Ultra-precision nano-sensor could detect iron disorders

April 29 2020

Dr. Pooria Lesani, University of Sydney. Credit: Dr Pooria Lesani, University of Sydney

Chronic iron imbalances—having either too little or too much iron in the blood—can result in medical conditions ranging from anaemia and haemochromatosis through to more severe diseases, such as cancer, Parkinson's Disease and Alzheimer's Disease.

Haemochromatosis is one of Australia's most common hereditary diseases and the Australian Bureau of Statistics estimates approximately 780,000 people live with anaemia.

School of Biomedical Engineering Ph.D. candidate and Sydney Nano Institute student ambassador, Pooria Lesani, who is undertaking his studies under the supervision of Professor Hala Zreiqat and Dr. Zufu Lu, has developed a multipurpose nanoscale bio-probe that allows researchers to precisely monitor iron disorders in cells, tissue, and body fluids as small as 1/1000th of a millimole.

The test is more sensitive and specific than blood testing currently used to detect iron disorders, which begin at very low, cellular level concentrations.

Using novel carbon-based fluorescent bio-nanoprobe technology, the test, which involves non-invasive subcutaneous or intravenous injections, allows for a more accurate disease diagnosis before the onset of symptoms, potentially allowing for the early treatment and prevention of more serious diseases.

"More than 30% of the world's population lives with an iron imbalance, which over time can lead to certain forms of cancer, as well Parkinson's Disease and Alzheimer's Disease," said Mr Lesani from the Tissue Engineering and Biomaterials Research Unit and the ARC Centre for Innovative BioEngineering.

"Current testing methods can be complex and time consuming. To counter this, and to enable the early detection of serious diseases, we have developed a hyper-sensitive and cost-efficient skin testing technique for detecting iron in the body's cells and tissue.

"Our most recent testing demonstrated a rapid detection of free iron ions with remarkably high sensitivity. Iron could be detected at concentrations in the parts per billion range, a rate ten times smaller than previous nano-probes.

"Our sensor is multifunctional and could be applied to deep-tissue imaging, involving a small probe that can visualise structure of complex biological tissues and synthetic scaffolds."

Tested on pig skin, the nanoprobe outperformed current techniques for deep tissue imaging, and rapidly penetrated biological tissue to depths of 280 micrometres and remained detectable at depths of up to 3,000 micrometres—about three millimetres—in synthetic tissue.

The team aims to test the nanoprobe in larger animal models, as well as investigate other ways in which it can be used to determine the structure of complex biological tissues.

We hope to integrate the nanoprobe into a "lab-on-a-chip" sensing system—a portable, diagnostic blood testing tool which could allow clinicians to remotely monitor their patients' health.

"Lab-on-a-chip systems are relatively simple to operate and require only small blood volume samples from the patient to gain an accurate insight of potential ferric ion disorders in the body, assisting early intervention and prevention of disease," he said.

The nano-sensors can also be made from agricultural and petrochemical waste products, allowing for low-cost, sustainable manufacturing.

More information: Pooria Lesani et al, Two-Photon Dual-Emissive Carbon Dot-Based Probe: Deep-Tissue Imaging and Ultrasensitive Sensing of Intracellular Ferric Ions, *ACS Applied Materials & Interfaces* (2020). DOI: 10.1021/acsami.0c05217

Provided by University of Sydney