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Potential use of meso-tetra (N-methyl-4-pyridyl) porphyrin to chlorogenic acid fluorescence detection

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Summary:

Chlorogenic acid (CGA) is widely used for biological and pharmacological activities. CGA can be harmful in high concentrations, so its control in wastewater became essential. Indicators or optical sensors are a practical and convenient way to detect CGA. In this context, porphyrins are widely used as optical receptors since they have a strong visible absorbance and may be fluorophores. Here, the UV-vis and fluorescence spectra revealed that meso-tetra (N-methyl-4-pyridyl) porphyrin (TMPyP) interacts with CGA at low molar ratios, suggesting its potential use for an optical sensor.

Keywords: fluorescence, porphyrin, polyphenol, sensor, wastewater.

Background, Motivation and Objective

Chlorogenic acid (CGA) is one of the most common polyphenols in plant, food, and biomedical products. Monitoring this antioxidant molecule is essential to evaluating the quality of manufacturing, such as coffee, and environmental aspects. The elevated abundance of CGA makes it an indicator of the total amount of polyphenols and an indicator of the quality of products [1]. As a consequence, the monitoring of CGA in water became of extreme importance to control the quality and contamination of waste.

In this context, optical and fluorescence sensors are appealing platforms in which the interaction between receptors and analytes can be detected by optical transducers. Fluorimetry is very attractive since it is a highly sensitive technique. On the other hand, the optical response occurring by analyte and sensing molecule interaction turns quick and easy visual monitor (change of color) [2,3]. Porphyrins are colored molecules with high extinction molar coefficients; they may be fluorescent with long emission wavelengths and have high chemical stability. This way, the target analyte interaction may be triggered by a change in absorbance or fluorescence spectra [4]. Sensors using porphyrins applied to CGA polyphenol have scarcely been reported [5] in the literature, with no examples of optical-based devices. Therefore, this study aimed to evaluate the possibility of developing an optical sensor based on meso-tetra (N-methyl-4-pyridyl) porphyrin (TMPyP) for detecting polyphenol CGA.

Description of the New Method or System

CGA (Sigma-Aldrich) monitoring was evaluated using the water-soluble porphyrin TMPyP. TMPyP is dissolved in DI water at 1.2 10^{-6} M concentration. Then CGA is added to the solution, considering TMPyP:CGA molar ratios ranging from 1:0.1 to 1:5 (1.2 10^{-7} – 6 10^{-6} mol L^{-1}). The spectroscopic methods were performed using ultraviolet-visible (UV-vis) range from 350 to 550 nm and fluorescence from 550 to 750 nm (with excitation at 422 nm).

Results

The initial results show that adding of CGA produces a decrease and a red shift of TMPyP absorbance spectra, proportional to the analyte concentration, as shown in Figure 1.

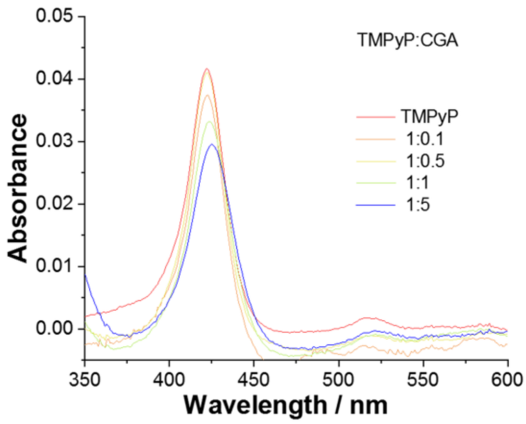

Fig. 1. TMPyP UV-vis spectrum vs CGA analyte ratio.

At the same time, the TMPyP fluorescence response in Figure 2 exhibits an intensity increase with the CGA addiction in this range evaluated (1.2 10^{-7} – 6 10^{-6} M). Remarkably, the concentration limit in wastewater by World Health Organization (WHO) is 2.8 10^{-7} M.

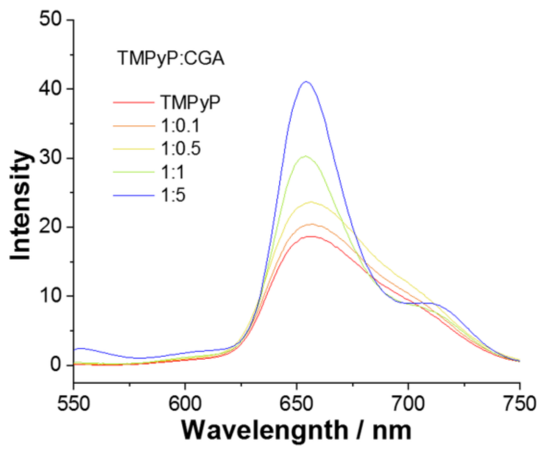

Fig. 2. TMPyP fluorescence spectrum vs CGA analyte ratio.

Conclusions

The results showed a potential use of TMPyP, a water-soluble porphyrin, as a chemical sensor to be applied in spectroscopic detection (UV-vis and fluorescence) of CGA polyphenol. The possibility to utilize this indicator in the solid state by its immobilization on substrates (such as filter papers, color catchers, nitrocellulose, etc.) or onto nanoporous structures (such as zeolite) may pave the way to the fabrication of susceptible sensors for this class of compounds.

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