

Fabrication of Non-Enzymatic Optical Glucose Sensors Based on Boronic Acid Derivatives

Centre for Data Analytics

Insight

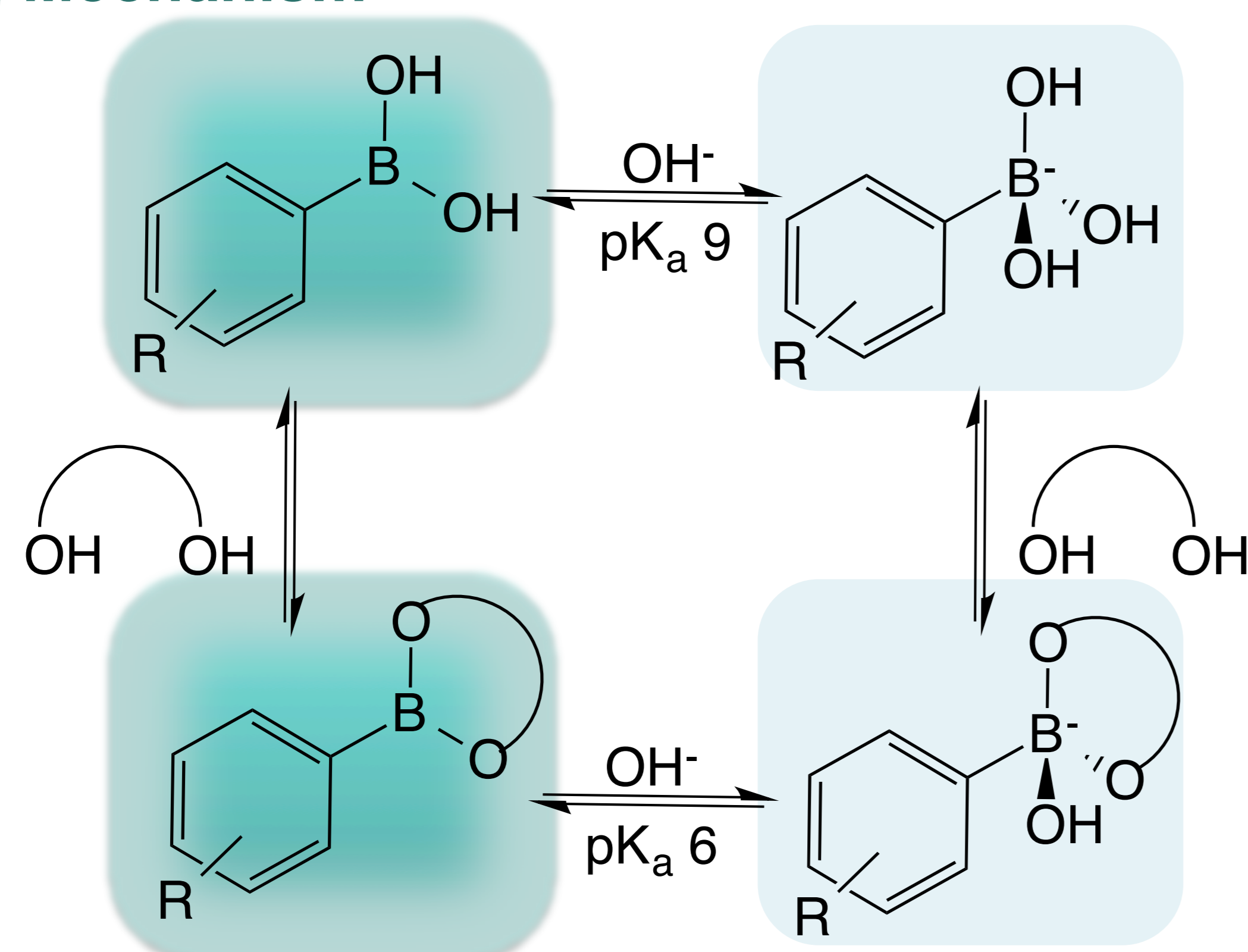
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Introduction

Diabetes is a worldwide incurable disease known to have acute and chronic health effects, such as blindness, heart or kidney failure. Monitoring physiological glucose concentrations is a means of managing diabetes, however no continuous noninvasive monitoring method currently exists. The use of boronic acids (BAs) for sensing sugars is well-known, as these Lewis acids have a high affinity for diol-containing compounds. In this context, fluorescent BA derivatives have been investigated for potential use in sensing-devices, such as smart contact lenses, as they have shown a decrease in fluorescent intensity on increased glucose concentrations. This approach aims to develop non-enzymatic optical glucose sensors through which people suffering from diabetes can track their condition.

