Determination of Vitamin C (Ascorbic Acid) in Orange Juices Product

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Abstract—This research describes a voltammetric approach to determine amounts of vitamin C (Ascorbic acid) in orange juice sample, using three screen printed electrode. The anodic currents of vitamin C were proportional to vitamin C concentration in the range of 0 – 10.0 mM with the limit of detection of 1.36 mM. The method was successfully employed with 2 μL of the working solution dropped on the electrode surface. The proposed method was applied for the analysis of vitamin C in packed orange juice without sample purification or complexion of sample preparation step.

Keywords—Ascorbic acid, Vitamin C, Juice, Voltammetry.

I. INTRODUCTION

VITAMIN is a nutrient that does not provide energy to the body but it is essential nutrients. It is necessary for the growth of the body and also associated with the enzyme function in the body [1]. It helps repair the body. Each vitamin has different components and different molecular structure. Vitamin C or L-Ascorbic acid (AA) is water-soluble, slightly alcohol-soluble and insoluble in chloroform, ether, and benzene [2]. The chemical formula of ascorbic acid is $C_6H_8O_6$ with a white or slightly yellow crystal or powder. Vitamin C is found in vegetables and fruits such as oranges, lemons, limes, melons, tomatoes, peppers, broccoli, green leafy vegetables, and potatoes [3]. Vitamin C minimum daily requirement for adults is 60 mg. Vitamin C is potent anti-oxidant and free radical scavenger, thus, helps in body tissue growth and repair. It is essential in synthesizing collagen, ligaments and blood vessels. Furthermore, Vitamin C has the properties of reducing agent and weak acid [4].

Vitamin C is instability because of its strong reducing agent [5] property therefore it can be deactivated in general oxidizing agents such as, atmosphere with oxygen, cooking, leaving it uncovered exposed to the air. Also, Vitamin C can be easily lost by boiling due to its water-solubility.

There are several methods to analyze Vitamin C content in food, spectrophotometric methods for example, because Vitamin C is able to absorb UV ray [6], [7]. However, interference is often found due to absorption of other rays. This study aims to present a selective method and capable of low detection limits, which electrochemical method will be a better option than other tradition methods like titration.

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II. EXPERIMENTAL

A. Chemical and Reagents

Silver ink and carbon ink were purchased from Acheson (california, USA). L-Ascorbic acid (AA), Diethylene glycol monobutyl ether, and Ethylene glycol monobutyl ether acetate were obtained from Merck (Germany). Sodium dihydrogen orthophosphate and phosphoric acid were purchased from BDH laboratory supplies (England). Graphite Nano powder was obtained from Sigma Aldrich (Switzerland). All chemicals and reagents were used of the analytical grade as received without further purification. 0.1 M Phosphate buffer solutions (PBS) was prepared from NaH2PO4·2H2O and phosphoric acid in the pH range 2.0. A freshly prepared solution of AA was used in all experiments. All aqueous solutions were prepared with doubly-distilled water, which was obtained from a Milli-Q water purifying system (>18.2 MΩ cm).

B. Instrumentals

Voltammetric measurements were performed with a potentiostat/galvanostat (PGSTAT100) electrochemical system (Metrohm, USA). The three-electrode system of a screen-printed electrode [6] consisted of carbon as working and counter electrode, and silver/silver chloride as a reference electrode (Fig. 1).

Fig. 1 The screen printed carbon electrode

C. Methods

For voltammetric experiments, 10 μL of the ascorbic acid solution in 0.1 M PBS (pH 2.0) was pipetted into the electrochemical cell. Then different volumes of AA solution (0.010 M) were added to the electrode surface as the voltammetric cell and the potential was scanned from - 0.0 to +1.0 V with cyclic voltammetry and from 0.0 to +1.2 V (vs. Ag/AgCl). The quantification of AA was achieved by

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measuring its voltammetric current by differential pulse voltammetry. The differential pulse voltammograms were recorded during the potential sweep from -0.0 to -1.2 V, and its parameters were selected: the step potential of 0.01V, pulse amplitude of 0.1V.

An orange juices product sample was purchased from super market in Bangkok, Thailand. The orange juice samples need to be strained through cheesecloth. After that, the samples were prepared with two methods. One method is dilute with phosphate buffer solution pH 2 in the ration as 1:1 and another one is dilute in 10 times of sample with phosphate buffer pH 2.

III. RESULT AND DISCUSSION

The cyclic voltammograms of 0.01 M AA in 0.1 M phosphate buffer solution (pH 2.0) on a screen-printed carbon electrode compared with blank solution (0.1 M PBS pH 2.0) were shown in Fig. 2. A well-defined irreversible anodic peak of AA at the potential of 0.68 V and no anodic peak current of 0.1 M PBS pH 2 at the same of AA oxidation peak were observed. It is clear that the electrochemical reactions of AA at the screen-printed carbon electrode are irreversible, indicating the sluggish electron transfer kinetics of these compounds at the electrode. The highest voltammetric current was obtained in the first scan of cyclic voltammetric analysis which may be related to the electrode fouling caused by the adsorption of these compounds and their oxidation products on the electrode surface. Then, the first scan of cyclic voltammetry with the screen printed carbon electrode was used for studied of the electrochemical properties of the ascorbic acid.
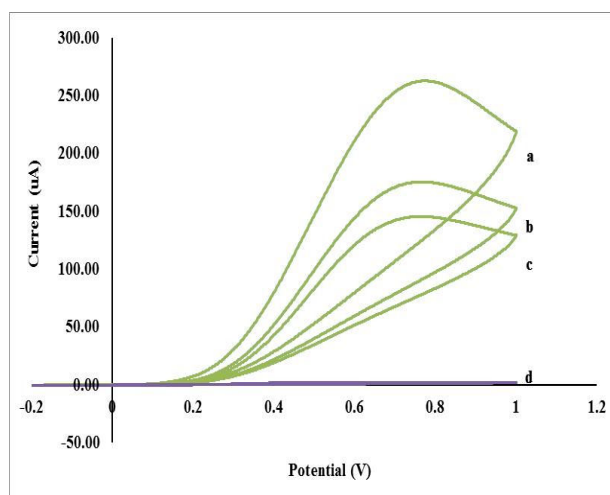

