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A Concept Note on an in Situ Electrochemical Biosensor and Validation for Metabolites Including Vitamin C and Essential

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Abstract

Citrus species possess essential nutritional elements. Being rich in vitamin C, they provide considerable health benefits. Likewise, essential oils of citrus peel vary in quantity as well as quality. This concept-note outlines using a novel electrochemical biosensor for easy and fast detection of citrus metabolites, which will be an immense help in the recognition and segregation of cultivars.

Keywords: Citrus Species, Cultivars, Electrochemical Biosensor.

Introduction

Citrus species, an important group of fruit crops, are extremely valued for their high vitamin C content and unique, essential oils. Vitamin C content of several Citrus fruits (such as pummelo, Assam lemon, Khasi mandarin, etc.) has been quantified and reported so far in many articles [1-4]. Similarly, the highly acclaimed essential oils of citrus peel also vary in quality and quantity. The commonly used methods for detection of these metabolites are mostly destructive, time- consuming, and laborious. Therefore, the use of sensors for easy and fast detection of citrus metabolites can be of immense help in recognizing and segregating cultivars [5-13]. Therefore, we will use the available collected germplasm to study various aspects like Ascorbic acid content and metabolites, including essential oils. Towards meeting that objective, we propose the following concept note in the form of an electrochemical biosensor which Hyperspectral Imaging further assis

Design

Figure 1 shows schematics of the laboratory-based electrochemical biosensing, which will be executed to study the metabolites found in Citrus species. As evident in the scheme, the prototype development is based on two functional units: the first one being the design of the probe cum transducer, which will give the output response while the second one engages the bio functional species, which will be conducive to producing the modulated response.

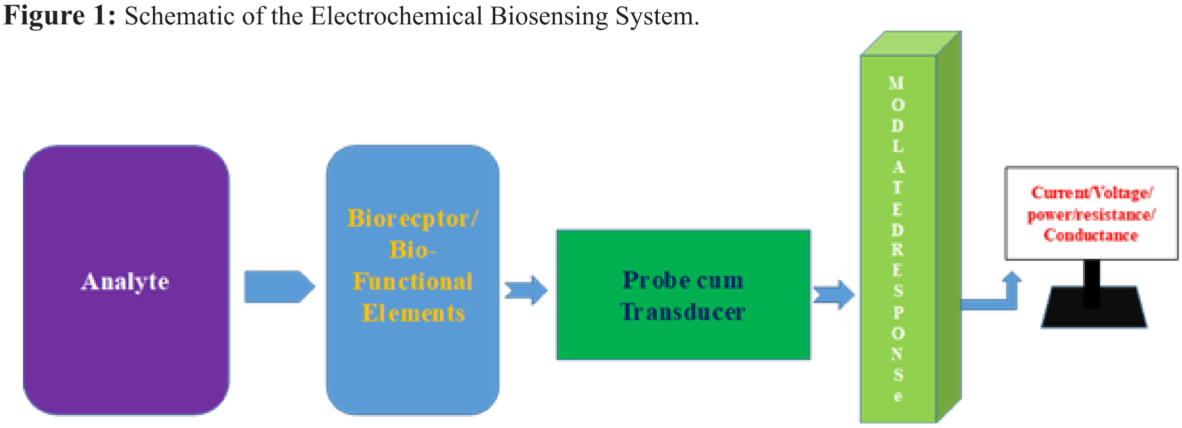
In the execution of the impregnation of bio-functional species, the bio-receptors will be taken in the form of aptamers, enzymes, or proteins, etc., whichever will be better to communicate with the signaling unit. The analyte shown in schematics refers to the processed citrus species. The bio- functional elements will then be characterized through AFM, TEM, FESEM, FTIR etc. to decipher the best binding properties with the target species (analyte).

The other crucial part, i.e., probe cum transducer, will be first simulated for better tunability, and the optimized design will be made ready for impregnation with the tested bio-functional elements.

Modulated Response

Once the transducer is ready as per expediency, the output will be measured through a customized detector, which gives rise to output in the form of current/voltage/power/conductance/resistance. The design of the probe will be first made through COMSOL, FTTD, MATLAB software. The setup will also provide a wide range of raw data that can be used as per requirement. Accordingly, as per the analyte, the in-situ testing will be executed for metabolites of the citrus species.

Figure 1: Schematic of the Electrochemical Biosensing System.



