Low-Cost Field-Based Sensor for the Detection of Atherosclerotic Biomarkers of Coronary Heart Disease

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Atherosclerotic Coronary Heart Disease (CHD) remains the world’s preeminent cause of mortality. Blood cholesterol, carried by low-density lipoproteins (LDL), is closely associated with CHD’s pathogenesis; oxidized-LDL is significantly more potent. Standard cholesterol and rare ox-LDL tests are lab-based, infrequent and expensive. With every third American at risk for CHD, this research aims to produce an on-site test for CHD biomarkers. A microfluidic cholesterol sensor was developed by depositing enzymes and one of three dye reagents, TMB, 4-AAP, and ADHP, onto a cellulosic substrate with an inexpensive consumer inkjet printer, enabling three-dimensional micro-scale deposition of enzymatic arrays. Enzyme ink rheology was engineered for optimal viscosity and surface tension, to prevent head clogging and dripping. A low-cost potentiostat and a functionalized carbon nanotube (FCNT) electrode were used to detect ox-LDL’s lipid peroxides. Cholesterol levels (50-400 mg/dL) were successfully detected and quantified by the inkjet-printed sensors utilizing a smartphone camera for image capture. Cost analysis shows a per test cost of around $0.02. The FCNT sensor’s detection of sub-μM H_2O_2 concentration confirmed the principle of detection; ox-LDL was successfully detected in subsequent tests. The sensors developed here enable a holistic assessment of CHD risk, aggregating data from two biomarkers. Furthermore, their ultra low-cost increases access to cardiac statistics while the inkjet printer's scalability enables sensor mass production. Finally, the novel inkjet printing system has applications in environmental quality, food purity, and diagnostic testing. Ongoing research explores iodometric ox-LDL detection and inkjet printing circuits and hydrophobic barriers.

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