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Development of a simple sol-gel based colorimetric sensor for the detection and quantification of Gallic acid

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The rapid and visual detection of Gallic acid (GA) is of significant importance, broadening its applicability to multiple domains. The primary goal of this research is to develop a colorimetric detection method for identifying gallic acid in unknown samples by exploiting gallic acid's chelating capability with iron (III). The sol-gel process is employed as a means to study and optimize the chelation of gallic acid with iron (III) for efficient detection purposes. Since various types of tetraethyl orthosilicate (TEOS) based sol-gel materials have been developed recently by incorporating polymeric/oligomeric components into silicate systems via the sol-gel process, the current work aimed at developing transparent monolithic silica disks doped with $FeCl_3$ (1666.67 ppm and 3333.34 ppm) prepared by acid-catalysed sol-gel reaction of TEOS. The sol-gel solution was prepared by hydrolysing precursors with ethanol as the solvent. Subsequently, $FeCl_3$ and a surfactant (Sodium Dodecyl Sulfate, SDS) were added to the sol-gel mixture. Distinctive colour response patterns of $FeCl_3$ doped monolithic disks, upon treatment with GA (10 ppm to 1000 ppm), were identified by extracting red, green, and blue (RGB) colour coordinates of digital images taken from a smartphone before and after the reaction with GA. The relationship between the Euclidean distances (EDs), calculated as the square roots of the sums of the squares of the ΔRGB values, and the concentration range of 10 ppm to 1000 ppm GA is linear. The limit of detection (LOD) for monolithic disks doped with $FeCl_3$ at 1666.67 ppm is 241.64 ppm, and for the monolithic disks doped with 3333.34 ppm of $FeCl_3$, it is 92.38 ppm, while the Limit of Quantitation (LOQ) is 732.25 ppm and 279.96 ppm, respectively. The colour shifts not only allow for visual estimation but also enable the quantification of GA concentrations. Currently, the dual nature of the analytical method ensures its practicality and effectiveness in assessing polyphenol content in the samples, measured in Gallic acid equivalents [mg (GAE)/ g]. However, it also indicates an opportunity for future refinement to achieve even greater precision and accuracy.

Keywords: Gallic acid, iron (III), Sol-gel, RGB, Euclidean Distance

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