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PREFACE

Biosensors – Topical issue

It is really interesting that the simple and short word "biosensor" covers such an amazingly diverse range of bioanalytical devices. Integration of various biorecognition molecules, transducing schemes and surfaces with immobilisation protocols offers almost unlimited variations of biosensor construction or application of the device for the analysis of particular analytes.

A biosensor by definition is a device based on immobilised biorecognition elements in close proximity to or directly on the surface of a transducer (Labuda et al., 2010; Thévenot et al., 1999). However, the term "biosensor" is in literature applied in a wider context: i.e. when a biorecognition element is applied for sensing purposes without fulfilling the requirement of immobilised biorecognition element; the term "biosensor" is used in this Topical Issue with this broader meaning.

The first biosensor was constructed by Clark and Lyons in 1962, when glucose oxidase (GOx) in combination with an oxygen electrode was applied to measure glucose levels in blood (Clark & Lyons, 1962). Since then, the field of biosensors has been slowly evolving, when other detection schemes and biorecognition elements – besides enzymes and electrochemistry – found applications in biosensing. A major breakthrough occurred in 1984, when the first mediated GOx biosensor designed to analyse glucose in blood was described by Cass et al. (1984) with the subsequent large commercial success of glucose blood testers. The second boom of biosensor development started around 1995, when the utilisation of both self-assembled monolayers and nanoparticles or nanostructured surfaces for the construction of biosensors was launched (Alivisatos, 1996; Daniel & Astruc, 2003; Love et al., 2005). Self-assembled monolayers of thiolated molecules on gold (Allara & Nuzzo, 1985; Porter et al., 1987) and quantum dots (Brus, 1984) were introduced a decade ago, but the application of gold nanoparticles in biosensor preparation started almost immediately after the introduction of the Brust's synthesis of gold nanoparticles (Brust et al., 1994). Initially, Iijima in 1991 discovered helical microtubules of graphitic carbon, now called multi-walled carbon nanotubes (Iijima, 1991), and within two years, single-walled carbon nanotubes were synthesised by Iijima and Ichihashi (1993). A decade later, an increased number of papers was published, when carbon nanotubes became a part of transducers or patterned surfaces in 2003. Another popular carbonaceous nanomaterial – a "hot nanomaterial" of today's science – was discovered in 2004 by Geim and Novoselov (Novoselov et al., 2004), which brought the Nobel Prize in 2010 for both scientists (Geim, 2011; Novoselov, 2011), and led to subsequent wider application of graphene in biosensor construction starting in 2010. Thus, the increased number of biosensor publications seems to be driven mainly by advances in material science affecting the development of new transducing schemes rather than by production of novel biorecognition elements including DNA aptamers, peptide aptamers, recombinant lectins, or antibodies. Similar trends can be observed in this Topical Issue showing value-added functionalities of biosensors after the integration of nanomaterials.

Pohanka reviews the application of enzyme biosensors for the analysis of toxic and/or neurotoxic compounds using various reading schemes based on enzyme inhibition; interestingly, some of them are applicable in field assays (pp. 4–16). Dimcheva and Horozova summarise on the nanoparticles enhanced performance of electrochemical enzyme biosensors via the formation of redox active interfaces and direct electronic wiring of some redox enzymes (pp. 17–26).

Bertokova and co-workers describe the potential of bacterial *Gluconobacter oxydans* cells for the preparation of robust electrochemical microbial biosensors, also utilisable in bioprocess monitoring and biobateries construction (pp. 27–41). Application of nanomaterials such as carbon nanotubes, graphene and gold nanoparticles in microbial biosensor construction is discussed by Šefčovičová and Tkac (pp. 42–53).

Prospective novel biorecognition molecules such as green fluorescent proteins as reporter probes for the analysis of various analytes based on fluorescence transfer to other fluorescent proteins, quantum dots or by fluorescence quenching is discussed by Heger and co-workers (pp. 54–61). Molecular beacons (short nucleic acid strands with fluorophore–quencher pairs attached to their ends) are another example of prospective novel biorecognition elements applicable for the analysis of small and large biomolecules with potential in cancer and other disease diagnostics, as summarised by Stobiecka and Chałupa (pp. 62–76).

