Towards accurate glucose sensing: Determining the effect of pH on glucose detection
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Abstract

Diabetes is a worldwide epidemic that can cause severe medical complications. There are limitations on accuracy and practicality with the current technologies used for diabetes management, so research on improving techniques and on new technologies is prevalent. One of the technologies with great potential for glucose detection is Raman spectroscopy. Raman Spectroscopy is a useful analytical tool that can be applied to study glucose properties and concentrations in physiologically relevant (i.e. aqueous) solutions. Glucose is a unique organic molecule and thus has a unique Raman spectrum. In addition, it is easily differentiated from other components in body fluids. The glucose molecule, however, is in a dynamic equilibrium with several molecular configurations, i.e. anomers. According to the literature the surroundings (pH, solvent, temperature and concentration) of glucose in solution influence the equilibrium. Measuring glucose concentrations in various bodily fluids thus means glucose will be monitored under varying conditions. Simultaneously, it has been shown that enzymatic test-strips, widely employed for self-testing in diabetic care, are far less reliable under acidic environments. In this MSC research project glucose was dissolved in aqueous solutions under varying acidity (pH 3 â€“ 8), and measured with Raman spectroscopy, enzymatic test-strips and NMR. This way it was possible to measure the proposed change of equilibrium as well as checking the potential for Raman spectroscopy to reliably detect glucose under varying circumstances. The results were that there was no change in equilibrium due to small pH changes or interaction with dilute formic/acetic acid. This is very relevant for glucose detection in bodily fluids other than blood. We support this using Nuclear Magnetic Resonance Spectroscopy, Raman, and Density Functional Theory modelling using the Amsterdam Density Functional. The modelling shows that there is little energetic difference between the ground states of each anomer, thus indicating that pH will not strongly influence anomeric ratios. The strong interaction between water and glucose seems to have more influence than the interaction between glucose and dilute organic acids. The results show that Raman spectroscopy has great potential as a monitoring technique under varying pH, in contrast to enzymatic sensors that fail under the same circumstances.