

(Bio)Electrochemical Catalysts for Sensitive Detection of Pathogens

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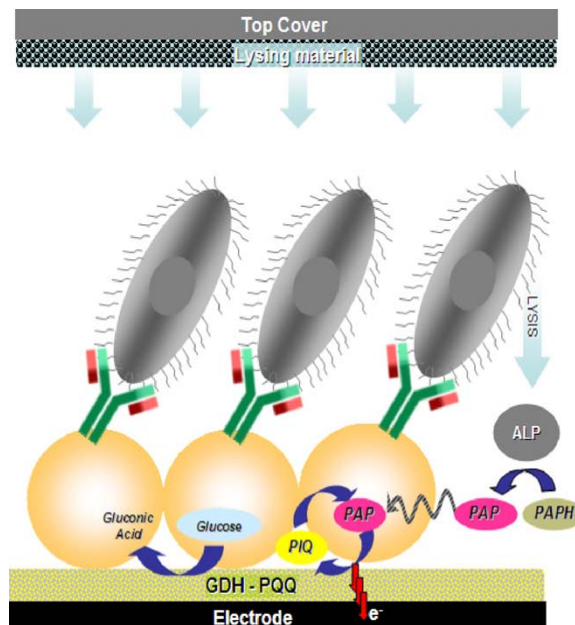
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Overview: The experimental work of the MSc project involves the development of new catalysts that can be used in a catalytic cascade to amplify the product of intracellular enzymes released after lysis of pathogens for the detection of very low concentrations of such enzymes. We have demonstrated the feasibility of the method for the detection of low concentration of pathogens(1). The Figure below is a schematic overview of the principle of detection: an intracellular enzyme (Alcaline Phosphatase or ALP) acts on its substrate (PAPH) and produces a product (PAP) that in its turn serves as substrate for a second, immobilised enzyme producing a product (PIQ) that can be recycled electrochemically in a cascade reaction. Every time that PIQ is recycled a pair of electrons is produced and detected. In this way up to 1000-fold amplification has been achieved (i.e. one ALP molecule produces up to 1000 electrons). Although such amplification permits very sensitive detection of pathogens (each cell contains about 100 ALP molecules), this Masters thesis will improve the immobilised catalysts ideally replacing the second immobilised enzyme by more stable and more efficient catalysts.

Background and State of the Art:

There is an urgent need in the food industry and in clinical diagnostics to achieve fast and sensitive detection of pathogens. Pathogen-caused food poisoning results in billions cost to the public health systems for hospitalisation and to social security systems due to the loss of working hours and (in extreme cases) human life. The food industry (from farm to fork) desperately needs efficient, fast, and low cost methods to detect the presence of pathogens and thus prevent such eventualities. In the clinical setting, antibiotic-resistant pathogens cost lives and money and complicate patient management. It is difficult to detect

pathogens routinely because the detection limits required (1 pathogen in 25-100 g of food material) are very low. Molecular techniques based on polymerase chain reaction (PCR) amplification of the pathogen DNA are cumbersome and expensive and do not allow differentiation between alive and inactivated cells. We have proposed a very simple and low cost system(2) based on the amplification of



products of intracellular enzymes that exist only when the cells are still alive. Although several unit operations are essential for the detection system, the cascade signal amplification of enzymatic products is key to the sensitivity of the method.

Project Contribution and Methodology: The expected contribution to the state of the art is the invention, development and characterisation of new bio or chemical catalysts that can electrochemically recycle the enzymatic products. The methodology includes: 1) The study of candidate structures that will permit the production of stable and efficient catalysts. 2) The synthesis of one or several catalytic structures. 3) The characterisation of such molecules, and 4) The application of the system in electrochemical systems and the calculation of the merit figures of the new catalyst with respect to the “standard” glucose-dehydrogenase scheme.

The ideal candidate: The ideal candidate is a highly motivated, rigorously formed in quantitative and formal abilities, able of acquiring new knowledge independently, computer proficient, laboratory experienced graduate or postgraduate in chemistry, chemical engineering or materials sciences. Previous experience in chemical synthesis is a plus.

Finishing this project: The graduate of this project will be able to find work both in academia and industry, especially in R&D positions. Our group encourages multidisciplinary training, complements communication and leadership abilities with formal seminars and has a broad network of collaborations in the private and public sectors. A career and personal improvement plan is worked upon from the first day of incorporation.

References:

1. Mata, D., Bejarano, D., Botero, M.L., P. Lozano, P., Constantí, M., Katakis I.; Screen-printed integrated microsystem for the electrochemical detection of pathogens, *Electrochimica Acta*, 2010, 55(14), 4261-4266.
2. Bejarano, D., Lozano, P., Mata, D., Cito, S., Constanti, M., Katakis, I.; Screen printing as a holistic manufacturing method for multifunctional microsystems and microreactors *J. Microm. Microeng.*, 2009, 19(11), Article Number: 115007 DOI: 10.1088/0960-1317/19/11/115007