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Shelf life of enzymatic electrochemical sensors

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Abstract

Shelf life estimation of bio-sensing devices are important, especially when one wants to consider the commerciality of the system or device. Here we propose a mathematical model from a set of laboratory experiments based on accelerated aging due to elevated temperatures on glucose oxidase modified screen printed electrodes as a model electrochemical biosensor.

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Keywords: SPE; shelf-life; accelerated temperature ageing, Glucose oxidase biosensor

1. Introduction

Due to significant progress in enzyme stabilization and immobilization [1], enzymatic biosensors are often used in the hearts of diagnostic devices working in complex clinical samples like saliva [2]. Regardless of their application, enzymatic biosensors are expected to deliver accurate and reliable results often at times without any calibration. As enzymatic biosensors encounter analogous product stability challenges as pharmaceuticals, the same standards may apply when it comes to shelf life prediction. Therefore, the product may be deemed expired if its activity falls under 90 % of the originally predicted activity [3].

Nomenclature

τ	temperature
t	time
a	approximation point

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2. Materials and Methods

Accelerated ageing models from food and pharmaceutical industry have been adapted for the aging studies of biosensors. Electrochemical Prussian blue mediated glucose biosensors (based on glucose oxidase) were utilized. First, the most critical chemical, physical or biological event that leads to product quality depletion was identified. In the second step, the changes of the previously selected value as a function of time were evaluated[4]. Hence, glucose oxidase degradation was selected as the weakest link of the glucose sensor and the signal at a certain glucose concentration as a quality indicator. The protocol that McAteer et al. reported in 19995 was optimized to suit our purpose by vacuum wrapping screen the printed sensors and storing them at different temperatures - inducing the accelerated aging[6] of the sensors. Extrapolating this data the shelf-life and continuous use life span of our sensors at lower temperatures can be predicted.

3. Mathematical Model Equation

Linear approximation of signals (% of original signal) versus time at different temperatures are intersecting with at the point of time= 0 and signal = 100%

$$f\tau(t) = f\tau(a) + f'(a)(x-a) \tag{1}$$

Where τ is temperature, *t* time and *a* approximation point. Co efficient of linear approximations is plotted in dependence of the temperature. Linear approximation of this plot is carried out with no intersection prescribed. Hence the temperature dependence of aging can be observed

4. Results

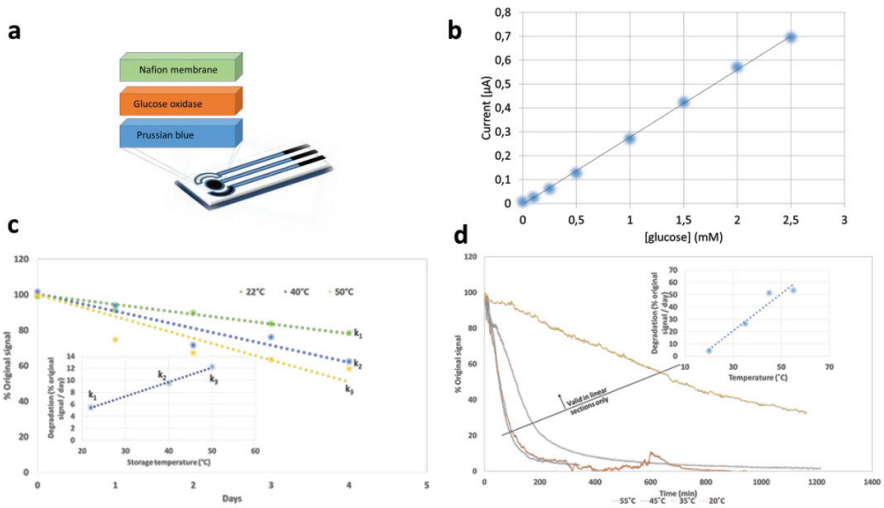

Fig. 1. (a) Individual fabrication layers of the glucose oxidase biosensor; (b) Calibration cure of glucose oxidase biosensor, (c) on shelf aging of glucose sensor at different temperature (inset: temperature dependence of degradation); (d) linear sections of graph displayed in inset; (inset: temperature dependence of degradation in continuous use)

4. Conclusion

- Ageing characteristics of biosensors are accelerated at elevated temperature.
- Sensors age faster when in used due to submersion, enzymatic activity, and potential applied and fouling.
- Determination of ageing characteristics is crucial for biosensors used in clinical, environmental, bioprocessing and other applications.
- When in use for continuous monitoring, ageing has to be taken into an account for calibration purposes and to determine when to renew the sensor.
- This rapid ageing methodology can be used to determine single use stability, continuous use stability and shelf-life. Plus thermally accelerated aging methodology that can be applied universally

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