Nanostructured Capacitive Biosensing Platforms for Clinical Diagnostics

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Nanostructured capacitive biosensing platforms illustrate the transformative potential of low-dimensional materials in advancing clinical diagnostics and biomedical technologies. By integrating two-dimensional (2D) nanomaterials, such as graphene, MXenes, and transition metal dichalcogenides, with metallic nanostructures, these systems achieve unprecedented sensitivity, label-free detection, and compatibility with flexible substrates [1]. The intrinsic physicochemical properties of these nanomaterials (including high surface-to-volume ratio, tunable electronic conductivity, chemical stability, and a high density of reactive surface functional groups) enable enhanced biomolecule immobilization and efficient charge transfer, which are essential for sensitive biosensing [2]. Capacitive transduction further offers advantages such as high sensitivity, rapid response times, and the capability to detect subtle changes in interfacial properties without requiring external labels or redox mediators [3]. Recent studies demonstrate the effectiveness of these platforms in monitoring clinically relevant biomarkers directly in human samples, paving the way for scalable, cost-effective, and point-of-care solutions [4], [5]. By combining 2D nanomaterials with capacitive transduction, these systems provide a versatile, sensitive, and minimally invasive approach to investigating complex biological processes and advancing precision medicine. This technology enables real-time monitoring of neurochemical activity, early disease detection, and the development of next-generation implantable devices. At the 2D-BioPAD workshop during NanoBalkan 2025, this contribution highlights the potential of low-dimensional architectures for applications in neurobiomedicine.

References

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