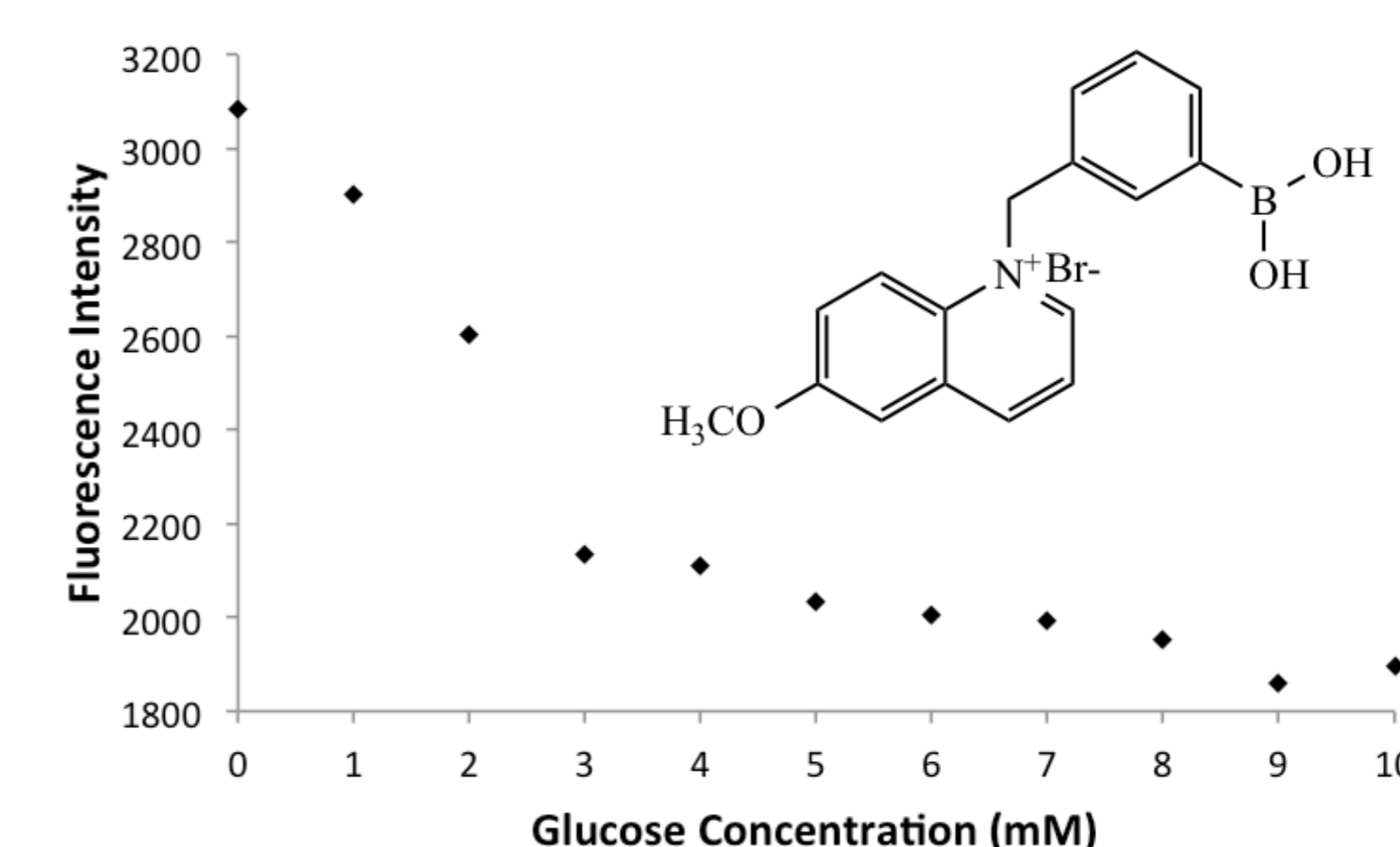
