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IIT-H's device detects heart attack early

Spots key cardiac biomarker even in very low concentrations, which can be a life-saver

R. PRASAD

A low-cost, ultra-sensitive device that is capable of detecting the cardiac biomarker troponin T protein has been fabricated by a research team from the Indian Institute of Technology (IIT) Hyderabad. Troponin T is a cardiac protein that is released into the bloodstream after a heart attack.

Unlike the commercially available test that can detect the protein at nanogram per ml concentration, this device can detect the protein at an extremely low concentration of femto gram per ml. This could help pave the way for early diagnosis of a heart attack, increasing a patient's survival rate. It even has the potential to be able to predict the onset of a heart attack.

Cost-effective fabrication

Unlike electrodes that are available, it costs very little to fabricate this bioelectrode. This is because a commercially available substrate was used. Further, very little antibody was needed to coat the electrode.

The electrode was fabricated by depositing perovskite (zinc tin oxide) material electrochemically onto the substrate (indium tin oxide coated polyethylene terephthalate). Glassy carbon electrode coated with the same perovskite material was then used as a control. Perovskite increases the volume-to-surface area of the electrode, thereby increasing its sensitivity.

The electrodes coated with perovskite were then functionalised to attract proteins. To increase the specificity of the electrode to bind only to the troponin T protein, the electrodes were decorated or coated with the troponin T antibody.

Test findings

The researchers added various concentrations of the biomarker (ranging from 1 femtogram per ml to 1 microgram per ml) to a buffer solution and measured the impedance (effective resistance in alternating current). Says Prof. Shiv Govind Singh from the Department of Electrical Engineering and corresponding author of a paper published in the journal *Analytical Methods*, "Compared with the current limit of detection, the bioelectrode was able to detect troponin T even when it is 10,000 times less in concentration."

> "We will have a prototype ready in six months to one year."
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> SHIV GOVIND SINGH,
> Department of Electrical Engineering, IIT Hyderabad

When the troponin antigen binds to the antibody present on the electrode, the impedance increases. Adds Prof. Singh, "As more and more biomarker binds to the antibody, there is increased impedance, which is what we measure." After some time, the electrode is saturated with the troponin protein, so no change in impedance is seen.

Principle: As more biomarker binds to the antibody, there is increased impedance, which is what is measured. • SPECIAL ARRANGEMENT/IIT HYDERABAD

The researchers measured impedance using different concentrations of the protein. They plan to use these impedance values to know the concentration of the protein when testing actual blood samples. Says Prof. Singh, "We can measure the impedance in real time. And by using a machine learning algorithm, we can measure the concentration of the biomarker in the sample."

To test the selectivity of the bioelectrode to bind to the biomarker, the researchers tested it on bovine serum albumin (BSA) and human serum albumin (HSA).

Says Patta Supraja from the Department of Electrical Engineering at IIT Hyderabad and first author of the paper, "Only a slight change in relative resistance was observed in the case of HSA and BSA as only a small amount of proteins [from HSA and BSA] bind to the bioelectrode. This is unlike troponin where more protein gets bound to the bioelectrode, leading to more impedance."

She adds, "We then tested for interference by mixing the same amount of biomarker with either BSA or HSA. The sensor's response was not adversely affected by either BSA or HSA." The bioelectrode also showed consistent values when measurements were taken repeatedly using the same concentration of the biomarker.

Focus on miniaturisation

The team is now working on how to miniaturise the readout instrument. Says Prof. Singh, "We will soon be able to capture the signal using a circuit the size of a chip. This will be connected to [a] mobile phone with an app that has a machine learning algorithm for quantification of the troponin biomarker." He adds, "We will have the prototype ready in six months to one year."