There is a block of five papers highlighting the need to develop novel ways of selective and sensitive analysis of prostate cancer (PCa) biomarkers – an effort currently funded within the European Commission Marie Curie Initial Training Network "Cancer Diagnosis: Parallel Sensing of Prostate Cancer Biomarkers" (PROSENSE, www.prosense-itn.eu). Jolly and co-workers review the application of label-free methods of PCa biomarkers analysis based on DNA aptamers, describing possibilities of its selectivity enhancement (pp. 77–89). Belicky and Tkac provide a review focused on the possibility of applying lectins for glycoprofiling of PCa biomarkers in order to enhance the reliability of biomarker analysis in a label-free mode of operation (pp. 90–111). The final review in this section, provided by Filip and co-workers, gives a summary of the integration of graphene as a signal amplifier for sensitive electrochemical analysis of biomolecules including various cancer biomarkers (pp. 112–133). Aliakbarinodehi and co-workers compare three different nanomaterials for the construction of electrochemical biosensors for the low-molecular weight molecule of H_2O_2 analysis, a platform possibly applicable for cancer drugs detection (pp. 134–142). Finally, Damborský and co-workers describe the application of surface plasmon resonance as an effective tool for the identification of prospective antibodies for PCa biomarkers analysis (pp. 143–149).

Sýs and co-workers describe an electrochemical tyrosine-biosensor for the analysis of a vitamin E analogue using carbon nanotube-modified carbon paste electrodes for enhanced analyte detection (pp. 150–157). Maixnerová and co-workers applied mathematical modelling to describe the response of an enzyme biosensor in the analysis of putrescine (a food freshness indicator), which can be applied to tune analytical performance of enzyme-based biosensors (pp. 158–166). Juřík and Skládal introduce an interesting way to analyse H_2O_2 and glucose through the formation of a precipitate by the action of horseradish peroxidase and GOx with the possibility of electrochemical surface regeneration (pp. 167–175).

Šefčovičová and co-workers describe an effective way of enhancing the performance of ethanol detection by a microbial biosensor, when nanoparticles are interfaced directly with bacterial cells (pp. 176–182). A whole-cell optical biosensor was applied by Solovyev and co-workers for the analysis of toxic mercury employing Hg^{2+}-induced bioluminescence of bioreporter *E. coli* cells in artificial sea water (pp. 183–191).

Milosavljevic and co-workers describe the synthesis of novel nanomaterial carbon quantum dots with different affinity towards ssDNA and dsDNA (pp. 192–201). Karastogianni and Girousi present an ultrasensitive way for hepatitis B virus detection using an Mn(II) complex-based electrochemical DNA biosensor (pp. 202–210). A novel controlled method of DNA aptamer immobilisation on the electrode surface via a DNA tetrahedron was characterised applying a range of tools by Poturnayová and co-workers (211–226).

Bovine serum albumin (BSA) is frequently applied for surface blocking after the immobilisation of a biorecognition element to resist non-specific interactions; the study by Xu and co-workers shows non-specific binding of a dye on BSA most likely via hydrophobic interactions pointing out to the fact that this blocking agent might not work properly in complex samples (pp. 227–236). A short communication by Gutierrez-Sanchez and co-workers describes an interesting application of the electrochemically "wired" laccase enzyme on a low-density graphite electrode as a sensitive oxygen biosensor (pp. 237–240). The final contribution by Trefulka and Paleček proves the usefulness of voltammetry in distinguishing glycan isomers, a feature important for further development in the field of glycomics (pp. 241–244).

We hope that this Topical Issue on biosensors is a tasty appetizer for everyone interested in biosensor technologies, showing recent trends in the field and introducing further application of biosensors beyond the commercially successful GOx-based ones.

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