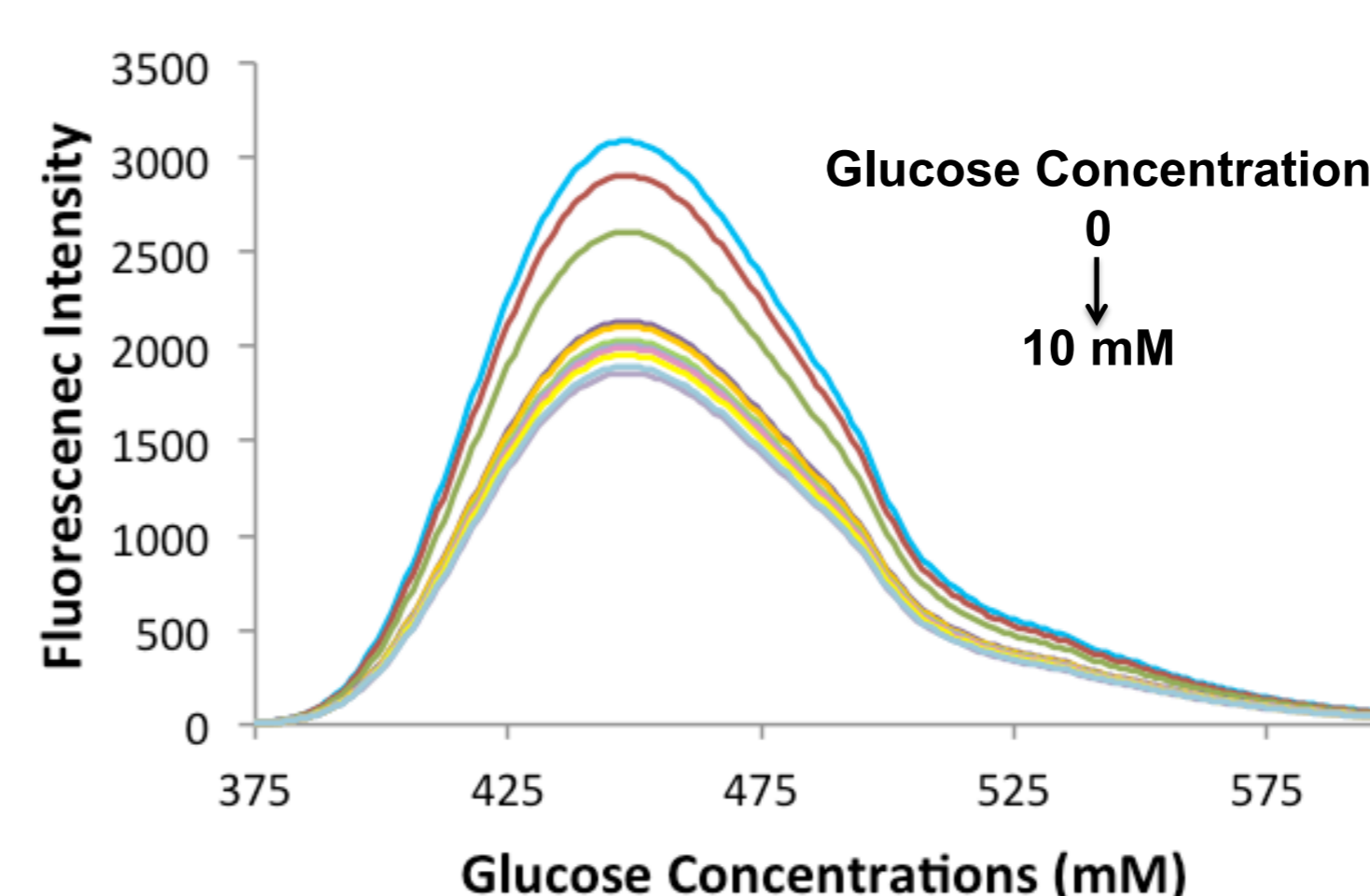
Sensing Mechanism



