Wearable Microfluidic Device for Capture and Quantitative Analysis of Glucose coupled with Skin Electrodermal Activity

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A multiparametric, non-invasive and reagentless sensing strategy for diabetic monitoring is proposed based on a bespoke graphite ink "writable" formulation (including biocompatible binders and modifiers) as conductive layer for glucose oxidase immobilisation within an epidermal patch. This enables encapsulation of the heterocyclic quinoid species 1,10-phenanthroline-5,6-dione [1] which acts as a proton and electron acceptor for $FADH_2$ cofactor regeneration. Surface characterisation of the ink layer was achieved via FTIR, thermal analysis (TGA/DSC) and scanning electron microscopy. Voltammetric and pulse techniques establish analytical performance criteria for the mediated device over physiological glucose levels in sweat (10-200 mM [2]) at neutral pH. Hygroscopic hydrogels (chitosan/poly vinyl alcohol) nanofibrous mats form overlaid membranes as sweat collection zones, sandwiched beneath a cotton fabric wicking layer for fingertip perspiration harvesting.

The prototype electronic control system involves a customisable Arduino based potentiostat [3] with off the shelf electronic components capable of performing the electrochemical measurements, together with temperature and galvanic skin sensor response (GSR) [4]. The addition of electrodermal activity via a GSR sensor detection module and a temperature probe makes for a multiparametric system which responds to electrical activity in the skin due to the variation in moisture level due to sweating. GSR reflects sweat gland activity and changes in the activity of the sweat glands in response to sympathetic nervous stimulation[4]. Calibration parameters can thus be adjusted dynamically relative to changes in temperature and other measurement variables. Such a system requires small sample volumes (<50 μL), provides rapid time to result <1 min and is portable and disposable. Integration of allied electronics has the potential for transduction and wireless transmission to be carried out enabling smart and remote healthcare.

References

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