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Colorimetric sensor based on silver faujasite for chlorogenic acid polyphenol detection

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Summary:

Silver-based materials show a great potential to be applied in sensors due to their optical, electronic, and chemical properties. In this work, we report the use of a zeolite framework modified with silver ions as a colorimetric sensing array for the detection of chlorogenic acid (CGA). The detection was done by digital image colorimetry (DIC) based technique integrated with a smartphone. Red, green, and blue (RGB) was able to monitor CGA in the range of 1 – 20 mg $L^{-1.}$ with the limit of detection (LOD) of 0.39 mg L^{-1}.

Keywords: polyphenol, coffee, smartphone, zeolite, silver.

Background, Motivation an Objective

Coffee is one of the most widely consumed drinks in the world and is a commodity with high production and significance. The coffee beans are obtained after washing stages to remove impurities, drying, and peeling the skin. Wetting rote eliminates coffee compounds, increasing the quality of the final bean [1]. The elevated abundance of CGA makes this polyphenol an indicator of the polyphenols and quality products [2]. *Colorimetric sensors* are a promising alternative, in which the color change occurs by analyte and sensor array interaction turns easy visual monitoring [3]. Silver-based materials are highly suitable for sensor platforms to electrons on the surface interacting with electromagnetic radiation in the visible spectrum region (400 nm). Thus, the target molecule promotes a surface modification accompanied by a change in color [4]. A colorimetric sensor applied to CGA polyphenol has yet to be fully elucidated [5], making further studies necessary. Therefore, this study aimed to evaluate a sensor based on faujasite zeolite with a surface modified with Ag^+ ions (AgFAU) as a colorimetric sensor for detecting the polyphenol CGA.

Description of the New Method or System

The colorimetric detection was performed by using a FAU-Ag dispersion (1 mg mL^{-1}) in sodium carbonate/bicarbonate buffer (pH 10.7). Different concentrations of CGA (1, 2.5, 5, 7.5, 10, 15 and 20 mg L^{-1}) were added to the FAU-Ag dispersion. RGB color detector smartphone APP was employed to obtain the color space parameters R (red), G (green), and B (blue) for statistical analyses. The photos were taken using a portable mini studio box (InstaFold) with cold white LED6000L lighting and defined dimensions (38 cm height, 36 cm length, and 39 cm depth). The box has an upper opening accommodating the cell phone and a fixed working distance. Hence, the object images were protected from the external environment's illumination.

Results

The optical behavior of the AgFAU in the presence of GCA at different concentrations 1 – 20 mg L^{-1} (0 to 56 µmol L^{-1}) is exhibited in Figure 4. As can be noted, the color changed from yellow to brown as the concentration of GCA increased.

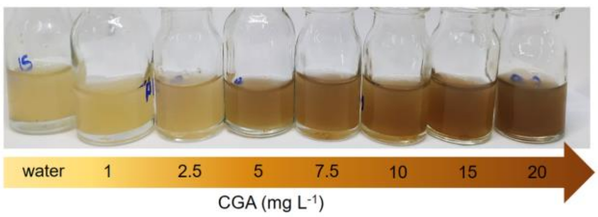

Fig. 1. FAU-Ag solution color by CGA concentration

Figure 2 shows that the R and G parameters best fit found was the cubic model with R^2 of

0.99282 and 0.98827, respectively. The best fit for the B parameter was the quadratic model with an R^2 of 0.90377. LOQ media was 1.3 ± 0.5 mg L^{-1}, being closest to the experimental result of 1 mg L^{-1} CGA, showing an adequate approach.

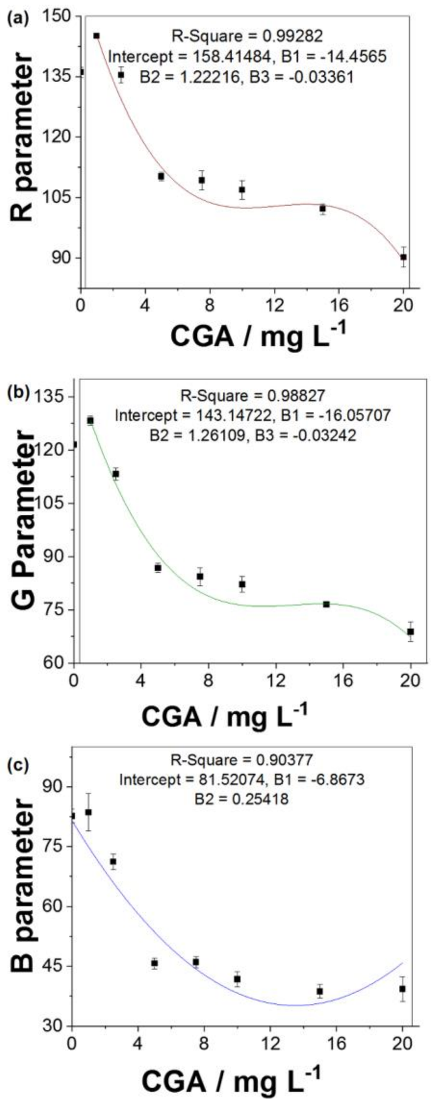

Fig. 2. Quantitative measurements of the CGA analyte from partial least square regression (PLSR)

PCA analysis shows a high dispersion at 50x dilution in the reproducibility of the analyzed samples.

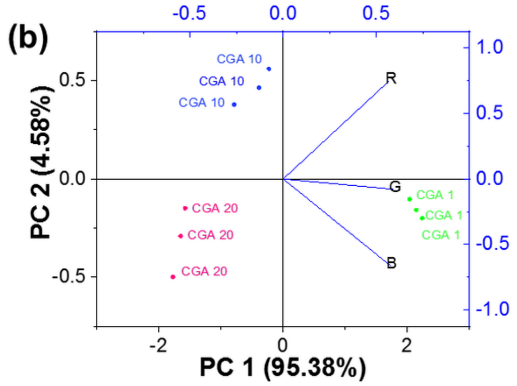

Fig. 3. PCA statistical analysis

This possible oxidative mechanism is also correlated to reactive groups in CGA molecule from hydroxyl radicals generated, causing the electron transfer. In general, phenols are associated to Fenton reactions showing as scaggering radicals (hydroxyls), maintained in a ressonance structure. As consequence, the electronic density is increased and free-radicals are avaliable to ion metal redox [6].

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