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Design of amino-functionalized MIP silica particles for biosensors development with selective recognition of lipopolysaccharides

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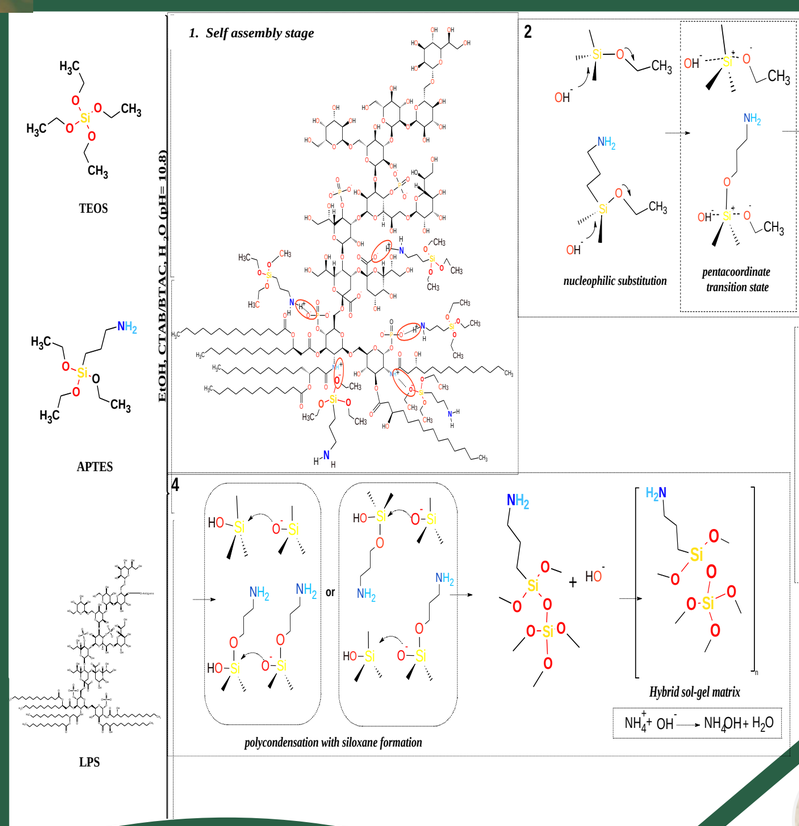
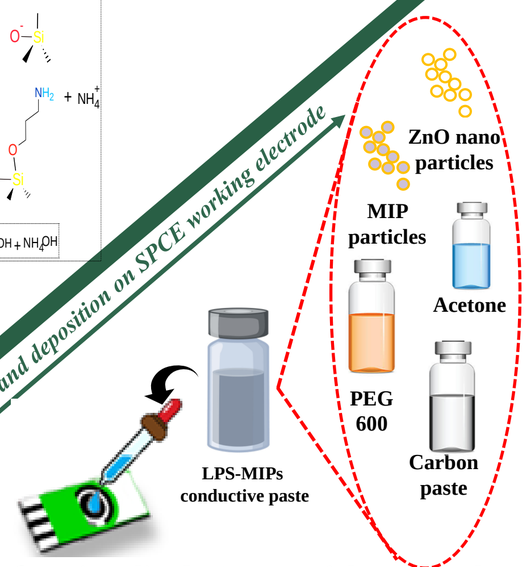
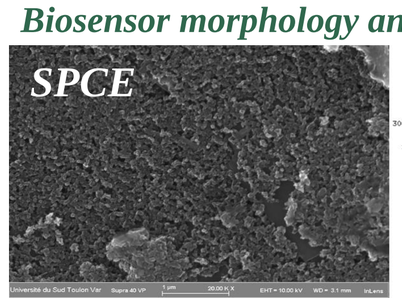
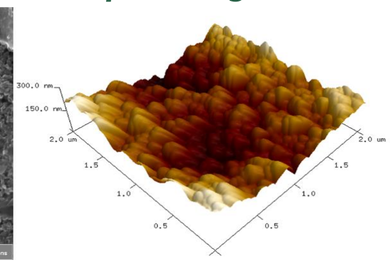


