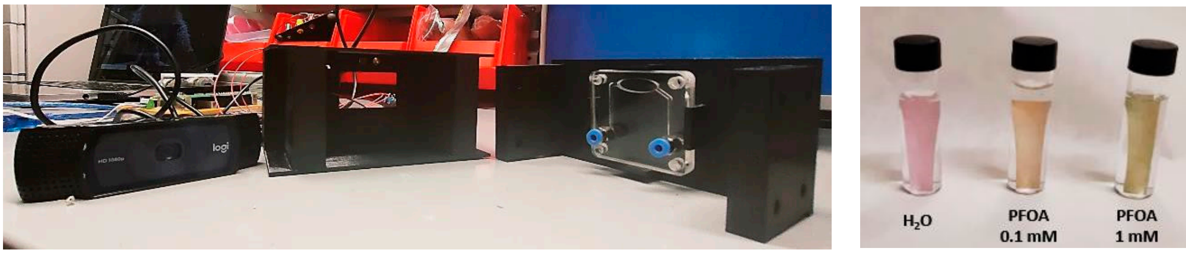
1. Introduction

Colour Catcher® (*CC*) is commonly used to prevent the release of textile dyes by clothes when washing laundry. *CC* is made of a cationic polymer and acts as an electrostatic trap for catching common negatively charged pigments. Due to this property, *CC* has been successfully used in the colorimetric sensor field as a solid support, anchoring commercial negatively charged receptors [1]. Nowadays, great interest is inspired by colorimetric sensors intended for environmental monitoring thanks to their properties: fast responses, good sensitivity, low-cost equipment, and easy signal acquisition. In this work, we developed innovative deposition protocols to anchor a silicon corrole [SiTTC(OH)] onto a *CC*, a sensing material belonging to the wide class of porphyinoids. The use of a novel PT-like instrumental setup (Figure 1a), employing a peristaltic pump, allowed the development of a low-cost sensor device able to perform in situ analysis of water samples with good reproducibility, high sensitivity, and a very low LOD [2,3].



(**a**) (**b**)

Figure 1. (**a**) The PT-like instrument setup used for optical measurements (webcam, LED, and homemade holder). (**b**) The optical responses of the *CC*-SiTTC(OH), ordered from left to right: distilled water, PFOA (0.1 mM), and PFOA (1 mM).

2. Materials and Methods

(Hydroxy)[5,10,15-tritolylcorrolato]silicon, [SiTTC(OH)] was synthesized in accordance with the literature [2]. HgCl2, NaF, and PFOA (Sigma Aldrich, St. Louis, MO, USA) are commercially available. Colour Catcher® (*CC*), distributed in Italy by Grey (Henkel Company, Düsseldorf, Germany), was bought in an Italian supermarket. A white LED was connected to the bench power supply. A digital camera, Philips SPC900NC, with a resolution of 352 $\times$ 288 pixels was used for recording the optical response. For flow measurement, a peristaltic pump PBI—international MS-Reglo—was used, setting the flow rate at 6.5 mL/min.

3. Discussion

The innovative specific deposition protocol involves a SiTTC(OH) immersion solution prepared using a H2O/EtOH mixture as solvent [3]; this method allows the mechanical immobilization of the neutral silicon receptors between the fibres on the *CC* strips, although the molecular structure does not present negative charges like typical commercial dyes. The indicator strips were utilized in optical measurements using a novel PT-like instrument setup (Figure 1a), which was able to record colorimetric variations upon the specific interaction between SiTTC(OH) and PFOA. In the mechanism for PFOA sensing, the silicon corrole axially coordinates the carboxyl group of the perfluoroalkyl chain, which initiates the aggregation process through the F-F interactions between the different units of PFOA axially coordinated to the receptor. The aggregation process leads to a colorimetric variation (Figure 1b), from pink to green, proportional to the PFOA concentration, which is then digitalized by a novel PT-like instrument setup. The *CC* sensor was inserted in a holder that has inlet and outlet connectors to allow sample solution fluxes. A commercial white LED served as a light source, and a digital webcam was utilized to record the indicator colour changes during the sample flow regulated by a peristaltic pump. The optical signal was elaborated by MATLAB R2023a codes through HSV codification. It was observed that the colour changes depend proportionally on PFOA concentration. The developed optical system represents an easy-to-use device, built with inexpensive and familiar instruments and using low-cost material. Its great sensor performance, good reproducibility, very low LOD, and device portability make this system perfect for the real-time and on-site analysis of natural water sources.

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