Ocular Glucose Bio-Sensing Using Boronic Acid Fluorophores

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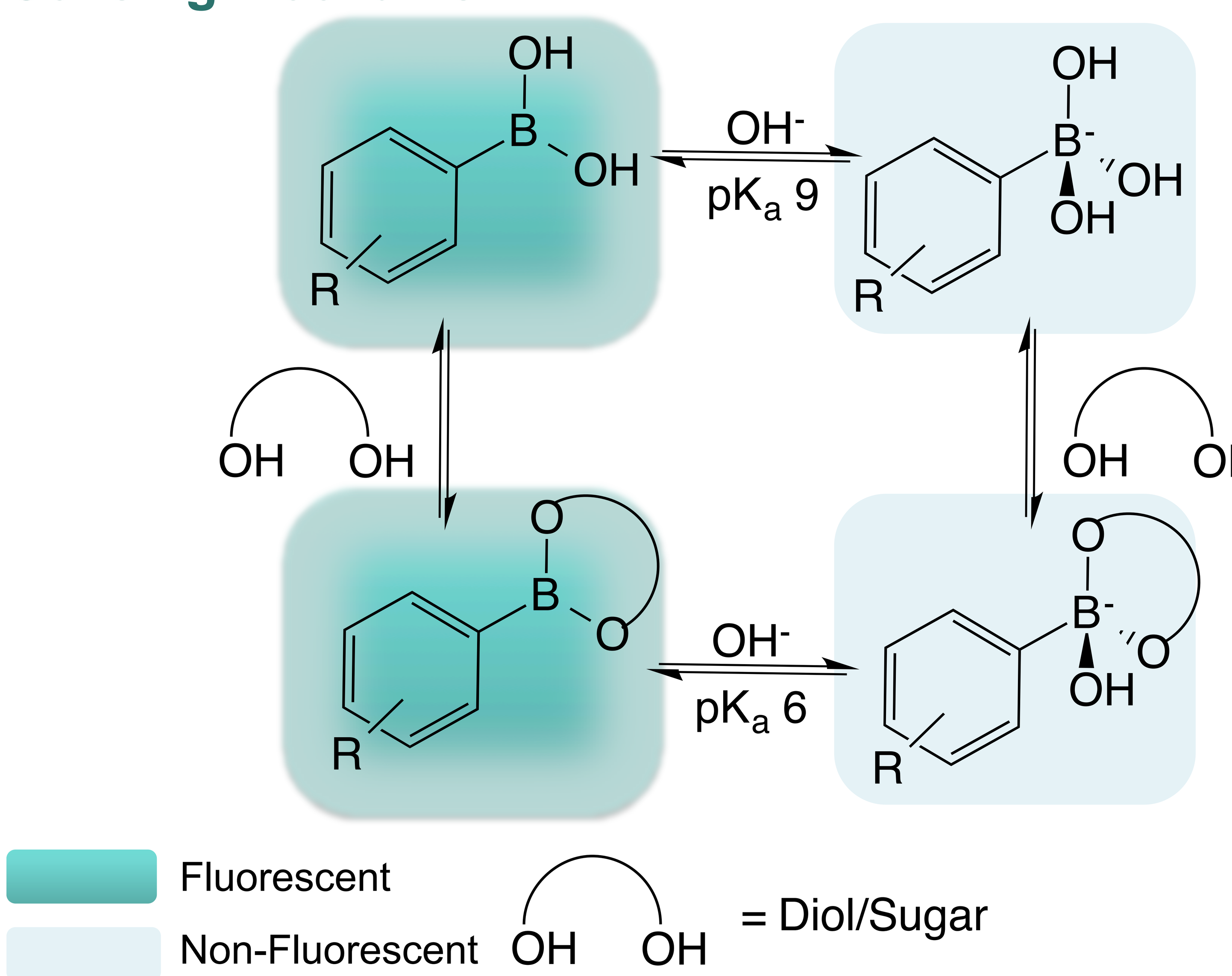
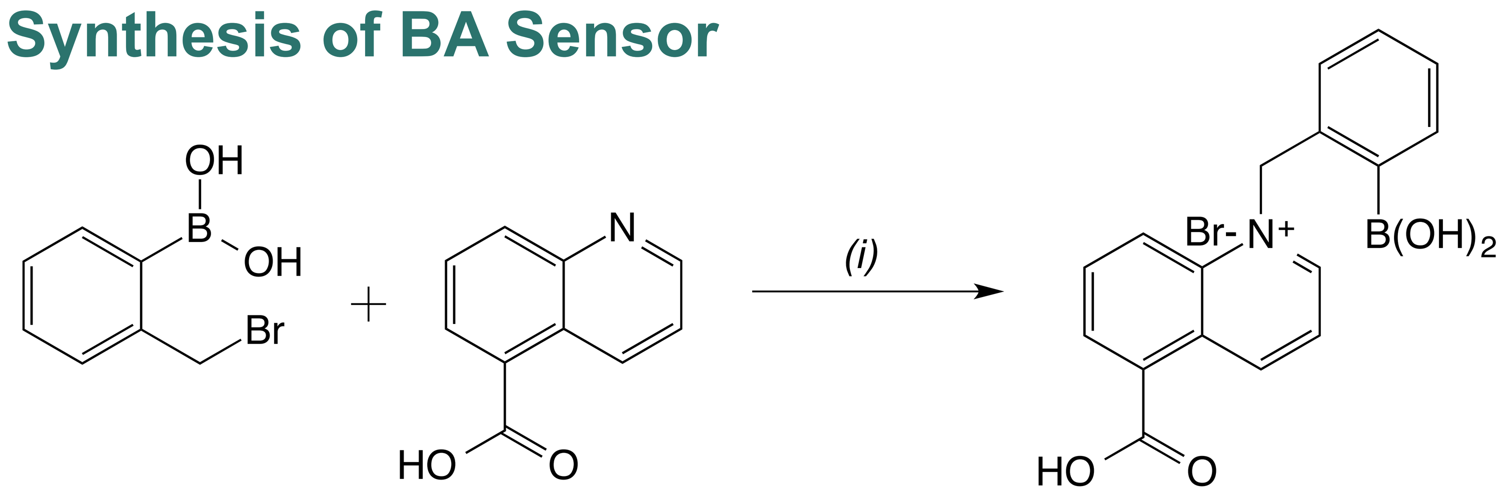
Introduction

