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Introduction to “Advances in Nanomaterials for Sensors in Early Disease Diagnosis”

 Anitha Devadoss, ^{*,a} Suman Singh ^{bc} and Murugan Veerapandian ^{cd}

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We are delighted to introduce the themed collection in *Sensors & Diagnostics* entitled “*Advances in Nanomaterials for Sensors in Early Disease Diagnosis*”. This collection highlights recent progress in the development and application of advanced nanomaterials for sensor technologies, aimed at early disease detection, with nine contributions that collectively explore a diverse range of nanomaterial platforms for the precise detection of biological biomarkers, underscoring their potential to transform early disease diagnosis.

Among the contributions, Lee *et al.* (<https://doi.org/10.1039/D5SD00100E>) present a comprehensive review of emerging trends in aerogel technologies for sensing and biosensing applications. Aerogels have recently gained significant attention in the sensing field owing to their exceptional physicochemical properties, including low density, tuneable porosity, high specific surface area with tailorable functionalities, and favourable biocompatibility. Consequently, aerogel-

based sensor technologies are advancing rapidly. This timely review highlights recent developments in aerogel synthesis strategies, the design of novel aerogel composites, and the integration of aerogels into sensor platforms for biosensing, biomarker detection, smart and wearable sensors, and microfluidic devices. In addition, the authors critically evaluate the mechanisms underpinning enhanced sensor performance and discuss opportunities for real-time biomolecule monitoring, as well as the development of portable, cost-effective lab-on-a-chip systems through the integration of aerogel-based sensors with microfluidic technologies.

Early detection is critical in cancer diagnostics, as it enables timely intervention, improved treatment outcomes, and increased patient survival rates. Dennany *et al.* (<https://doi.org/10.1039/D5SD00110B>) report the potential translational application of electrochemiluminescence (ECL) as an analytical tool for imaging chemotherapeutic agents. In this study, the authors demonstrate a proof-of-concept for the *in vitro* detection of the chemotherapeutic drug gemcitabine (GEM), released *via* a heat-triggered mechanism from the surface of hybrid iron oxide–gold theranostic nanoparticles in pancreatic cancer cells. Notably, this work represents the first real-time detection of GEM released from hybrid iron oxide–gold nanoparticle platforms. The authors

also provide a detailed discussion of the challenges associated with analysing complex biological matrices and how these challenges were addressed, highlighting the robustness, translational potential and future outlook of the ECL-based approach. Another communication by Lee *et al.* (<https://doi.org/10.1039/D5SD00108K>) reports the development of a compact, image-based flow cytometry system that integrates acoustic focusing with machine-learning-driven image analysis for CD4 and CD8 cell detection. In this work, the authors demonstrate the rapid detection of stained CD4 and CD8 cells by directing cells along an acoustically defined focal plane, offering an alternative to conventional hydrodynamic focusing and enabling a more compact system configuration. The custom-built platform is capable of detecting up to three fluorescently labelled signals, while the integration of a machine-learning-based image capture and analysis algorithm enables automated cell segmentation and quantitative analysis of the acquired image data.

Reflecting the central theme of this special issue, five articles address the application of advanced nanomaterials for the detection of a range of biological analytes. Among these, Sharma *et al.* (<https://doi.org/10.1039/D5SD00165J>) reported the development of a low-cost, rapid, and scalable electrochemical biosensor for point-of-care (POC) monitoring of rifampicin during

^a Institute of Biological Chemistry, Biophysics and Bioengineering, School of Engineering and Physical Sciences, Heriot-watt University, Edinburgh, EH14 4AS, Scotland, UK. E-mail: a.devadoss@hw.ac.uk

^b CSIR-Central Scientific Instruments Organisation, Chandigarh, 160030, India

^c Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, 201002, India

^d Electrodeics and Electrocatalysis Division, CSIR-Central Electrochemical Research Institute, Karaikudi 630003, Tamil Nadu, India



collection will inspire further accelerate the development of robust, diagnostic technologies for early interdisciplinary research and accessible, and patient-centred disease detection.

