Journée d'Electrochimie 2024
1er – 5 Juillet 2024
Saint-Malo, France

Electrochemistry of single impacts for bacterial sensing

Estelle Lebègue,[a] Hassiba Smida,[a] Arthur Langlard,[a] Christine Thobie-Gautier,[a] and Mohammed Boujtita[a]

[a] *Nantes Université, CNRS, CEISAM, UMR 6230, F-44000 Nantes, France*
estelle.lebegue@univ-nantes.fr

Nowadays, the main objective in the detection and analysis of bio-entities such as bacteria is a low detection limit, a short assay time and a high selectivity in identification, ideally combined with easy-handling and cheap instrumentation [1]. These last years, different innovative analytical methods have emerged with high sensitivity and spatial-temporal resolution allowing qualitative and quantitative analysis at single-cell and subcellular levels. The four major areas of analytical methods usually reported are electrochemical analysis, super-resolution microscopy, mass spectrometry imaging, and microfluidics. The crucial and unique advantage of electrochemistry is to combine high sensitivity and easy handling with a light and possible portable instrumentation allowing to work with miniaturized devices for micro-biosensor applications [1]. In this way, fast and easy handling instruments for detection of bacteria at the single-cell level (the highest possible sensitivity) have become reachable with the promising electrochemistry of single impacts onto an ultramicroelectrode surface [1, 2].
Single-impact electrochemistry provides a low limit of detection (in principle, one single entity) inherent to this electro-analytical method and the ability to study single entities (cells, viruses, bacteria, nanoparticles…) in real-time through a dynamic measurement. Single-impact electrochemistry method can provide unique information on various single nanoparticles through detection of discrete events in contrast to ensemble (bulk) measurements [1]. The electrochemical nano-impacts method or discrete collisions technique (stochastic events) consists in detecting single impact of various entities (nanoparticles, bacteria, liposomes...) in solution at a polarized ultramicroelectrode. For each collision event, a specific signal is recorded in the chronoamperometry curve (current as a function of time) corresponding to an "impact" of the entity onto the ultramicroelectrode surface. The recording of single collision events in the chronoamperometry curve corresponding to bacteria impacts onto the ultramicroelectrode surface is performed in an aqueous solution usually containing a redox active probe and about 10^9 to 10^{10} bacteria per milliliter [2]. Since 2015, most of the reports in this area concern *Escherichia coli* as model bacterium but this sensitive electro-analytical technique has not proved to be efficient for selective detection yet, except for the discrimination between Gram-positive and Gram-negative bacteria. An original and recent approach is to detect the virulence factors released by pathogenic bacteria rather than the cells themselves, based on redox liposomes single-impact electrochemistry [3].

References

(1) Smida, H.; Langlard, A.; Ameline, D.; Thobie-Gautier, C.; Boujtita, M.; Lebègue, E. *Anal Bioanal Chem* **2023**, *415*, 3717.
(2) Smida, H.; Lefèvre, F.-X.; Thobie-Gautier, C.; Boujtita, M.; Paquete, C. M.; Lebègue, E. *ChemElectroChem* **2023**, *10*, e202200906.
(3) Luy, J.; Ameline, D.; Thobie-Gautier, C.; Boujtita, M.; Lebègue, E. *Angew. Chem. Int. Ed.* **2022**, *61*, e202111416.