Boronic Acid Derivatives for Indirect Fluorescent Glucose Sensing

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Abstract

Boronic acids (BAs) are well-known for their interactions with diol-containing compounds like glucose. Fluorescent moieties are commonly considered to enable monitoring of this interaction by changes in fluorescence. Hence, a novel cationic pyrimidine BA derivative, DBA2, has been investigated for it's indirect glucose sensing capabilities. This approach aims to develop smart-contact lenses that will allow people suffering from diabetes to track their condition continuously and non-invasively in real-time using a mobile phone application.

1. Introduction

Diabetes is a worldwide incurable disease known to have acute and chronic health effects [1]. Blindness, heart or kidney failures are among the most common life-threatening effects of diabetes [1]. Monitoring physiological blood-glucose concentrations is a means of managing the disease, however few non-invasive continuous monitoring methods currently exist [1]. Consequently, there is considerable interested in using aqueous ocular fluid as a sample medium for tracking the disease marker glucose.

2. The Sensing Mechanism

Incorporation of a BA component into charged molecules, can be used to induce quenching in the emission of a known fluorescent molecule, thereby creating a two-component sensing system [1-2]. In this approach, the fluorescence of 7-hydroxycoumarin, is monitored. Increasing concentrations of our novel BA sensor, quenches the fluorescence of 7HC. The change in fluorescence intensity of the system is achieved *via* the formation of a ground-state complex, through electrostatic interactions between the fluorophore and BA-quencher [1-2]. In the presence of saccharides, the Lewis acidic BA moiety of the sensor is known to form strong, reversible interactions [2]. This leads to the formation of a boronate diester [2], resulting in the dissociation of the BA-quencher and fluorophore ground-state complex, causing a sequential recovery of fluorescence in 7HC [1-2].

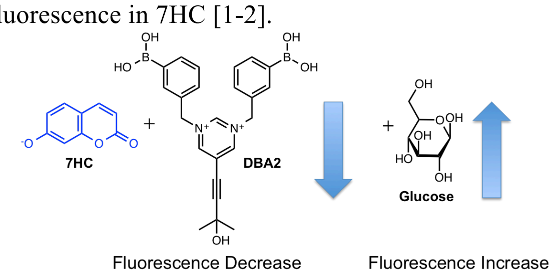

Figure 1: Indirect glucose-sensing mechanism.

3. Fluorescence

3.1 Fluorescence Quenching

Photophysical characterisation shows that upon increased BA-quencher concentrations an extremely efficient and sequential decrease in the fluorescence intensity is observed in 7HC.

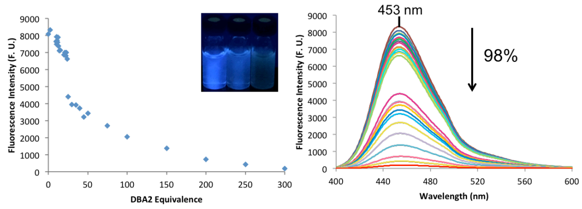

Figure 2: Fluorescence quenching of 7HC with DBA2 at pH 8.6 when excited at 370 nm.

3.2 Fluorescence Recovery

The introduction of glucose to this two-component system allows for a recovery in fluorescence, which can be used to indirectly quantify glucose concentrations.

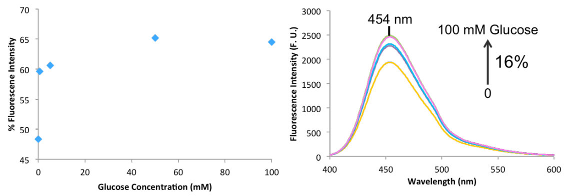

Figure 3: Fluorescence recovery of 7HC with glucose (up to 100 mM) at pH 8.6 when excited at 370 nm.

4. Conclusion

To conclude, this glucose-sensing switch shows a high sensitivity for sugar detection, where DBA2 showed great potential to act as a glucose sensor exhibiting a decrease in fluorescence intensity by 98% and on incremental additions of glucose, the fluorescence can be recovered. Moreover, the inclusion of anchoring moieties to the BA-quencher shows wonderful potential for the incorporation of this molecule into porous hydrogel platforms.

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5. References

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[2] Y. H. Li, L. Zhang, J. Huang, R. P. Liang, J. D. Qiu, *Chem. Commun, 49:5180-5182,* 2013.