A Detailed Review on Biosensors

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ABSTRACT

In the study of molecular cell biology, fluorescent biosensors are increasingly needed to detect the true occurrences of physiologically relevant chemicals in live cells. Recent developments in fluorescence biosensors have contributed much to clarifying not only the functions of the individual biomolecules, but also the intracellular dynamics between these molecules. However, fluorescent biosensors' rational design methodologies are not as advanced as they are. An unquenchable yearning for a more universal and adaptable strategy is still an enticing alternative, a so-called modular strategy, which allows easy fabrication of biosensors with custom features by a simple coupling of a receiver and a signal transducer. This review describes progress in fluorescent biomass sensor design strategies, such as autofluorescent protein based biosensors, protein-based biosensors that have covalently been modified with synthetic fluorophorese, and signalling aptamers, and illustrates how a certain receptor has been converted into a fluorescent bio-sensor. In addition, we will highlight the relevance of the modular sensor design concept.

Keywords: Biosensors, Review, Fabrication

INTRODUCTION

The complicated interaction between macromolecules, signalling molecules, and physiologically essential ions inside the cells plays a major role in molecular and cell biology using molecular instruments to shed light. During the last two decades, chemists and biologists have been devoting much work to developing a "biosensor," which enables a tiny molecule of interest in live cells to be tracked in real time. A biosensor is composed of a receptor component that captures a target ligand and a signal transduction to transform the ligand binding event into measuresable signals such as fluorescence. Especially, because of its high sensitivity and selectivity, appropriate temporal and space resolution, and cheap use costs [1-5], fluorescence detection is now the most extensively used technology in biomolecular imaging. In this study, we concentrate on the biosensor that detects an interest analysis using fluorescence signals due to space limits.

Different types of fluorescence biosensor built using synthetic [6-13] and biological macromolecular receptors have been described to date, such as proteins [5,14] and aptamers [14]. While we acknowledge the importance of synthetic fluorescence sensors to our knowledge of biochemical processes in live cells [7-9], this study is restricted to a general overview of the construction of fluorescent biological macromolecular receptor composites. In general, the building of fluorescent bio sensors depends on the logical design method. The first phase needs an attempt to discover a macromolecular receptor that has enough affinity and target specificity. In the second stage the signal transduction function of the molecular recognition event into the receiver is integrated. As the original biological receptor often lacks an intrinsic

feature in the signal transduction function, the receptor must be positioned according to foreign reporter moieties like auto-fluorescent protein (AFP) and synthetic fluorophor. Despite an apparently straightforward method, researchers trying to make a new fluorescent biosensor for a specific objective would inevitably fight against unforeseen work. Adopting the procedures already defined would allow us to sidestep most of the issues. This article gives a short examination of a range of fluorescent bio-sensors design methodologies with a focus on the guiding concept. Aside from the standard design technique, in the area of aptamers signalling, there is lately a unique modular method to create fluorescence biosensors using simple combinations of a receptor and a signal transducer [16,17]. We shall examine the benefit of the Strategy and refer to fluorescence biosensor perspectives based on macromolecular receptors.

Auto-fluorescent proteins (AFPs) such as jellyfish green fluorescent protein (GFP) have become well-established and adaptable reporters of profiles[18] and protein locating proteins in a range of systems for monitoring gene expression[19]. It is worth noting that following translation AFPs display spontaneous fluorescence emissions in cells by autocatalytics of the chromophore [21,22]. Consequently, AFPs can only be produced endogenously in cells or tissues by plasmid DNA transfection without interfering with their fluorescent characteristics and injuring cells. Besides the use of AFPs as a reporter, other types of biosensors based on AFPs were recently produced through fusion of receptor proteins or AFP mutation. Almost two methodologies are in place for building biosensors based on AFP; (a) analyte sensor and (b) conformation sensor[24].

