Ultra-Fast Pathogen Identification in Sepsis Diagnosis Using an Optomechanical Sensor Assisted by Artificial Intelligence

Irene Colomar[1]*, Alejandro Iregui[1]*, Casilda Muñoz[1], Carolina Heras[1], Daniel Ramos[2], and Blanca Caballero[1†]

[1]Nanological SL

[2]Institute of Material Science of Madrid (ICMM), CSIC, Spain

† blanca.caballero@nanological.es

Sepsis and bacteremia are major global causes of mortality, requiring rapid and accurate pathogen identification to optimize antimicrobial therapy. Current diagnostics, like blood cultures, are time-consuming and limited in sensitivity, especially at low bacterial concentrations, while molecular methods rely on costly reagents and predefined genetic targets. We present an **optomechanical platform enabling label-free detection to identify pathogens directly from whole blood**, addressing these critical limitations.

The system integrates **optical and nanomechanical sensing within a disposable microfluidic cartridge**, measuring bacterial **biophysical properties** like mass, size, and optical absorption with unprecedented sensitivity. Real-time pathogen identification is achieved using **machine learning algorithms trained on biophysical signatures of clinically relevant bacteria** (e.g., *Escherichia coli*, *Klebsiella pneumoniae*, *Staphylococcus aureus*). **Validation on blood samples spiked with controlled bacterial concentrations** demonstrated performance **benchmarked against the gold standard** (blood culture with MALDI-TOF mass spectrometry).

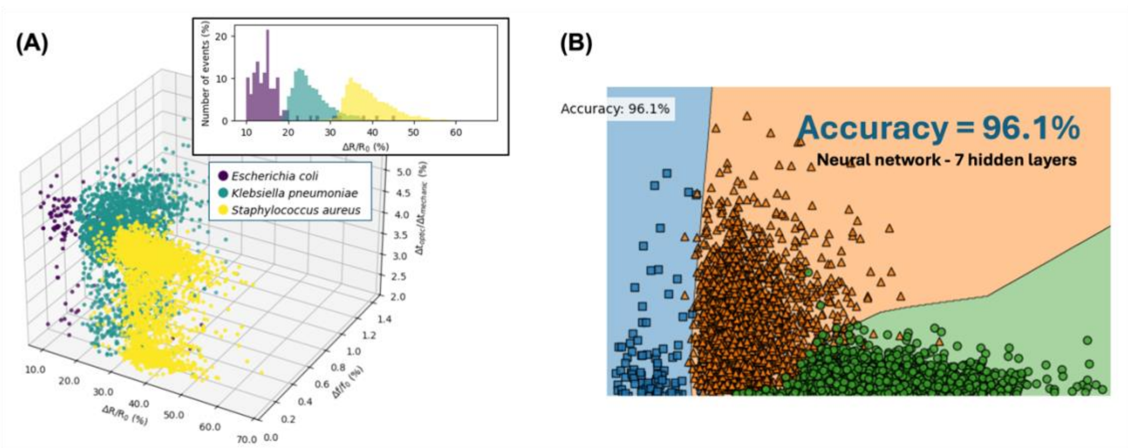

Figure. Optomechanical detection and identification of live bacteria in blood plasma with AI algorithms. **(A)** Experimental results of multiparametric measurements for three bacterial species: *E. coli* (purple), *K. pneumoniae* (green), and *S. aureus* (yellow), including a histogram of the relative reflectivity parameter ($\Delta R/R$). **(B)** Prediction results using a neural network model with 7 hidden layers, achieving an accuracy of 96.1%.

The optomechanical platform **achieved species-level identification accuracy exceeding 96% within 20 minutes**, demonstrating exceptional precision and reliability even at **bacterial concentrations as low as 50 CFU/mL**. Sample processing involved microfluidic cell segregation to isolate bacteria, combined with the training of AI algorithms on labeled datasets to enhance identification accuracy.

This novel optomechanical platform represents a transformative advancement in the rapid diagnosis of sepsis and bloodstream infections. Its ability to achieve **species-level bacterial identification without the need for pre-enrichment or genetic amplification** streamlines the diagnostic process, **reducing time-to-result and operational complexity**. The platform's high analytical performance, combined with its **minimal infrastructure requirements**, places it as a promising tool for improving clinical workflows and outcomes.