Hyperspectral Imaging

Figure 2: shows the laboratory-based proposed hyperspectral polarization imaging system, which can aid us in studying the different stages of citrus fruits. The setup is based on an imaging unit and a data processing unit. The polarization measurement will be followed as described in reference 15. The imaging unit consists of a CCD camera and imaging spectrograph. The imaging spectroscope operates in the 400-1000 nm range and will be combined with a CCD camera. This combination will provide a line-scan spectral imaging device. The spectroscope has a spectral resolution of 2.8 nm and a numerical aperture of F/2.4. The CCD camera is monochrome sCMOStype with an 8 mm x 8 mm imaging area, a frame rate of 50 fps, and 16-bit digital images. The camera setup is mounted to the mounting tower, allowing the alignment of the components in the XZ axis for further adjustment. The lighting assembly consists of halogen lights with a range of ~300-1100 nm and is attached to the mounting tower, which allows height adjustment. The lighting system is connected to the lighting system power supply. The sample is kept on the XY translationstage. The data processing unit consists of a powerful computer with a graphic processing unit. This system will help in fast data acquisition and processing. The advantage of using a custom- made hyperspectral system, other than procuring a hyperspectral camera, is the flexibility of wavelength and setup modification as per the requirement. The setup will also provide a wide range of raw data which can be used as per requirement.

Figure 2: Schematic of Hyperspectral Polarization Imaging System.

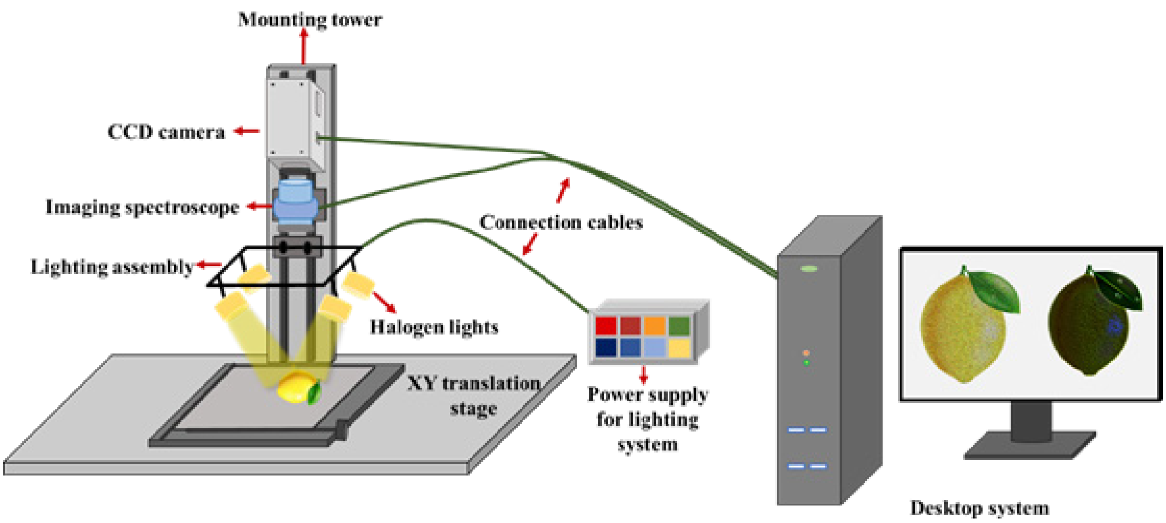


Image Processing

Natural pigments in the plants, such as chlorophyll and carotenoids, provide elegant colors to the plants and are responsible for energy production by photosynthesis. Hence, the quantification of pigment levels in the plant can help in grading plant diseases [3-4]. Accordingly, healthy and infected parts from the plant image (including leaves and fruits) could be segmented using ImageJ software, and different gray level co-occurrence matrix (GLCM) features such as contrast,correlation, energy, entropy etc. are calculated for is segmented region using MATLAB software [6,16-19]. From the GLCM statistics, a significant difference between healthy and infected partsof the plant can be observed, enabling us to decipher the different stages of citrus species.

Concluding Remarks

In summary, a novel electrochemical biosensor is proposed to estimate vitamin C from different parts of the citrus fruits. It is further asserted that the potential role of the hyperspectral polarizationimaging system will lead to effective assessment of the quality and progression stages of maturation of citrus fruits as well as leaves. It is envisioned that this investigation may help in theidentification of metabolites present and the quality of citrus fruits, which will be a big boon for the agriculture sector.

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Conflicts of Interest

The authors declare no conflict of interest

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