Fluorescent
Non-Fluorescent
OH OH = Diol/Sugar

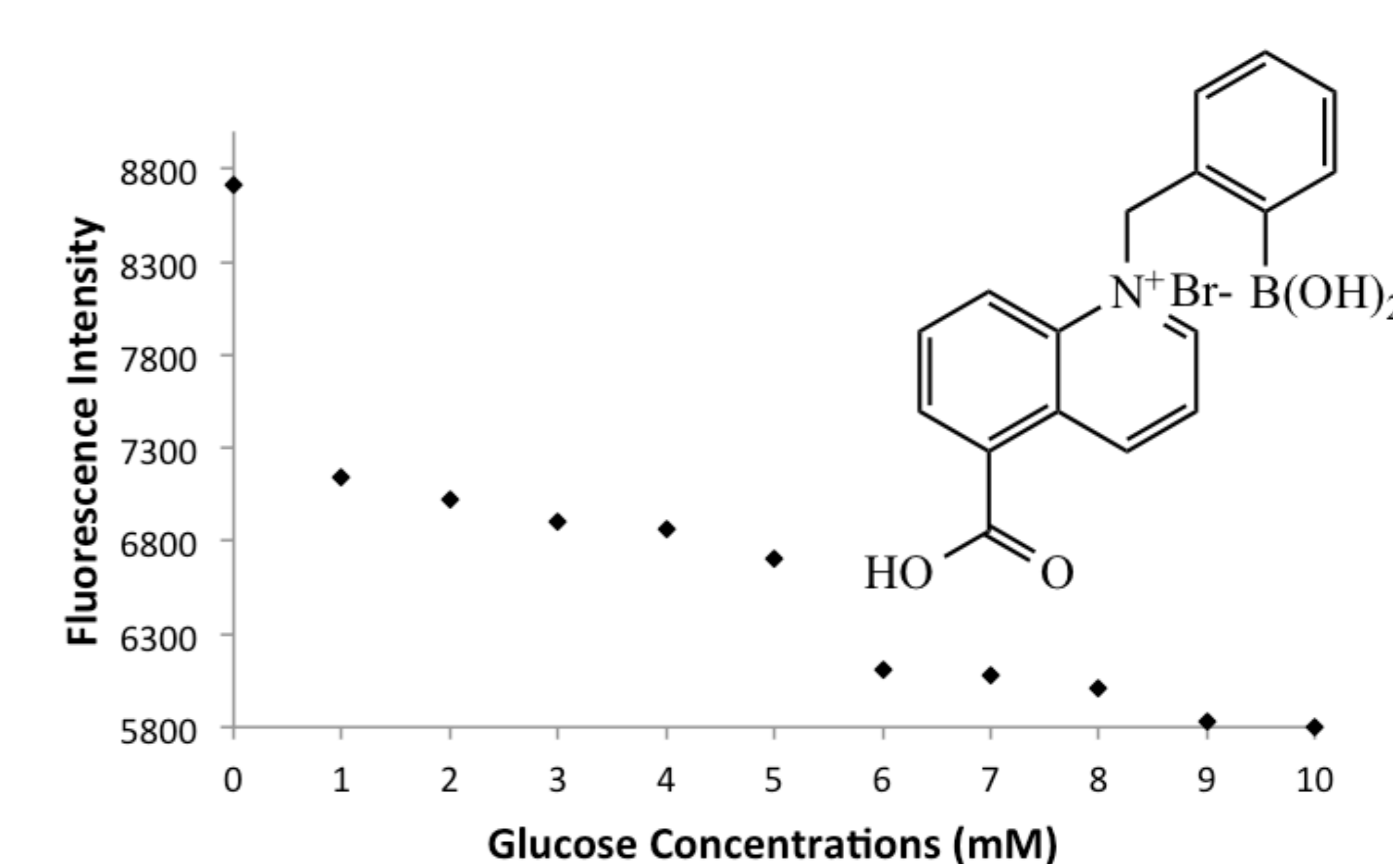
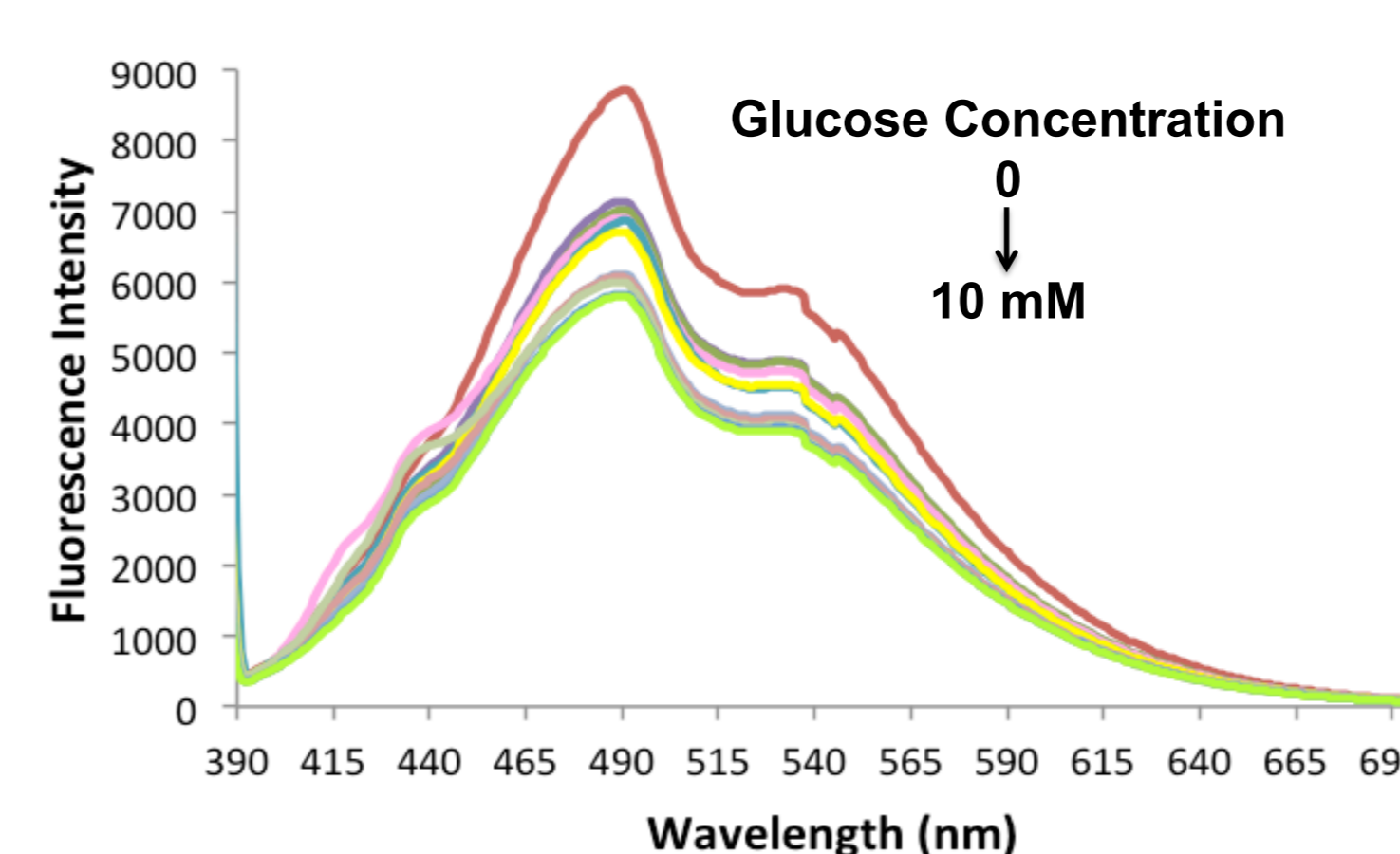
Glucose Sensing

The fluorescence of *o*-COOHBA, a novel BA sensor, has been compared to the fluorescence of *m*-MethoxyBA, a reported BA sensor, when studied in solution at pH 7.4. Both BA sensors were shown to respond to glucose in the dynamic range of 0-10mM, which corresponds to the ocular glucose concentration range in diabetics (~500 μ M – 5mM).