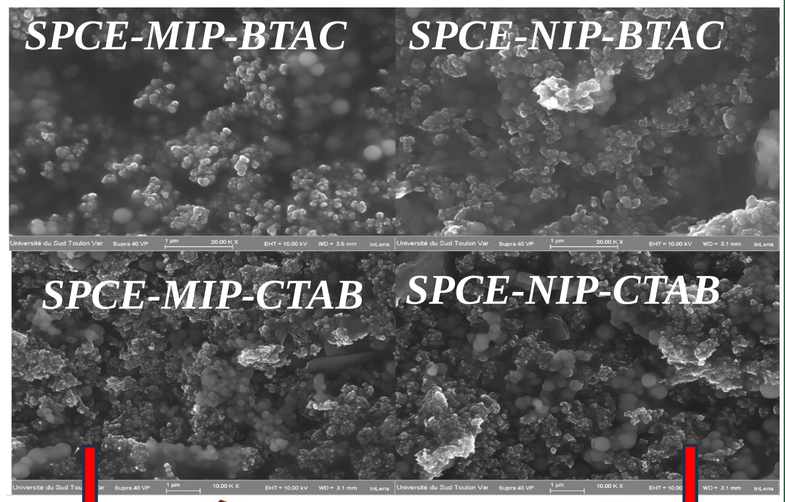


Biosensor morphology and surface roughness

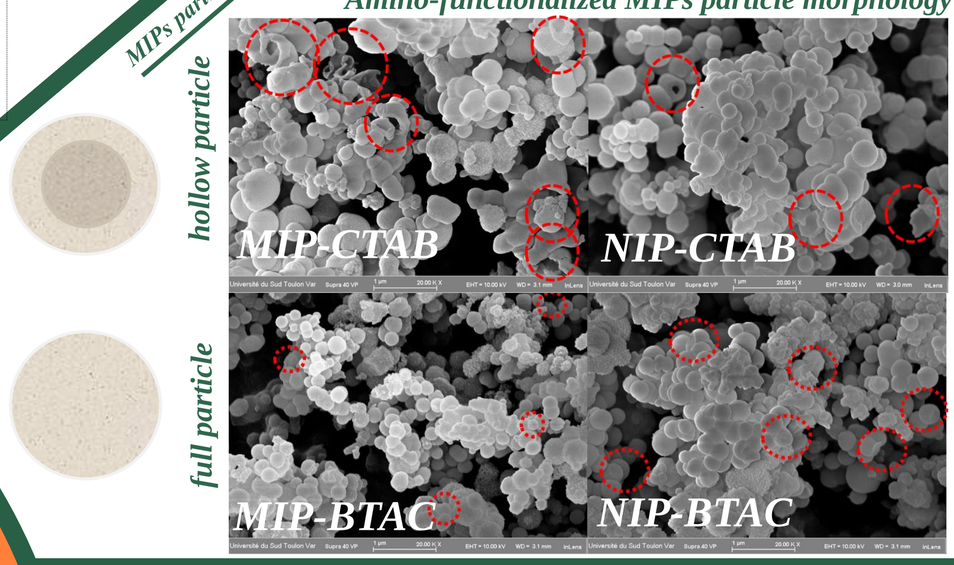


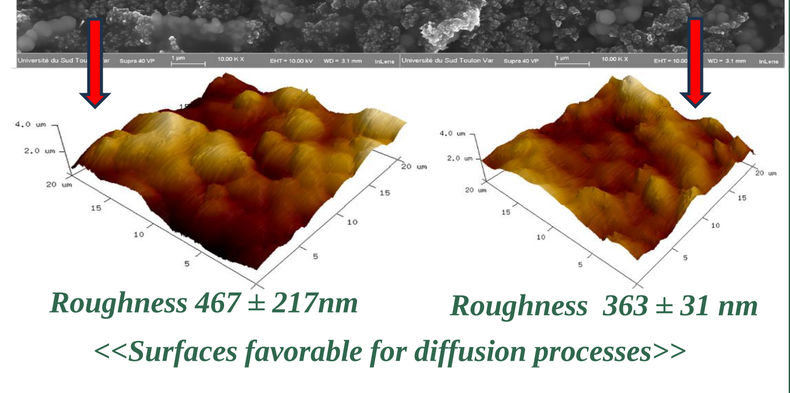


Roughness 250 nm



Amino-functionalized MIPs particle morphology





Roughness 467 ± 217nm

Roughness 363 ± 31 nm

<<Surfaces favorable for diffusion processes>>

Reaction mechanism

Morphology

Computational docking

Conclusions Electrochemical analysis

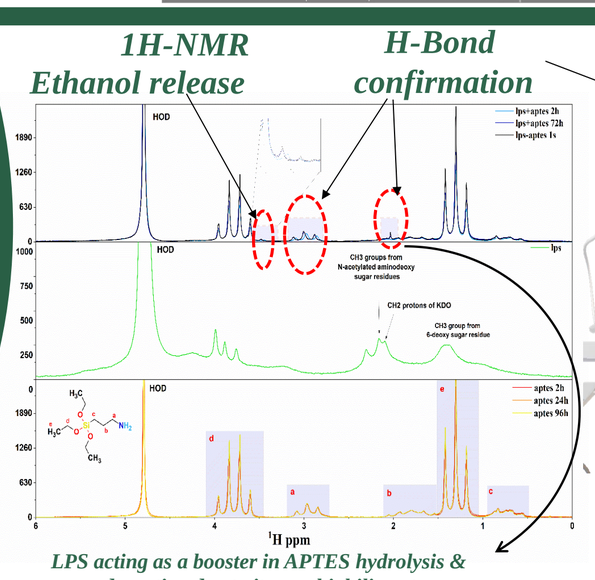
Abstract

Lipopolysaccharides (LPS) is responsible for various infections and has recently been implicated in the development of Parkinson's disease. Traditional methods for detecting LPS as ELISA and LAL assay, have significant drawbacks e.g low sensitivity, complicated,time-consuming processes. Thus, there's an increasing demand for the development of innovative and cost-effective methods, e.g., electrochemical detection, especially in the fields of environmental science and medicine.

This work describes the design of amino-functionalized MIPs silica particles for selective recognition of a specific targeted type of LPS (i.e., LPS from Pseudomonas aeruginosa) from different bacterial strains. The obtained MIP particles were incorporated in a lab-made carbon paste formulation and drop-casted on the working electrode surface of a screen-printed electrode (SPCE). MIP silica particles were synthesized using the Stöber method in the presence of the target molecule LPS via polycondensation of the functional monomer 3-Aminopropyltriethoxysilane and the structural monomer, tetraethyl orthosilicate in basic medium. Herein, two types of cationic surfactants (cetyltrimethylammonium bromide and benzyl trimethyl ammonium chloride) were utilized to stimulate and control the formation of silica particles at a nano level. To ensure the capacity of the MIP particles to recognize LPS, computational docking was assessed to predict the binding affinity of 3-aminopropyltriethoxysilane towards LPS. The 1H-NMR results sustained the docking predictions. Other modern techniques, including structural and morphological analyses, were employed to characterize the obtained MIP particles in the raw phase and after their embedment and deposition on the final biosensors. CV, DPV, along with the static and selective adsorption analysis were submitted to determine the imprinting factor, sensitivity, and selectivity for the targeted LPS. As a result, the obtained amino functionalized MIPs silica particles proved to be an effective and low-cost alternative for biosensor development for the detection of lipopolysaccharide from *Pseudomonas aeruginosa*.

