Differential pulse voltammetry as an analytical tool for raw milk analysis using electrochemical biosensors

C. Pérez-González[1,3], C. Salvo-Comino[2,3], P. Nájera-Morales[2,3], F. Martin-Pedrosa [1,3], M.L Rodríguez Méndez [2,3*], C. García-Cabezón[1,3*],

(1) Material Science Department, University of Valladolid
(2) Inorganic Chemistry Department, University of Valladolid
(3) Group UVaSens, University of Valladolid
(*) e-mail corresponding: mluz@eii.uva.es; crigar@eii.uva.es

Electronic tongues (ETs) have attracted considerable interest due to their potential to contribute to food quality control. ETs are based on sensor arrays with low selectivity and high cross-selectivity combined with statistical tools that analyse multiple sensors outputs [1].

The aim of this work was to develop a voltammetric bioelectronic tongue (bio-ET) modified with silver nanoparticles (AgNPs) and enzymes for its implementation in the analysis of milk samples.

Sensors and milk samples

Sensors were created in two stages. First, IDE sensors were modified by an AgNPs dropcast and then enzymes were immobilised to their surfaces.

The bioeletronic tongue was conformed by **4 sensors** coupled with a potentiostat galvanostat :

- 1 Sensor modified only with AgNPs
- 1 Biosensor for Lactic Acid detection.
- 1 Biosensor for Galactose detection.
- 1 Biosensor for Glucose detection.

The performance of the ET was evaluated by analysing standard solutions of compounds found in milk, targeted by the enzymes (LDH, GaOx and Gox).

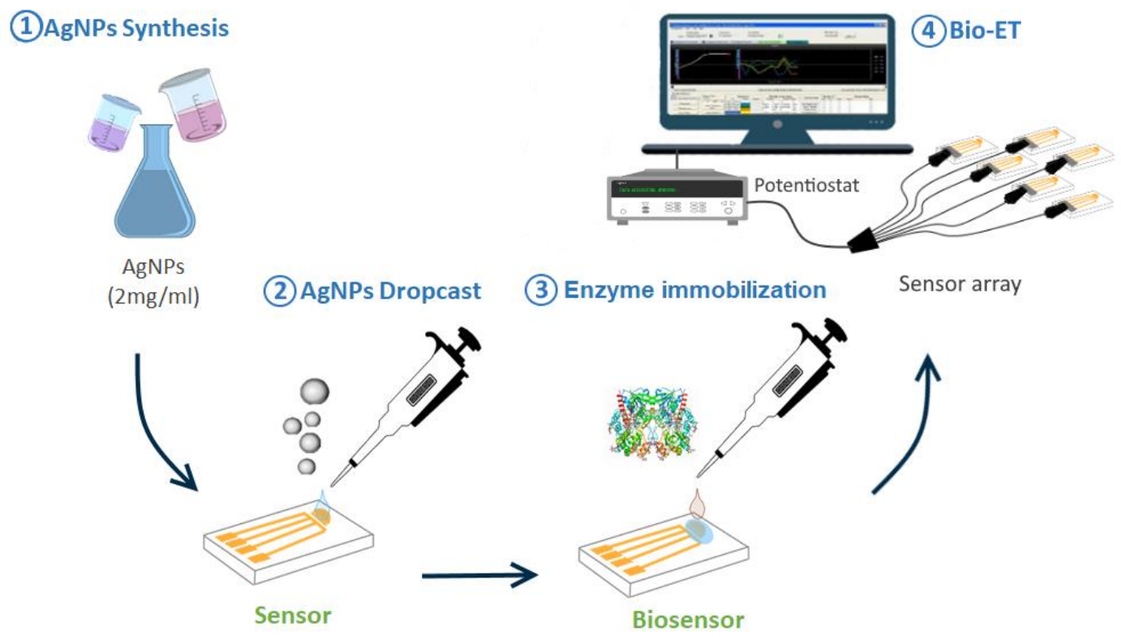

Figure 1. Diagram of the construction of the Bio-ET.

RESULTS

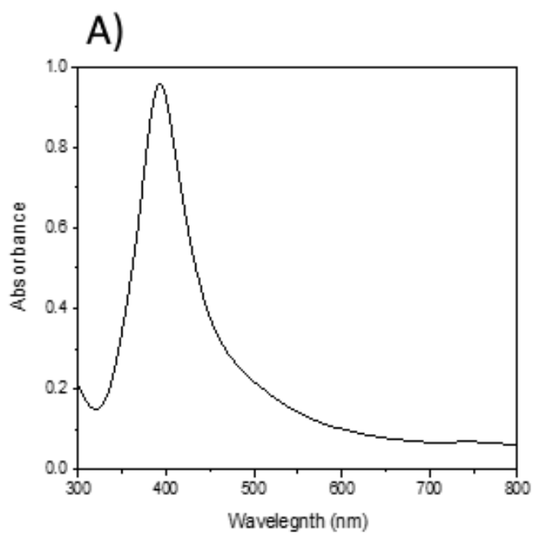

Figure.2- Characterization of AgNPs. A) UV-Vis absorption spectra, B) TEM micrograph and ED pattern.

The presence of AgNPs (20nm) enhanced the electron transfer rate on the surface of the sensors, increasing the intensity of the DPV signals. In addition, sensors modified with AgNPs and enzymes showed higher sensitivity than unmodified sensors or sensors modified only with AgNPs or enzymes.