Boronic acids (BA) are well-known for their interactions with diol-containing compounds like glucose. Fluorescent moieties are commonly incorporated into a BA derivative's framework to monitor the effect of varied glucose concentrations in a given environment. In this study, a novel carboxylic acid BA derivative, *o*-COOHBA, has been synthesized and investigated for glucose sensing, in solution and when immobilised on to a polydimethylsiloxane (PDMS) "lens"-like surface. In both cases on increased glucose concentrations, a decrease in fluorescence intensity was observed in the range of 0-10mM in solution and similarly, in the range of 0-5mM when anchored to a PDMS surface, corresponding to the ocular-glucose concentrations for diabetics (~500µM – 5mM). In contrast to the Google electrochemical sensor approach, our goal is to provide personal and continuous management of ocular-glucose levels for diabetics via a contact-lens compatible optical sensor.

Sensing Mechanism

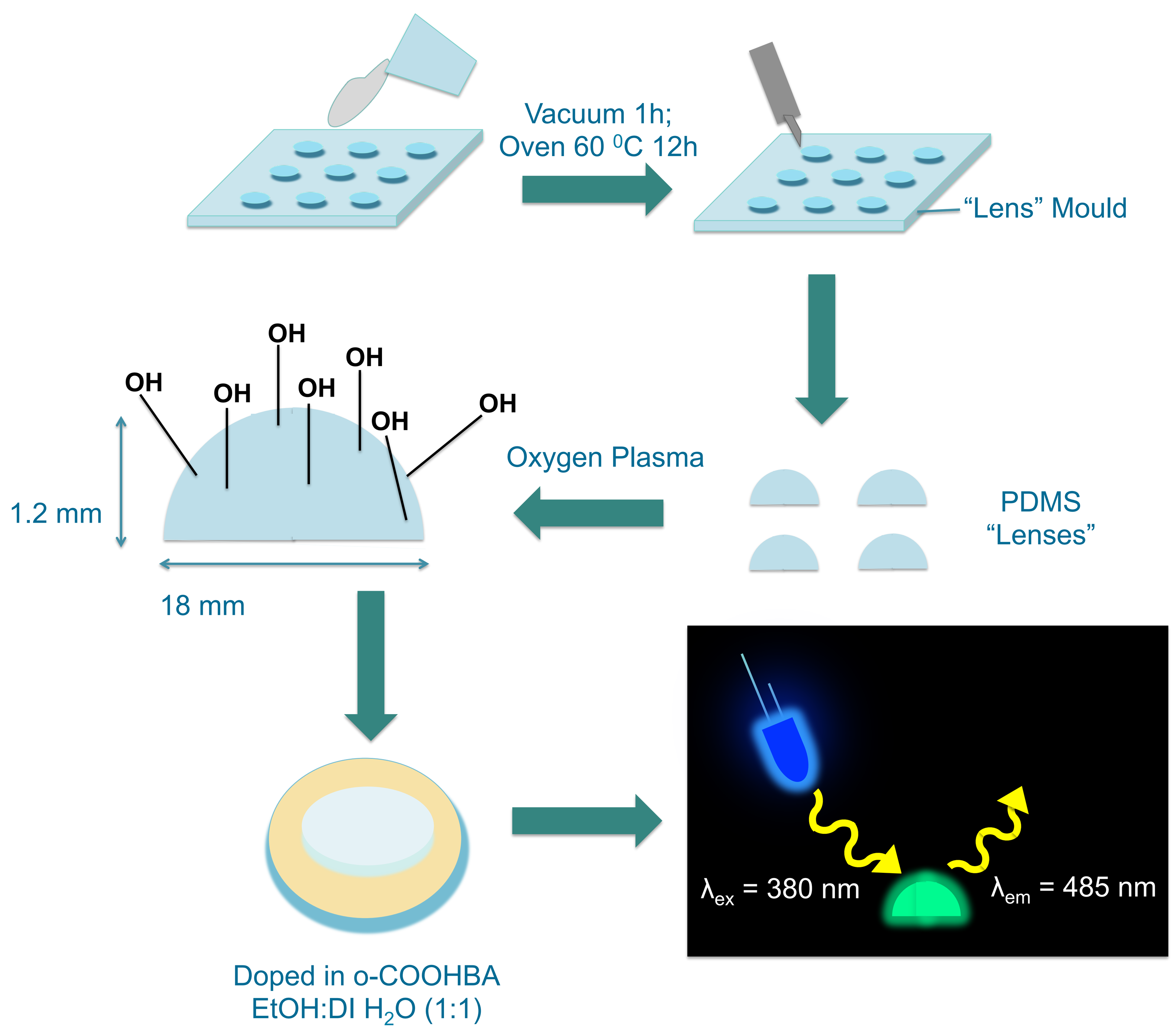


Synthesis of BA Sensor



Synthesis of o-COOHBA; (i) anhydrous dimethylsulfoxide, N_2, 70 ^{0}C for 48h. Formation of o-COOHBA was confirmed by ^{1}H NMR.