The design of analyte-sensitive sensors was based on AFP variations, the interaction between a target molecule and a chromophore mode in the AFP directly altered their fluorescence characteristics. Initially, a version of pH and halide-sensitive AFP has been produced using the GFP mutants' inherent pH sensitivity[24-26] and the YFP mutants' high pKas [27-29]. Mutations near to the GFP chromophore or the BFP barrel structure lead to the particular Hg2+ [30] and Zn2+ [31] biosensors, respectively. The receptor function was incorporated directly into the chromophore by altering the chemical composition of the chromophore.

The most convenient way to build biosensors is by using a rational design technique that has successful supplied fluorescent biosensors including not only the protein-driven biosensor, but also the aptamer-driven biosensor. However, this technique generally needs redundant sensor modification, since fluorophore drives typically affect the initial receptor function and do not always ensure the performance of the desired optical signals. Further, since the interaction between the chemical detection event and the signal transduction function is fundamentally unique to the individually built biosensor, experimentally gained insights from the building of a biosensor also are fairly difficult to apply to the other biosensors. Recently, a modular technique for easier manufacture of biosensors with customizable properties by simply combining a receptor and a signal transducer emerged as a new paradigm for a variable design of fluorescent bio-sensors. Stojanovic and colleagues have described a modular design based on the allosteric modulation of binding events for signalling aptamers[32]. These chemericals consisting of two modular

aptamers, one intended for the identification of the target and the other for holding a reporter colour, showed strong fluorescence responses to three distinct targets [33].

CONCLUSION

At now, protein-based biosensors are the most practical and reliable means to detect different physiologically relevant compounds in live cells in real-time and have really considerably contributed to the elucidation of the function of such cell molecules. However, the absence of a common method to integrating the signal transduction function into the receptors reflects the reality that there are a broad range of design strategy for protein-based biosensors. A general approach to successfully integrate a signal transducer with a receiver remains a demanding need for tailor-made biosensors.

Aptamer-based bio-sensors are full of practical obstacles in cell applications, but this technology is also a potentially promising approach to the visualisation of intracellular molecules. This is due primarily to the difficulties of building aptamers with an affinity and selectivity similar to the natural receptor protein and to the intrinsic lability of intracellular RNA molecules. The enhancement of the selection and evolution approach and the building of signalling Aptamers' resistance to cellular degradation activities would overcome these constraints.

REFERENCES

1. Arshak, K., Moore, E., Lyons, G. M., Harris, J., & Clifford, S. (2004). A review of gas sensors employed in electronic nose applications. *Sensor Review*, *24*(2), 181–198. https://doi.org/10.1108/02602280410525977
2. Bao, M., & Yang, H. (2007). Squeeze film air damping in MEMS. *Sensors and Actuators, A: Physical*, *136*(1), 3–27. https://doi.org/10.1016/j.sna.2007.01.008
3. Basu, S., & Bhattacharyya, P. (2012). Recent developments on graphene and graphene oxide based solid state gas sensors. *Sensors and Actuators, B: Chemical*, *173*, 1–21. https://doi.org/10.1016/j.snb.2012.07.092
4. Becker, H., & Heim, U. (2000). Hot embossing as a method for the fabrication of polymer high aspect ratio structures. *Sensors and Actuators, A: Physical*, *83*(1), 130–135. https://doi.org/10.1016/S0924-4247(00)00296-X
5. Dietrich, I., & Dressler, F. (2009). On the lifetime of wireless sensor networks. *ACM Transactions on Sensor Networks*, *5*(1). https://doi.org/10.1145/1464420.1464425
6. Farahani, H., Wagiran, R., & Hamidon, M. N. (2014). Humidity sensors principle, mechanism, and fabrication technologies: A comprehensive review. *Sensors (Switzerland)*, *14*(5), 7881–7939. https://doi.org/10.3390/s140507881
7. Fraden, J. (2016). Handbook of modern sensors: Physics, designs, and applications. In *Handbook of*

Modern Sensors: Physics, Designs, and Applications. Springer International Publishing. https://doi.org/10.1007/978-3-319-19303-8

