

Label-Free Screen-Printed Sensors: Electroanalytical Tools for Fast and On-Site Sensing

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Label-free electrochemical immunosensors (ELFIs), electrochemical layer-by-layer characterisation (LbL-EC), and emerging carbon-based materials such as biochar are collectively reshaping next-generation electrochemical (bio)sensing. ELFIs merge the speed and sensitivity of label-free electrochemical detection with the high-affinity specificity of antigen–antibody interactions, enabling compact, high-performance lab-on-a-chip devices. LbL-EC complements this approach by providing *in-operando* control over multilayer assembly, allowing precise tuning of film thickness, composition, and bioreceptor orientation to enhance sensitivity, stability, and operational durability. Techniques including cyclic voltammetry and electrochemical impedance spectroscopy offer real-time insight into deposition kinetics, interfacial charge transport, and surface loading density while reducing nonspecific interactions.

Within this evolving landscape, biochar has emerged as a sustainable, low-cost, and electroactive carbon material capable of increasing surface area, improving conductivity, and facilitating bioreceptor immobilisation. Its integration into ELFI platforms and LbL-EC-engineered architectures further boosts analytical performance and structural robustness. Emphasis is placed on the practical applicability, reliability, and limitations of these technologies across environmental monitoring, clinical diagnostics, and food safety, highlighting their growing impact on advanced biosensor development.

References

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