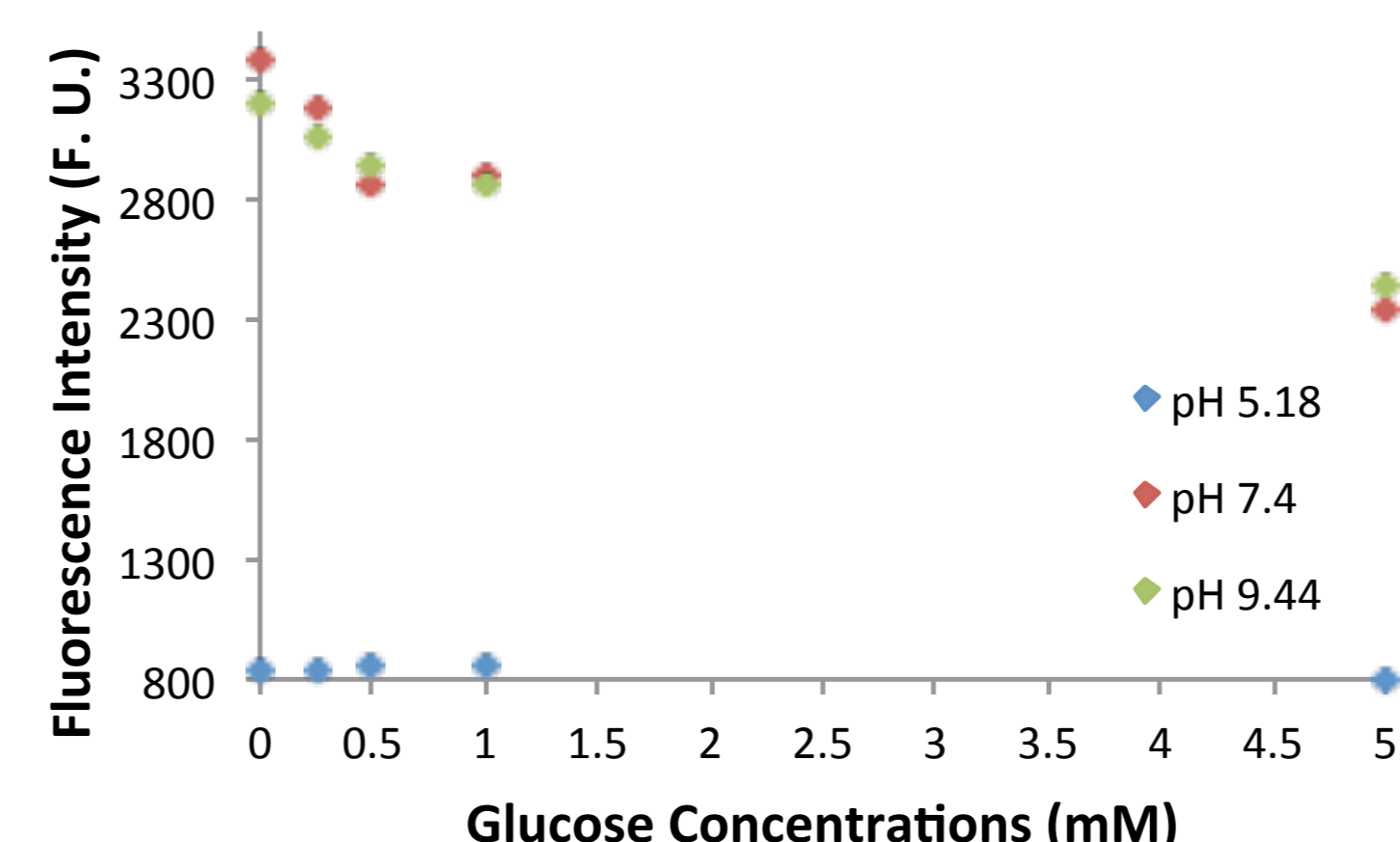
m-MethoxyBA; 0.25 mM in pH 7.4 phosphate buffer and methanol (1:1)