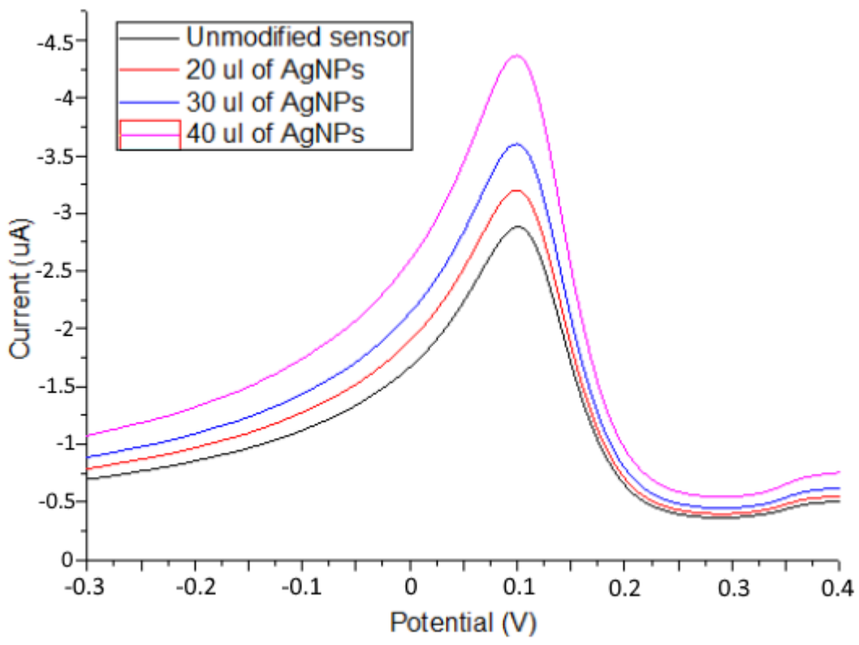

Figure.3- Characterization of the sensors in potassium ferrocyanide [K4Fe(CN)6] for increasing concentrations of silver nanoparticles (AgNPs).

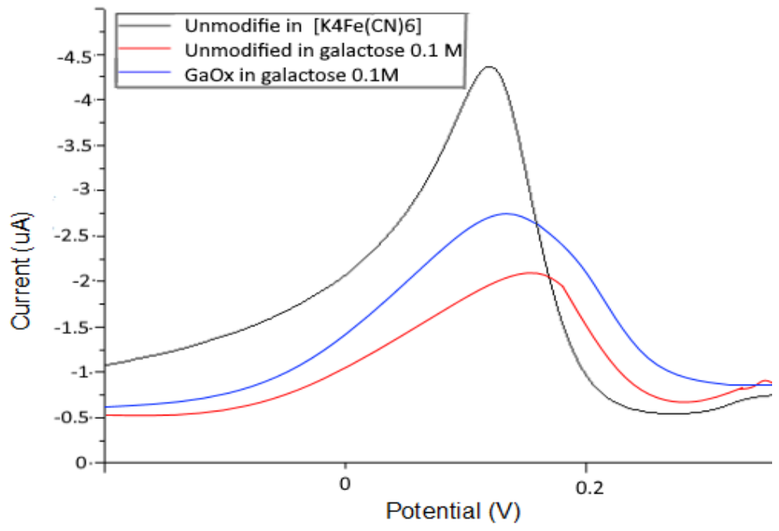

Figure.4- Characterization of the biosensors in [K4Fe(CN)6] and galactose 0,1M.

A first approach on the analysis of raw milk samples was also made by analyzing milks from individual cows diluted in [K4Fe(CN)6].

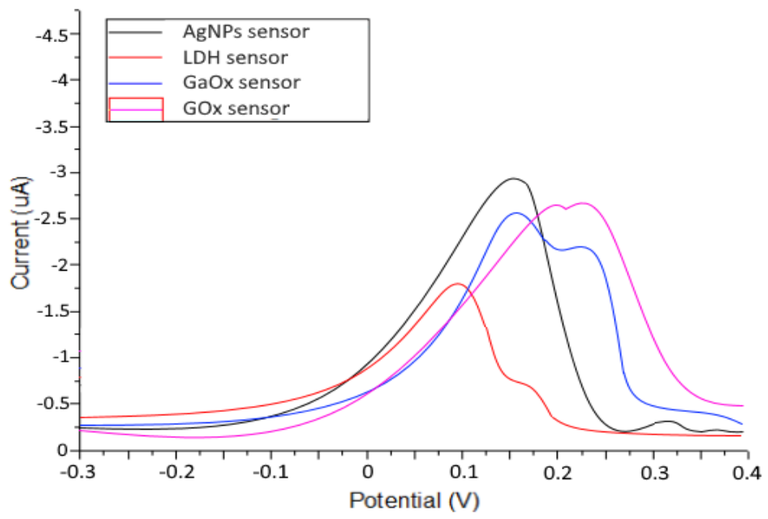

Figure.5-Sensor array response in milk.

CONCLUSIONS

The combination of AuNPs and enzyme have proved to increase the sensor sensitivity and selectivity of voltammetric sensors. The cross selectivity of the sensor array towards milk samples was also demostrated. The bio-ET have demonstrated to have the ability for its application on milks sample analysis with different nutritional characteristics and to predict which would allow in further works to predict physicochemical parameters in dairy industry.

[1] Ródriguez-Mendez, M.L., De Saja, J.A., González-Antón, R. “Electronic Noses and Tongues in Wine Industry” Frontiers in bioengineering and biotechnology, 2016, 4, 81.

[2] Yin, T., Qin, W. “Applications of Nanomaterials in Potentiometric Sensors.” Trends in Analytical Chemistry, 2013, 51, pp.79-86.