

Determination of allergens, adulterants and toxics in food using electrochemical biotechnologies

Brief description

The developed technologies enable either individual or simultaneous multiomics detection of allergens, adulterants, and food toxics. Immunoplatforms target proteins and oligosaccharides, while nucleic acid platforms analyze characteristic fragments of nuclear, mitochondrial, or chloroplast DNA, as well as food toxics. These platforms, based on the use of magnetic particles to facilitate biorecognition reactions and disposable electrodes for amperometric transduction, have demonstrated direct applicability in food extracts (raw or processed), PCR products, lysates, organelles (nuclei, mitochondria, or chloroplasts), and undiluted and untreated human saliva samples.

How does it work?

The biotechnologies are based on the implementation of affinity assay formats on commercial magnetic particles (MBs) and enzymatic tagging, particularly horseradish peroxidase enzyme (HRP), using amperometric transduction on disposable printed electrodes.

Regarding the determination of proteins and oligosaccharides, either competitive or sandwich immunoassays have been employed, depending on immunoreagents availability as well as required sensitivity and performance, using specific antibodies and adequately conjugated biomolecules, leading to both, efficient immobilization on MBs and sensitive tagging (Figure 1). Nucleic acid determination was performed selectively capturing characteristic gene fragments on MBs modified with synthetic DNA or RNA sequences properly functionalized and complementary to the target sequence. The obtained DNA/RNA heterohybrids were detected using specific antibodies and enzyme-tagged bioreceptors such as secondary antibodies or bacterial proteins conjugated to single or multiple HRP units.

In all cases quantification is carried out through amperometric transduction by monitoring the variation in the cathodic current after magnetically capturing the bioconjugates on the surface of either single or n-plexed disposable electrodes in the presence of the HRP/Hydroquinone/H₂O₂ system.

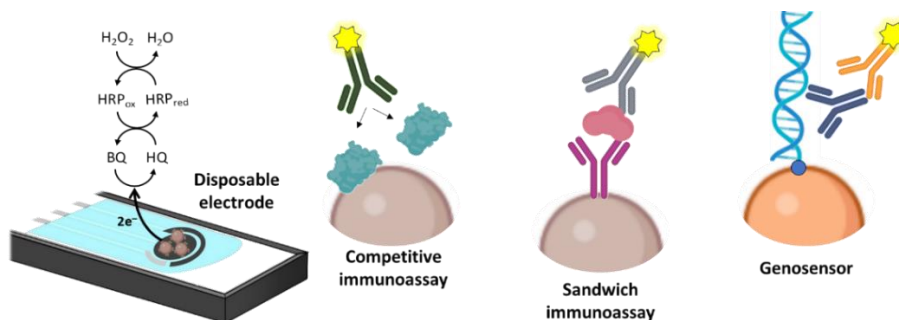


Figure 1. Bioelectroanalytical technologies for the determination of allergens, adulterants or toxics in food.

What problem does it solve?

The results obtained support the improved analytical performance achieved by the platforms to perform reliable allergen determinations, highlighting the following aspects:

- Accurate and easy discrimination of emerging allergens, adulterants and toxics, even at trace levels.
- Simplification of extraction and isolation processes, commonly used in molecular biology, both at protein and genetic levels, avoiding the need for costly and centralized instrumentation.



- Successful coupling with gene amplification strategies, such as PCR.
- Interrogation capability with design-tailored sensitivity for detecting characteristic fragments of nuclear, mitochondrial or chloroplast genes.
- Application to the analysis of either direct or simply diluted dairy products, protein or nucleic acid extracts, amplification products (PCR) and mitochondrial lysates from food products of various origin and complexity, as well as biological fluids such as saliva.

What future products will it develop?

The integration of these technologies into glucometer-type electroanalytical biodevices would facilitate the rapid, simple, affordable and decentralized analysis of potentially allergenic foods, competitive with conventional methods (ELISA and PCR). In addition, its implementation on magnetically driven carriers improves and simplifies extraction processes without the need for expensive equipment, enabling its direct application in food matrices and complex biofluids. Its compatibility with multiplexed and multi-omics analysis paves the way for the development of multitasking devices capable of comprehensively assessing the allergenic potential of foods according to various treatments, monitoring tolerance therapies and digestion and absorption processes, and even contributing to clinical diagnosis.

Competitive advantages

The main advantages of these electroanalytical biosensing technologies include:

- High sensitivity, specificity and speed and capability for simultaneous analysis of multiple biomarkers.
- Simple and low-cost instrumentation, suitable for decentralized, remote or low-resource environments.
- Reliable detection of allergens, adulterants and toxicants in food, even at trace levels.
- Direct analysis on complex samples such as turbid extracts, cell lysates and raw saliva.
- Versatility for multiplexing of relevant proteins, oligosaccharides, DNA sequences and toxicants in food.
- Potential for application in other areas, such as clinical diagnosis of allergies or nutritional disorders.

Where has it been developed?

These bioplatfroms have been developed in the Electroanálisis y (Bio)sensores Electroquímicos Group at the Facultad de Ciencias Químicas of the Universidad Complutense de Madrid (UCM) and in collaboration with other researchers of the UCM (Estructura-Función de Proteínas Group, Dpto. Bioquímica y Biología Molecular I; Biotecnología de Plantas Group, Dpto. Genética; Investigador en el Desarrollo de Metodologías Avanzadas de Trazabilidad, Detección de Microorganismos en los Alimentos y Bioseguridad de los Alimentos Group, Dpto. Nutrición y Ciencia de los Alimentos; Dpto. Inmunología, Oftalmología y ORL), the Investigación en Ciencias de la Alimentación Institute (CIAL), CSIC-UAM and sector companies (ZEULAB, S.L., Zaragoza, Spain).

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