Excitation wavelength: 365 nm; Emission wavelength: 448 nm; Slit width 2.5 nm for excitation and emission, using a high sensitivity.



o-COOHBA; 0.5 mM in pH 7.4 phosphate buffer

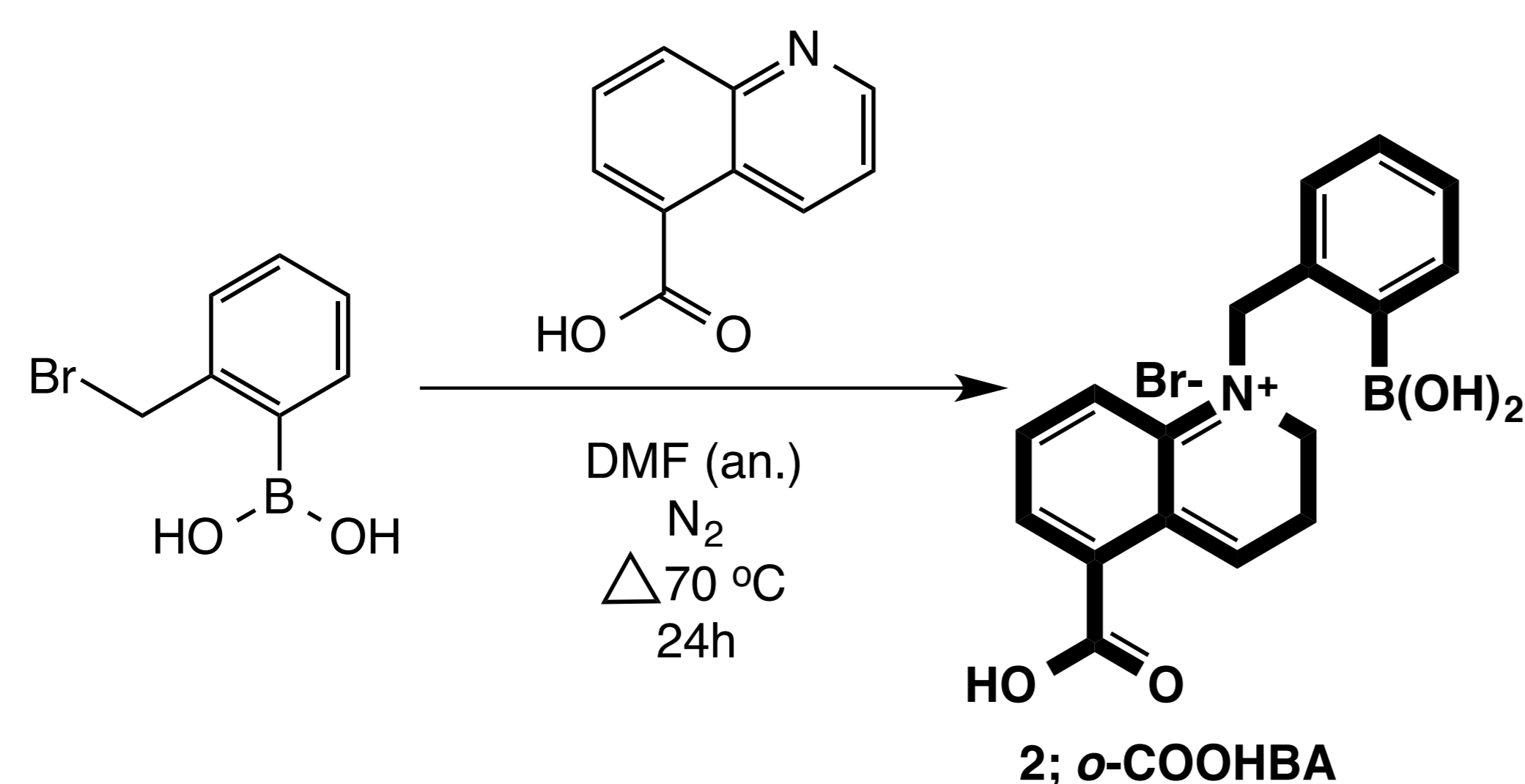
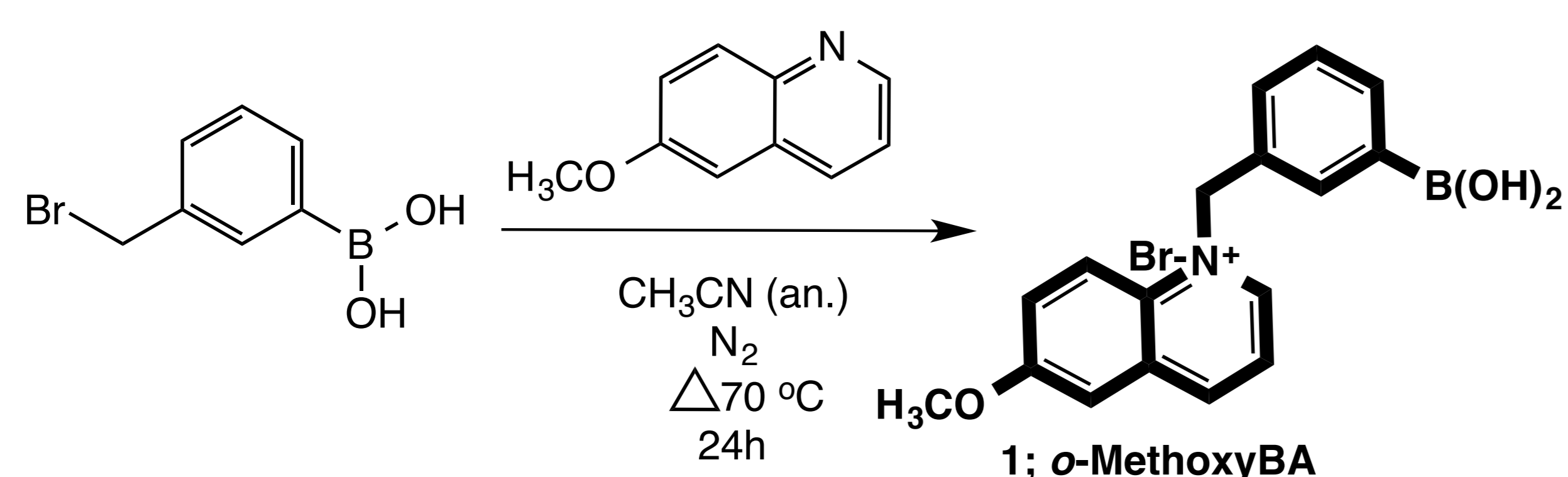
Excitation wavelength 380 nm; Emission wavelength: 485 nm; Slit width 5 nm for excitation and emission, using a high sensitivity.



o-COOHBA 0.5 mM was studied in pH buffers 5.18, 7.4 and 9.44 with glucose, correlating to the ocular glucose concentrations. The change in fluorescence intensity was not seen below pH 6, due to the pK_a of 6 for the fluorescent sugar-bound BA form.

Excitation wavelength 380 nm; Emission wavelength: 485 nm; Slit width 5 nm for excitation and 2.5 nm for emission, using a high sensitivity.

Synthesis



Successful synthesis of novel BA sensor *o*-COOHBA was confirmed by 1H NMR.

Conclusions

Both BA sensors presented here have demonstrated a decrease in fluorescence intensity on increased glucose concentrations. Although *m*-MethoxyBA has shown the highest fluorescence intensity, *o*-COOHBA has demonstrated the ability to sense glucose in the micromolar concentrations correlating to the ocular glucose range in diabetic patients, 0.5-5mM. The higher excitation wavelength of 380 nm is also advantageous, as it lies close towards the visible-region of the electromagnetic spectrum, which allows for the use of cheap, readily available LEDs as excitation sources. Moreover, the carboxylic acid substituent of *m*-COOHBA is desirable for immobilizing the BA sensor on to various polymer substrates.