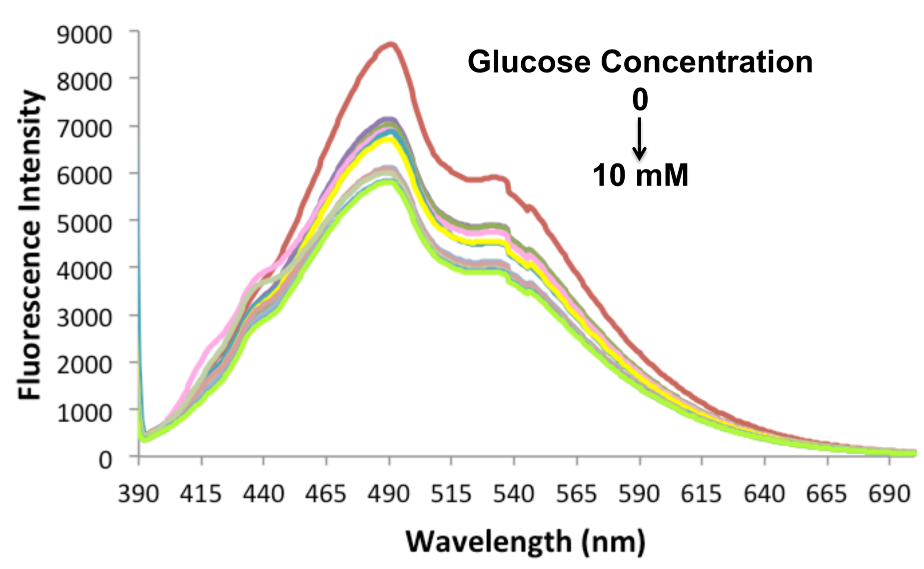
PDMS Lens Fabrication

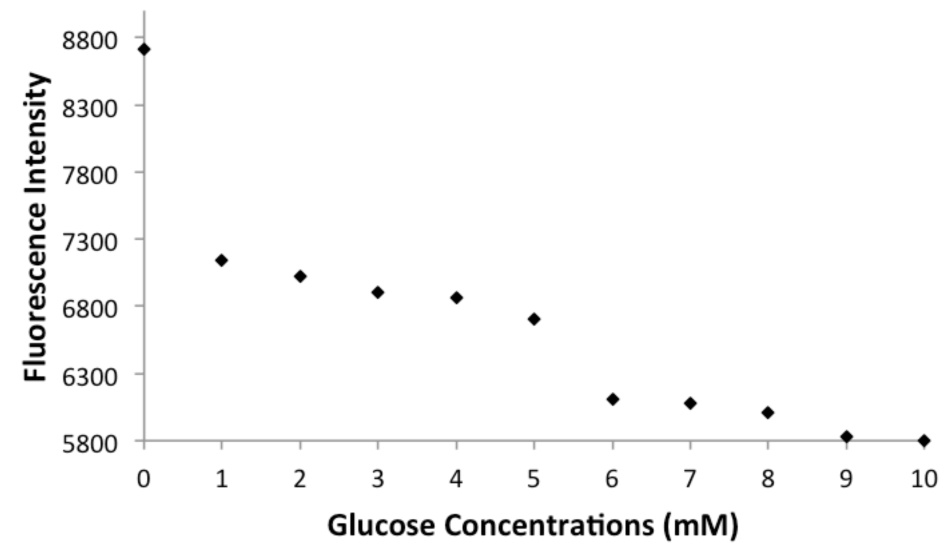


Glucose Sensing

The fluorescence of *o*-COOHBA has been studied in solution and when anchored to a PDMS surface. *o*-COOHBA has shown to respond to glucose in the dynamic range of 0-10mM, which corresponds to the ocular-glucose concentration range in diabetics (~500µM – 5mM).

