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Design of a portable urine glucose monitoring system for health care[☆]

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Abstract

This paper describes the design of a monitoring system that can be used to measure urine glucose during daily life. It consists of a bio-chemical sensor, hardware with PIC microcontroller and control circuits, and signal analyzing part. To evaluate the performance, we compared the analyzed glucose levels of the developed system to a standard instrument, YSI glucose analyzer, based on regression analysis using standard glucose solutions mixed with urine. Also, standard deviation and coefficient of variation were computed. In conclusion, the developed system showed it could be used for the measurement of urine glucose.

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1. Introduction

Diabetes is a chronic disease found in many people. This disease can cause problems for families, society, and especially the patients that suffer from its various side effects and complications, unless proper medical treatment is received. To be treated properly, glucose monitoring is very important because regularly measured blood glucose levels over a long period can serve as a basis for diagnosis and management of diabetes. Also, for diagnosis and prevention of diabetes in a healthy person, the need for regular measurements of glucose levels over time is suggested [1,2]. Recently,

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the self-monitoring of blood glucose in patients with *Diabetes mellitus* is now widely established and supported by a variety of test strips and meters.

Nowadays, most of the blood glucose measuring devices on the market are invasive types, like lancet, which are painful and require blood-gathering. There is a noninvasive type using a colorimetric method that decodes the color response shown on a urine glucose measuring strip. This method is routinely used in health examinations as an indirect diagnostic index for diabetes. But the colorimetric method has many defects in terms of carrying a sample, preprocessing, quantity, and response time [3]. Recently, a new kind of glucose measuring system was developed. The GlucoWatch is an example. The GlucoWatch, which automatically extracts and measures glucose every 10 min for a period of up to 13 h before requiring replacement, is a noninvasive and painless device for measuring and monitoring the glucose level, but the GlucoWatch must be calibrated with a standard blood glucose measurement and takes 2 h to warm up. Because measurement of glucose level is available after long warm up period, it is not convenient to use [4].

In this paper, we describe our design of a biosensor that measures urine glucose level noninvasively and of a new portable urine glucose monitoring system for health care, where the measured glucose level is displayed digitally. The proposed system improves on the existing blood glucose measurement systems by reducing the amount of pain patients receive and also improves on the limitations of the type using the colorimetric method. The developed urine glucose measurement system, based on amperometric electrochemistry, is a light-weight, card-sized instrument designed for self-monitoring of urine glucose concentrations. The sample is aspirated by capillary action directly into the chamber housing the strip, and then measurement commences automatically detecting the result within 23 s. The user is not required to regulate the sample volume, remove excess urine from the strip or monitor the measurement steps in any way. The measured glucose levels are stored in the memory and can be transferred to the home health care monitoring system through the Infrared Data Association (IrDA).

The home health care monitoring system uses the transferred glucose data to generate statistical reports and graphs that are designed to create a comprehensive picture of a patient's recent glucose level history.

2. The design of urine glucose monitoring system

The designed system computes glucose level by measuring the differential current caused by response of urine with the biosensor. This system consists of biosensor for measuring urine glucose level, system hardware and signal processing unit.

2.1. Bio-sensor for urine glucose measurements

We designed a biosensor for urine glucose measurements with the electrochemical properties of screen-printed carbon paste electrodes (CPEs) assembled with immobilized glucose oxidase and hexamine ruthenium (III) chloride ($[\text{Ru}(\text{NH}_3)_6]\text{Cl}_3$) containing a nitrocellulose (NC) strip. Because YSI Glucose Analyzer, which is widely used as the gold standard in examination and comparison of glucose level, uses the glucose-oxidase method, the developed biosensor as shown in Fig. 1 also adopt same method as mentioned above.

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