8. Ganeriwal, S., Balzano, L. K., & Srivastava, M. B. (2008). Reputation-based framework for high integrity sensor networks. *ACM Transactions on Sensor Networks*, *4*(3). https://doi.org/10.1145/1362542.1362546

9. García-Martín, J., Gómez-Gil, J., & Vázquez-Sánchez, E. (2011). Non-destructive techniques based on eddy current testing. *Sensors*, *11*(3), 2525–2565. https://doi.org/10.3390/s110302525

10. Huang, X.-J., & Choi, Y.-K. (2007). Chemical sensors based on nanostructured materials. *Sensors and Actuators, B: Chemical*, *122*(2), 659–671. https://doi.org/10.1016/j.snb.2006.06.022

11. Korotcenkov, G. (2005). Gas response control through structural and chemical modification of metal oxide films: State of the art and approaches. *Sensors and Actuators, B: Chemical*, *107*(1 SPEC. ISS.), 209–232. https://doi.org/10.1016/j.snb.2004.10.006

12. Lefeuvre, E., Badel, A., Richard, C., Petit, L., & Guyomar, D. (2006). A comparison between several vibration-powered piezoelectric generators for standalone systems. *Sensors and Actuators, A: Physical*, *126*(2), 405–416. https://doi.org/10.1016/j.sna.2005.10.043

13. Li, C., Ye, M., Chen, G., & Wu, J. (2005). An energy-efficient unequal clustering mechanism for wireless sensor networks. *2nd IEEE International Conference on Mobile Ad-Hoc and Sensor Systems, MASS 2005*, *2005*, 597–604. https://doi.org/10.1109/MAHSS.2005.1542849

14. Lim, L.-H. (2005). Singular values and eigenvalues of tensors: A variational approach. *IEEE CAMSAP 2005 - First International Workshop on Computational Advances in Multi-Sensor Adaptive Processing*, *2005*, 129–132. https://doi.org/10.1109/CAMAP.2005.1574201

15. Malan, D. J., Welsh, M., & Smith, M. D. (2004). A public-key infrastructure for key distribution in TinyOS based on elliptic curve cryptography. *2004 First Annual IEEE Communications Society Conference on Sensor and Ad Hoc Communications and Networks, IEEE SECON 2004*, 71–80. https://www.scopus.com/inward/record.uri?eid=2-s2.0-20344381294&partnerID=40&md5=f4103f2fc31a0df2bec8ecb3e105022f

16. Mannini, A., & Sabatini, A. M. (2010). Machine learning methods for classifying human physical activity from on-body accelerometers. *Sensors*, *10*(2), 1154–1175. https://doi.org/10.3390/s100201154

17. Maurer, U., Smailagic, A., Siewiorek, D. P., & Deisher, M. (2006). Activity recognition and monitoring using multiple sensors on different body positions. *Proceedings - BSN 2006: International Workshop on Wearable and Implantable Body Sensor Networks*, *2006*, 113–116. https://doi.org/10.1109/BSN.2006.6

18. Mitcheson, P. D., Miao, P., Stark, B. H., Yeatman, E. M., Holmes, A. S., & Green, T. C. (2004).

MEMS electrostatic micropower generator for low frequency operation. *Sensors and Actuators, A: Physical*, *115*(2-3 SPEC. ISS.), 523–529. https://doi.org/10.1016/j.sna.2004.04.026

19. Muro-de-la-Herran, A., García-Zapirain, B., & Méndez-Zorrilla, A. (2014). Gait analysis methods: An overview of wearable and non-wearable systems, highlighting clinical applications. *Sensors (Switzerland), 14*(2), 3362–3394. https://doi.org/10.3390/s140203362

20. Rabbat, M., & Nowak, R. (2004). Distributed optimization in sensor networks. *Third International Symposium on Information Processing in Sensor Networks, IPSN 2004*, 20–27. https://doi.org/10.1145/984622.984626