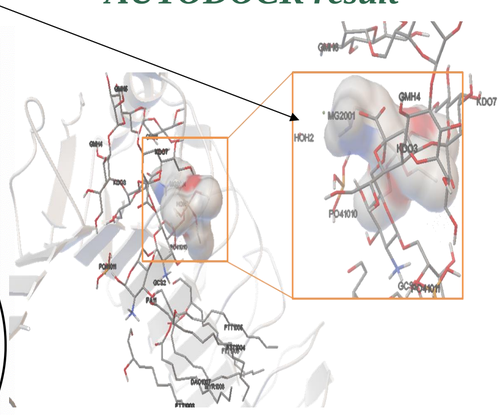
1H-NMR Ethanol release

H-Bond confirmation



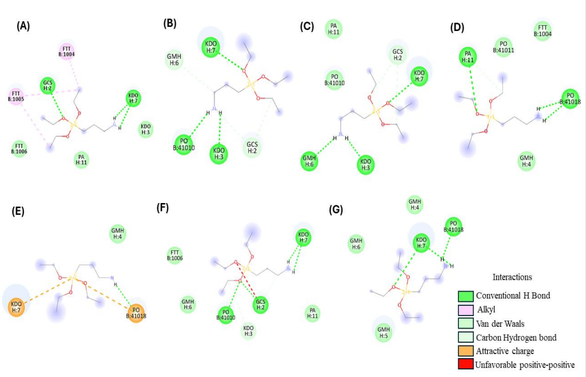
LPS acting as a booster in APTES hydrolysis & condensation due to its amphiphilic nature

AUTODOCK result



Electrostatic interactions and hydrogen bonding

BIOVIA STUDIO result



7 possible bindings H-Bond formed between amine (APTES) and KDO (Lipid A)

Particle adsorption

Contact with LPS from Pseudomonas Aeruginosa

	Q MIP (U.E/mg)			Q NIP (U.E/mg)			Imprinting factor		
Time	30 min	3h	24h	30 min	3h	24h	30 min	3h	24h
MIP/NIP CTAB	0,009	6,005	6,628	0,004	2,411	5,411	2,491	1,976	1,225
MIP/NIP BTAC	0,008	3,969	4,568	0,004	2,800	3,497	1,900	1,417	1306

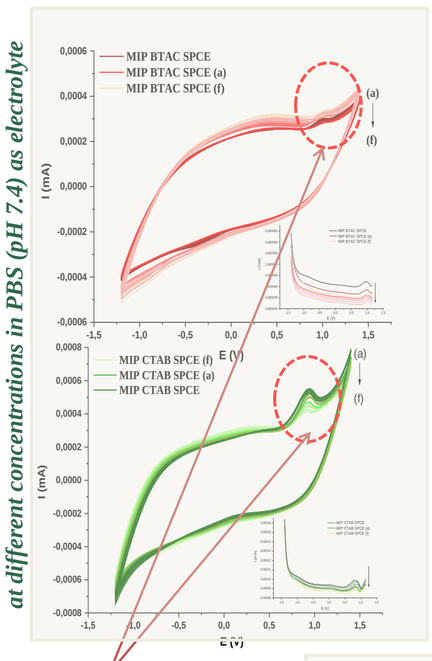
Contact with LPS from E. Coli

	Q MIP (U.E/mg)			Q NIP (U.E/mg)			Imprinting factor		
Time	30 min	3h	24h	30 min	3h	24h	30 min	3h	24h
MIP/NIP CTAB	0,002	5,956	8,355	0,007	5,932	7,613	0,234	1,004	1,098
MIP/NIP BTAC	0,006	3,768	7,586	0,005	3,497	7,155	1,281	1,078	1,060

