Flow Cytometry Beyond Cells: Exploring Nanoparticles in Biomedical Research

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Abstract

The term extracellular vesicles (EVs) refers to particles that are released from all cell types and characterized by a lipid bilayer and cannot replicate. EVs have emerged as key mediators of intercellular communication and represent one of the most promising sources of biomarkers for precision medicine. Their molecular cargo has been associated with disease onset, progression, treatment response, and patient monitoring, making EVs attractive candidates.

Despite their clinical potential, the reliable characterization of EVs remains challenging because of their small size (approximately 30–1000 nm), heterogeneity, and the lack of standardized analytical workflows. Among the available technologies, high-sensitivity flow cytometry has become an increasingly powerful approach for the rapid characterization, quantification, and phenotypic analysis of nanoparticles.

The Beckman Coulter Life Sciences CytoFLEX platform, including the CytoFLEX, CytoFLEX SRT, and the recently CytoFLEX nano instrument, combines avalanche photodiode (APD) detectors, optimized optics, and violet side scatter (VSSC) detection to maximize signal collection while minimizing background noise, enabling the analysis of nanoparticles well below the detection limits of traditional flow cytometers. The cytometers perform absolute EVs counting (EVs/µl), and can analyse and characterize different EVs sizes ranges from 40-1000 nm of diameters.

Moreover, the used of NIST (National Institute of Standards and Technology) polystyrene beads mixture the nanoVIS™ Sizing Standard with a known refractive index the data could be converted from arbitrary units into nanometres (standardised units) using the FCMPASS software. Furthermore**,** CytoFLEX-SRT offers the additional capability of sorting fluorescently labelled EVs subpopulations for downstream molecular analyses.

The technological advances offered by the CytoFLEX family of instruments are expected to accelerate EV research by improving detection sensitivity, reproducibility, and the implementation of standardized analytical workflows, supporting the translation of EVs analysis into precision medicine and clinically relevant biomedical applications.