o-COOHBA in Solution

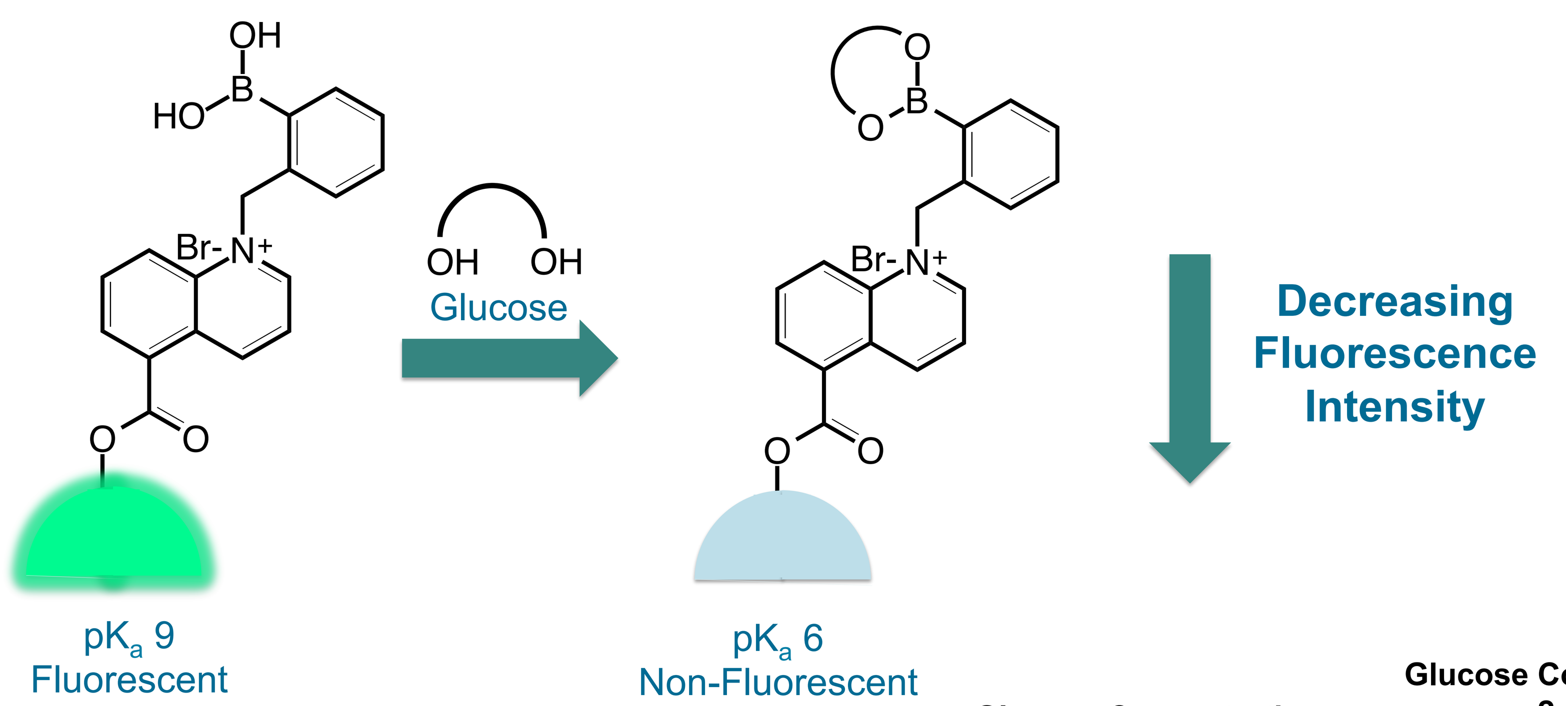




o-COOHBA; 0.5mM in pH 7.4 phosphate buffer

Excitation wavelength 380 nm; Emission wavelength: 485 nm

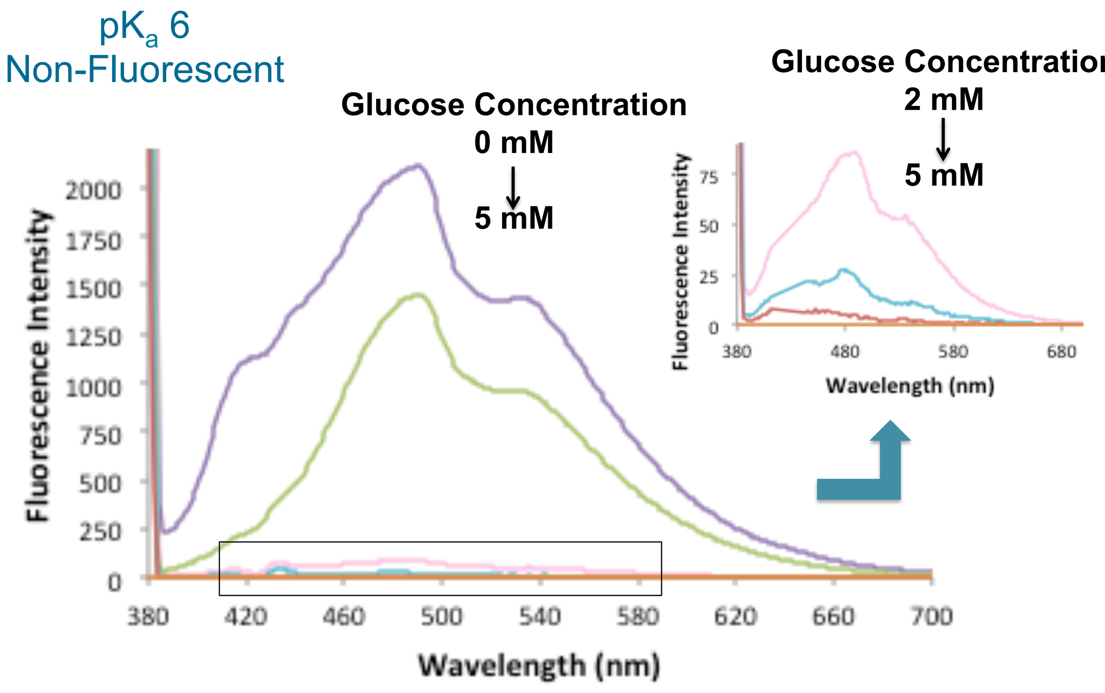
o-COOHBA Immobilized onto PDMS



o-COOHBA immobilized on a PDMS surface, immersed in pH 7.4 phosphate buffer

Excitation wavelength 380 nm

Emission wavelength: 485 nm



Conclusions

In both solution studies and when anchored on to the PDMS surface, a decrease in fluorescence intensity was observed on increased glucose concentrations. The excitation wavelength of 380 nm is advantageous, as it lies close to the visible-region of the electromagnetic spectrum, which allows for the use of cheap, readily available LEDs as excitation sources. The large Stokes shift of 100 nm is also ideal for a sensing application. Moreover, the carboxylic acid substituent of *o*-COOHBA is desirable for immobilizing the BA sensor on to various polymer substrates.

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