Fig. 2 Cyclic voltammogram of 0.01 M ascorbic acid in 0.1 M PBS pH 2.0 (a,b,c) and blank (d) at the screen printed carbon electrode at the condition of 0.01 V step potential and 0.10 V potential amplitude, scan from the potential range of 0.00 to 1.00 V

The electron transfer process of ascorbic acid on the electrode surface, which can be denoted as follows. In the conclusion, the screen printed electrode can be investigated the electrochemical properties of ascorbic acid.
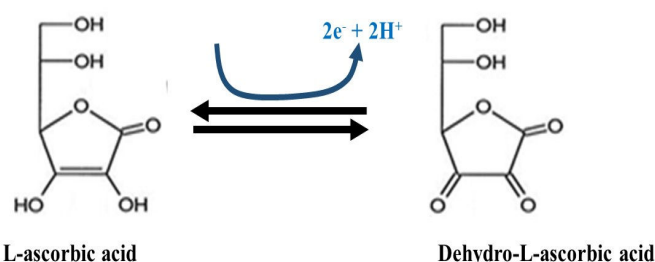

Fig. 3 The electron transfer process of the AA oxidation on the electrode surface

As we know that, the differential pulse voltammetry has a higher sensitivity than cyclic voltammetry. These implied that the differential pulse voltammetry was used for the optimum technique for determination of AA. The effects of step potential and potential amplitude on the anodic peak currents of AA were investigated by differential pulse voltammetry in a solution containing 0.01 M AA in 0.1 M PBS pH 2.0. As the potential amplitude and the step potential increased, the oxidation current increased. The current response was proportional to the potential amplitude over the range of 0.01 to 0.10V. The optimum value of the potential amplitude is 0.10 V. The influence of the step potential was studied in the range of 0.002 to 0.10 V. The optimum result of the step potential was selected at 0.01V.

After the investigation of the optimum parameters, the calibration plot of AA was constructed in the concentration range of 1.0 to 10 mM. Fig. 4 displays the calibration response between the current responses and the concentration that was obtained in the linearity corresponded with the correlation coefficient of 0.9928. The limit of detection was 1.36 mM (S/N = 3). The proposed method has sufficient detection limit and wide linear range for detection of AA in sample sources.
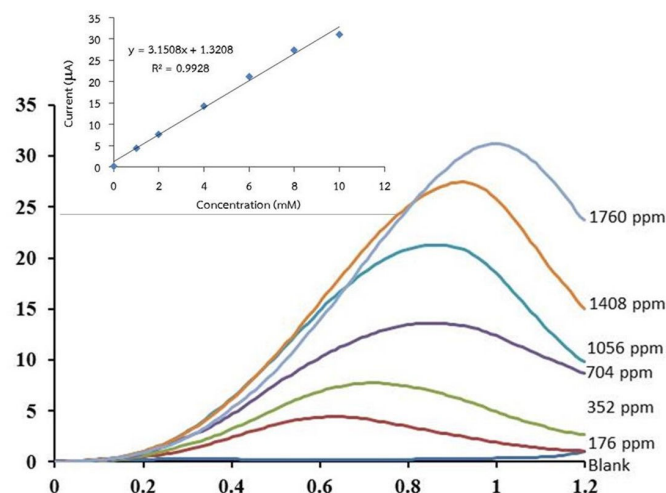

Fig. 4 Plots of the anodic peak current as a function of AA concentrations and calibration curve (in set)

We found that the oxidation current of AA in orange sample from two preparation methods lower than bank solution.

A distorted voltammograms were obtained (Fig. 5) may the results from the matrix in the orange juice. Then, we should try to eliminate the matrix before voltammatric analysis.
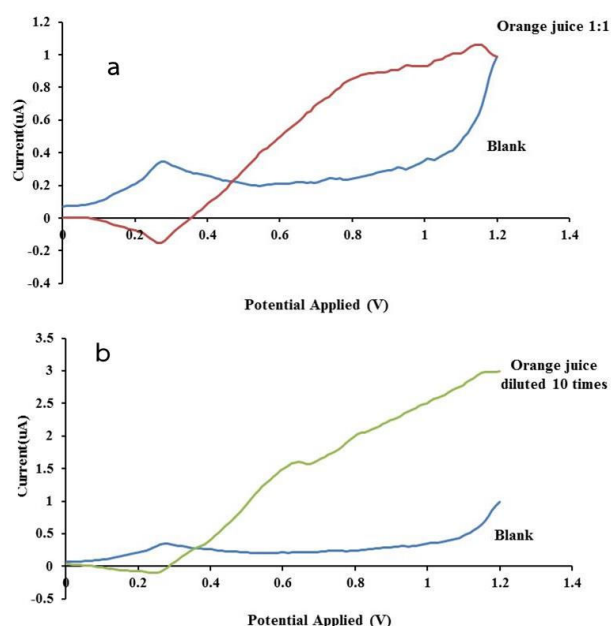

Fig. 5 Differential pulse voltammogram of AA in orange sample (a) dilute in ration 1:1 and (b) dilute 10 times

IV. CONCLUSION

In summary, this report presents an approach to determine amount of vitamin C in packed orange juice sample

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