21. Rahman, M. M., Ahammad, A. J. S., Jin, J.-H., Ahn, S. J., & Lee, J.-J. (2010). A comprehensive review of glucose biosensors based on nanostructured metal-oxides. *Sensors*, *10*(5), 4855–4886. https://doi.org/10.3390/s100504855

22. Rajendran, V., Obraczka, K., & Garcia-Luna-Aceves, J. J. (2003). Energy-efficient, collision-free medium access control for wireless sensor networks. *SenSys'03: Proceedings of the First International Conference on Embedded Networked Sensor Systems*, 181–192. https://doi.org/10.1145/958491.958513

23. Rana, R. K., Chou, C. T., Kanhere, S. S., Bulusu, N., & Hu, W. (2010). Ear-phone: An end-to-end participatory urban noise mapping system. *Proceedings of the 9th ACM/IEEE International Conference on Information Processing in Sensor Networks, IPSN '10*, 105–116. https://doi.org/10.1145/1791212.1791226

24. Sakai, G., Matsunaga, N., Shimanoe, K., & Yamazoe, N. (2001). Theory of gas-diffusion controlled sensitivity for thin film semiconductor gas sensor. *Sensors and Actuators, B: Chemical*, *80*(2), 125–131. https://doi.org/10.1016/S0925-4005(01)00890-5

25. Simon, I., Bârsan, N., Bauer, M., & Weimar, U. (2001). Micromachined metal oxide gas sensors: Opportunities to improve sensor performance. *Sensors and Actuators, B: Chemical*, *73*(1), 1–26. https://doi.org/10.1016/S0925-4005(00)00639-0

26. Sun, C., Fang, N., Wu, D. M., & Zhang, X. (2005). Projection micro-stereolithography using digital micro-mirror dynamic mask. *Sensors and Actuators, A: Physical*, *121*(1), 113–120. https://doi.org/10.1016/j.sna.2004.12.011

27. Tolle, G., Polastre, J., Szewczyk, R., Culler, D., Turner, N., Tu, K., Burgess, S., Dawson, T., Buonadonna, P., Gay, D., & Hong, W. (2005). A macroscope in the redwoods. *SenSys 2005 - Proceedings of the 3rd International Conference on Embedded Networked Sensor Systems*, 51–63. https://doi.org/10.1145/1098918.1098925

28. Varghese, O. K., Kichambre, P. D., Gong, D., Ong, K. G., Dickey, E. C., & Grimes, C. A. (2001). Gas sensing characteristics of multi-wall carbon nanotubes. *Sensors and Actuators, B: Chemical*,

81(1), 32–41. https://doi.org/10.1016/S0925-4005(01)00923-6

29. Varghese, S. S., Lonkar, S., Singh, K. K., Swaminathan, S., & Abdala, A. (2015). Recent advances in graphene based gas sensors. *Sensors and Actuators, B: Chemical*, *218*, 160–183. https://doi.org/10.1016/j.snb.2015.04.062

30. Watro, R., Kong, D., Cuti, S.-F., Gardiner, C., Lynn, C., & Kruus, P. (2004). TinyPK: Securing sensor networks with public key technology. In S. S. Swarup V. (Ed.), *Proceedings of the 2004 ACM Workshop on Security of Ad Hoc and Sensor Networks, SASN'04* (pp. 59–64). https://www.scopus.com/inward/record.uri?eid=2-s2.0-14844304757&partnerID=40&md5=afafe645696e24f52481f2fc641f9992

31. Yoo, E.-H., & Lee, S.-Y. (2010). Glucose biosensors: An overview of use in clinical practice. *Sensors*, *10*(5), 4558–4576. https://doi.org/10.3390/s100504558

32. Zoha, A., Gluhak, A., Imran, M. A., & Rajasegarar, S. (2012). Non-intrusive Load Monitoring approaches for disaggregated energy sensing: A survey. *Sensors (Switzerland)*, *12*(12), 16838–16866. https://doi.org/10.3390/s121216838