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Research Article

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Study on detection methods for sucrose

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Abstract

Sucrose is a disaccharide, composed of monosaccharides glucose and fructose with the molecular formula of $C_{12}H_{22}O_{11}$. It has been known that sucrose is a natural product extracted from sugar beet or sugarcane and it plays a vital role in human nutrition and health. Sucrose has also been widely used as a raw material. In addition, sucrose permeability has been suggested as a simple and non-invasive marker of gastric mucosal damage in human subjects and experimental animals. Therefore, the development of rapid, sensitive, and reliable analytical methods is necessary to determine the content of sucrose in many situations. In this article the studies of detection methods for sucrose in recent years are reviewed.

Keywords: sucrose; determination; detection; sensor.

1. Introduction

Sucrose has the chemical formula $C_{12}H_{22}O_{11}$ often found in the form of white crystal and soluble in water. Generally sucrose is produced from sugar cane or sugar beet and is the common sugar which is a major ingredient of many foodstuffs and sweet drinks [1-3]. Furthermore, in rats, rabbits, dogs, and people, permeation of sucrose across the gastric mucosa has been demonstrated to be a reliable marker of gastroduodenal permeability and may be a useful alternative to gastroscopy for diagnosis of gastric ulcers [4-6]. In addition, decomposition of sucrose into glucose and fructose in microbial cells is of interest to the microbiologists [7-9]. Therefore, sucrose is an important analyte in clinical and industrial food analysis, and developing a sensitive and efficient method for determining sucrose in both food and biological samples is extremely necessary. In this paper, the attributes of different analytical technique for the determination of surcose in recent years are reviewed.

2. Analytical Methods

2.1. HPLC method. High-performance liquid chromatography (HPLC) is a powerful tool that enables the separation of complex mixtures into individual components, and is a highly sensitive and reproducible analytical technique. In recent years, HPLC has been combined with many sensitive detection techniques and has experienced continuous improvement of stationary phases, which have improved its sensitivity and specificity. HPLC is currently widely used for the analysis of drugs and dosage forms with respect to quality control, quantitative determination of active ingredients and impurities, monitoring drug blood concentration in patients, and bioequivalence assessment [10-12].

Filip *et al.* [13] developed and validated a HPLC method with refractive index detection for simultaneous determination of glucose, fructose, sucrose and sorbitol in leaf and/or apple peel samples from nine apple cultivars and rootstocks, originating from a germplasm collection. They applied Box–Behnken design of response surface methodology for the method optimization. The Carbosep Coregel 87H3 column was used, and the mobile phase was 0.005 mol L^{-1} H_2SO_4

solution with flow rate of 0.3 mL min^{-1} and column temperature of 35℃. The limits of detection were 2.67–4.83 μg mL^{-1} and the recovery was 93.94–103.06%.

Grembecka *et al.* [14] reported a simple, sensitive and accurate method for simultaneous determination of glucose, fructose, sucrose, maltose, erythritol, mannitol, maltitol, sorbitol and xylitol by HPLC coupled to corona charged aerosol detector for the first time. The method was elaborated using a Shodex Asahipak, NH2P-50 4E, column packed with 5 μm shell particles and acetonitrile–water gradient mobile phase at 25 °C. The method showed wide concentration range and good accuracy. Limits of detection for nine analytes were in the range of 0.12–0.44 μg ml^{-1}, respectively. The results obtained for real samples illustrated the ability of the proposed method to quantify a range of sugars and sugar alcohols in a single analysis, making it appropriate for food analysis.

2.2. Electrochemical method. Since the early 70s electrochemistry has been used as a powerful analytical technique for monitoring electroactive species in living organisms. It allows for a direct detection of sugars without the necessity of derivatization and is often characterized by lower detection limits at less equipment cost, a high selectivity and sensitivity [15-17].

Shekarchizadeh *et al.* [18] developed successfully a novel and selective electrochemical sensor for the determination of sucrose by integrating electropolymerization of molecularly imprinted polymer with multiwall carbon nanotubes. The sensor was prepared by electropolymerizing of o-phenylenediamine in the presence of template, sucrose, on a multiwall carbon nanotube-modified glassy carbon electrode. A mixture of acetonitrile/acetic acid was used to remove the template. Hexacyanoferrate(II) was used as a probe to characterize the sensor using electrochemical impedance spectroscopy, cyclic voltammetry and differential pulse voltammetry. Capturing of sucrose by the modified electrode caused decreasing the response of the electrode to hexacyanoferrate(II). Calibration curve was obtained in the sucrose concentration range of 0.01–10.0 mmol L^{-1} with a limit of detection 3 μmol L^{-1}. This sensor provided an efficient way for eliminating interferences from compounds with similar structures to sucrose. The sensor was successfully used to determine sucrose in sugar beet juices with satisfactory results.

Das *et al.* [19] reported the formation of almond-shaped carbon nanoparticles (ASCNs) from peeled potatoes and the fabrication of a highly sensitive and selective non enzymatic sucrose sensor based on this carbon nanoparticle electrode. The potato was pyrolyzed initially at 400-500 ℃ in vacuum, followed by slow heating at around 800 ℃, which produced the ASCNs. The ASCNs were examined by SEM, XRD, EDX and AFM and were further characterized by fluorescence microscopy, which clearly suggested their fluorescent nature. Electrochemical detection of sucrose was examined by cyclic voltammetry, differential pulse voltammetry and linear sweep voltammetry in an acidic solution. The new sensor showed a good response towards the sucrose oxidation, with a wide linear range (R^2= 0.99679), a high sensitivity of ~41.73725 ± 0.01 $\mu A{\cdot}M^{-1}{\cdot}cm^{-2}$ and a low detection limit of 1 μmol/L. Moreover, it is also stable and has a short response time (9s).

2.3. Other methods. In addition to these main approaches mentioned above for sucrose detection, still a few special techniques with high sensitivity have been applied. Pan *et al.* [20] proposed the determination of sucrose content in sugar beet by portable visible and near-infrared spectroscopy. Fa *et al.* [21] developed the capillary ion chromatography–mass spectrometry for simultaneous determination of glucosylglycerol and sucrose in intracellular extracts of cyanobacteria. Hewetson *et al.* [22] developed and validated a gas chromatography–flame ionization detection method for quantifying sucrose in equine serum. Soldatkin *et al.* [23] developed the conductometric biosensor array for simultaneous determination of maltose, lactose, sucrose and glucose.

3. Conclusion

Sucrose is a highly significant compound among carbohydrates because of its extensive applications in health, food industry, pharmacy, and cosmetics. Especially sucrose permeability can be used to detect the presence and severity of gastric ulcers in other species [24-26]. Therefore, the rapid, accurate, inexpensive, selective, sensitive and simple determination of sucrose content should be clearly established. This review has highlighted the significant developments in rapid and alternative techniques for the detection of sucrose in recent years. We believe the development of sucrose sensors with better sensitivity and specificity, lower cost, simplicity, along with *in vivo* analytical technique is still the future effort.

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