Nanoflower Sensor for Screening Pregnancy Complications via Profiling Circulating Placental Extracellular Vesicles

Mostafa Kamal Masud[1] *, *Carlos Palma*[2], *Carlos Salomon*[2] *and Yusuke Yamauchi*[1]

[1]Australian Institute for Bioengineering and Nanotechnology (AIBN), The University of Queensland, Brisbane, QLD 4072, Australia
[2] of Queensland Centre for Clinical Research, Faculty of Medicine, The University of Queensland, Brisbane City, QLD QLD 4006, Australia.
Presenting and corresponding author e-mail address: m.masud@uq.edu.au

Pregnancy complications, such as hypertension, diabetes, infections, and congenital anomalies, pose significant risks to maternal and fetal health.[1] Current diagnostic methods often fail to detect these conditions early, underscoring the need for advanced screening tools. Extracellular vesicles (EVs) have emerged as promising biomarkers for pregnancy-related conditions, acting as liquid biopsies detectable from the first trimester.[2] However, their isolation remains challenging due to their small size and heterogeneity. To address this, we developed a highly sensitive screening sensor utilizing superparamagnetic mesoporous flower-shaped nickel ferrites (SMNFs) for rapid EV isolation and detection (**Figure 1**).[3] Targeted Multiple Reaction Monitoring (MRM) of CD9 and Placental Alkaline Phosphatase (PLAP) proteins in circulating EVs from maternal plasma (<18 weeks gestation) identified distinct expression patterns linked to pregnancy complications. Using a classification model trained and validated on patient data, we achieved >90% accuracy in distinguishing high-risk pregnancies from normal cases. The SMNFs' flower-like flakes provide an enhanced surface for antibody loading, enabling efficient EV capture (CD9+ve/PLAP+ve) on a 4-flex glass strip sensor. This nanosensor offers a simple, cost-effective, and highly sensitive nanozymatic readout using minimal chemistry. Applied to plasma or EV samples, the system demonstrated a sensitivity of 95% and specificity of 100% for identifying women at risk of gestational diabetes mellitus. This innovative nanoplatform has strong translational potential for early clinical screening of pregnancy complications, offering a robust, non-invasive, and cost-effective diagnostic solution.

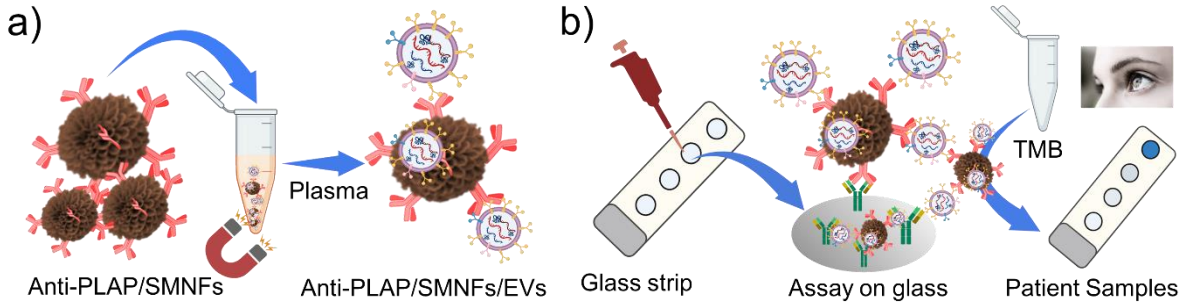

Figure 1 (10 pt, bold): SMNF-based 4-flex glass nanosensor for PLAP+ EVs isolation and detection. (a) direct isolation of $PlAP^{+ve}$ using anti-PlAP modified SMNFs; (b) schematic representation of the assay on the 4-flex glass sensor.

References:

[1]Attwaters, M. *Nature Reviews Genetics* **2022,** *23*, 136-136.
[2]C. Salomon *et al.*, *Diabetes* **2015***, 65*, 598-609.
[3]Masud, M.K.; Palma, C.; et al., Science Advances **2025**, *11*, eadr4074.