Development of self-powered biosensors for non-invasive monitoring

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Self-powered sensors are analytical devices that generate the energy they need to operate either from their surroundings or from the sample to be measured[1]. The construction of these devices typically involves the heterogeneous integration of the sensors together with (silicon-based) control electronics. These integration processes increase the complexity and drive the final cost of the devices to unaffordable limits. This PhD thesis explores ways in which these limitations can be overcome, mainly though the elimination of silicon-based electronics. Removing this technology barrier will open new possibilities for self-powered electrochemical sensors across a very wide range of application areas, particularly in non-invasive monitoring tools such as skin patches and contact lenses, but also in food safety, environmental monitoring and security. The ultimate aim of this thesis is to design, fabricate, and test a fully-printed operative demonstrator.

The following three different stages will be followed. First, we will study and develop screen-printing processes and produce a screen-printed electrochemical cell that we will use to carry out electrochemical measurements in lateral flow conditions[2]. Second, we will use the acquired knowledge to build a fully-integrated self-powered and autonomous device for the determination of glucose. This demonstrator will work on the well-known electrochromic compound Prussian blue[3,4]. The device will be configured as a single galvanic cell that will perform the functions of sensor and display, and a small surplus of energy will be produced. This demonstrator will be built using materials of the highest quality available (and hence expensive and difficult to translate to a mass production setting), so the third part of the thesis will aim at producing a printed version of this device using commoditized materials and industry-standard screen printing methods. If successful, this device will be finally tested with real samples.

Figure 1. Prototype of a skin patch for glucose monitoring.

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References:
[1] R. L. Arechederra, S. D. Minteer, Anal. Bioanal. Chem. 400 (2011) 1605-1611.
[2] M. Aller Pellitero, M. Kitsara, F. Eibensteiner, F. J. del Campo, Analyst. 141 (2016) 2515-2522.
[3] V. D. Neff, J. Electrochem. Soc. 125 (1978) 886-887.
[4] B. Kong, C. Selomulya, G. Zheng, D. Zhao, Chem. Soc. Rev. 44 (2015) 7997-8018.