Liquid Crystal-Based Enzymatic Biosensor for Detection of Lactic Acid

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Liquid crystals (LCs) are characterized by their unique mesophase, which combines the fluidity of liquids with the ordered structure of solid crystals. Their long-range orientational order and optical anisotropy enable LCs to change their alignment in response to chemical and biomolecular binding events transforming these interactions into amplified, measurable optical signals. This dynamic responsiveness is exemplified by 5CB (4-cyano-4'-pentylbiphenyl), a widely utilized nematic liquid crystal known for its rapid response to external stimuli such as surface topography, molecular configuration, pH levels, and temperature, making it ideal for biosensing. In this work, we introduce a novel lactate oxidase (LOx) LC biosensor that is particularly designed for the precise detection of lactic acid. This biosensor demonstrates how the enzymatic conversion of lactic acid to pyruvate and hydrogen peroxide can induce pH changes that significantly alter the alignment of 5CB molecules, thereby enhancing signal transduction. The biosensor assembly involves a functionalized coating of Dimethyloctadecyl [3-(trimethoxysilyl)propyl] ammonium chloride (DMOAP) and (3-Aminopropyl) triethoxy-silane (APTES) on a glass substrate. Glutaraldehyde is employed as a crosslinker to robustly immobilize the LOx enzyme on the coated surface, optimizing interaction with lactic acid. This interaction not only disrupts the LC orientation but also highlights the LCs' response to pH changes, enhancing the detection of optical signals. The biosensor structural and functional properties will be characterized using scanning electron microscopy (SEM), polarizing optical microscopy (POM), UV-VIS spectroscopy and other spectrometric techniques. This orientation sensitive design offers enhanced accuracy, demonstrating potential for widespread applications in clinical diagnostics, quality assurance in food

industry, bioprocess monitoring and environmental surveillance This research emphasizes the integration of biochemical method with LC technology paving the way for setting a new standard for biosensing functionality that enables precise, real-time tracking of lactic acid levels and is potentially leading to the development of portable, non-invasive diagnostic tool.