

Molecular Imprinted Polymer-Based FET Sensor for Sensing of Sweat Testosterone to Monitor Athletic Performance

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Abstract

High testosterone is associated with increased physical performance in sports due to its stimulation with body-muscle ratio, lean mass (muscle and bone), and bone density. Several studies show athletes with better explosive strength and sprint running performances in football, have a higher basal level of testosterone. The results suggest a relationship between testosterone production and the development of fast-twitch muscle fibers, endurance training, lean mass, resistance training in athletes as well as motivation for competition. Thus, monitoring testosterone levels is gaining attention to evaluate athletic performance of one's physical performance in sport, fitness, and bodybuilding as well as prevent health risk factors for low levels of testosterone. There have been attempts using optical, electrical and biochemical sensors to monitor testosterone but are difficult to reproduce in large quantities and suffer from limitations of sensitivity, and detection limits. This can be addressed using Molecularly Imprinted Polymers (MIPs) in a point of care (POC) system. Molecularly Imprinted Polymers (MIPs) are a synthetic polymer with cavities in the polymer matrix serve as recognition sites for a specific template molecule, which are detected using electrochemical amperometry.

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In this paper, we have used MIPs in conjunction with cyclic voltammetry, to produce a viable, ultrasensitive electrochemical sensor for the detection of testosterone from a human sweat sample. This combination of MIPs and cyclic voltammetry allows for a simple, low-cost, mass-producible, and non-invasive method for detecting testosterone in human males. This method is extremely simple and cheap, allowing for consistent measurement of Testosterone levels in humans and allows for the detection of Testosterone in a POC. In our work, a Screen-printed carbon electrode (SPCE) using polypropylene fabric was used as the base working electrode in a three-electrode system. The screen-printing technique was implemented to layer a carbon paste over both sides of the fabric and was air-dried for one hour at 75°C. The SPCE was immersed into an acetate buffer solution that contains a 2.0mM monomer called o-phenylenediamine and with a 0.1mM testosterone template.

Electropolymerization was carried out with cyclic voltammetry from a range of 0V to 1.0V, at a scan rate of 50 mV/s, a sensitivity (A/V) of 1e-5A, and for a total of 30 cycles. The set concentration tested was 100-1600 ng/ml of testosterone. The electrochemical characterization will have a potential sweep of -1.2 V to 1.2 V, a scan rate of 0.05 (V/s), a sensitivity (A/V) of 1e-5A, and a singular cycle. The wearable biosensor showed a detection range for testosterone from 100ng to 1600ng, electrochemical results also showed a clear and measurable result with an R-square value of 0.9417 which proves the accuracy of the developed sensor. Although this is not the complete saturation point and theoretically maximum limit of 28,842ng/ml can be achieved although this was not tested. The detectable lowest concentration of testosterone was found to be ~100ng/ml, and it was noted that lower than 100ng gives a weaker signal,

In conclusion a novel electrochemical sensor based on a molecularly imprinted polymer used as the extended gate of a field effect transistor was developed for the ultrasensitive detection of sweat Testosterone. This sensing technology paves the way for the low cost, label-free, and point of care detection which can be used for evaluating and monitoring athletic performance.

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