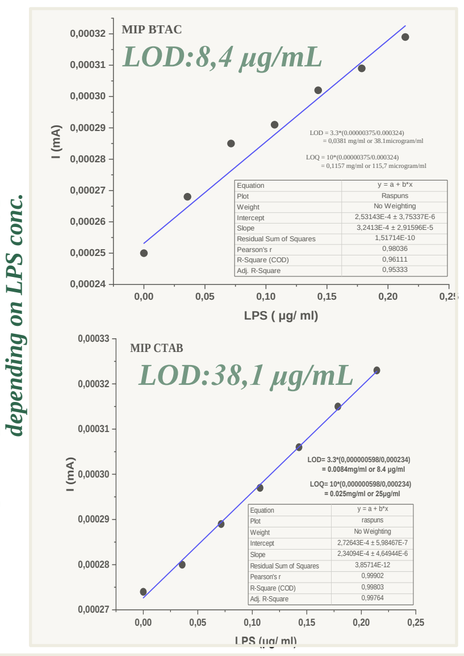
Contact with LPS from Salmonella enterica

	Q MIP (U.E/mg)			Q NIP (U.E/mg)			Imprinting factor		
Time	30 min	3h	24h	30 min	3h	24h	30 min	3h	24h
MIP/NIP CTAB	0,001	5,701	3,064	0,001	5,712	3,900	0,064	0,988	0,786
MIP/NIP BTAC	0,009	2,280	4,607	0,008	2,229	3,201	1,183	1,022	1,439

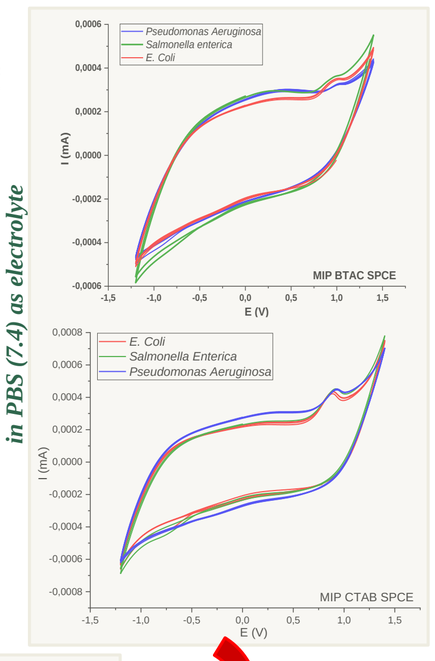
Contact with LPS from Pseudomonas aeruginosa, at different concentrations in PBS (pH 7.4) as electrolyte



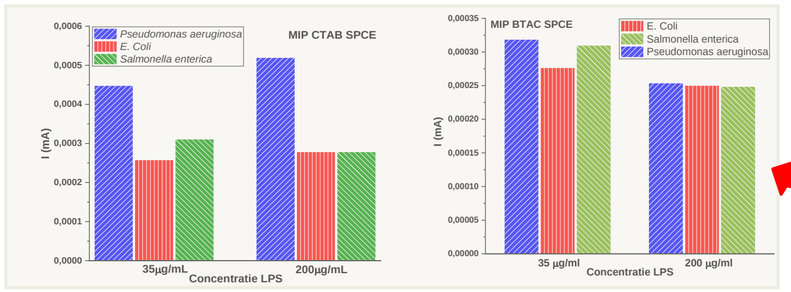
Corresponding calibration curves of peak current depending on LPS conc.



Contact with LPS from other strains at a conc. of 35 µg/mL in PBS (7.4) as electrolyte



Peak decrease, Specific binding taking place Diffusion process



Selectivity test at two different concentrations

The obtained amino-fuctionalized MIPs particle proved to be efficient for LPS recognition. Their embedment into electrochemical paste followed by deposition onto the working electrode of SPCEs led to cost-effective biosensor development.

The biosensor based on MIP CTAB particles seemed to be more sensitive due to the increased surface area of hollow particles which provided more binding sites formation through hydrogen bonds

Check this paper

https://doi.org/10.1016/j.electacta.2024.145044

Good preliminary result Starting biosensor optimization

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Acknowledgements

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