Polydopamine-based Nanoparticles for Lateral Flow Diagnostics

Aurora Patrizi[1*,2], Helena Torné-Morató[2], Francesco Olimpico[2], Francesco Cardarelli[1], Stefano Mariani[2]

1 Scuola Normale Superiore, Pisa 56126, Italy

2 Fondazione Pisana per la Scienza ETS, San Giuliano Terme (PI) 56017, Italy

*aurora.patrizi@sns.it

Lateral Flow Assays (LFAs) are widely used point-of-care diagnostic tools. However, traditional LFAs rely on gold nanoparticles suffer from weak and non-specific biomolecules adsorption and require heterobifunctional linkers or EDC/NHS chemistry. Polydopamine (PDA) overcomes these limitations through its surface rich in quinone and catechol groups, which enable direct covalent antibody conjugation via Michael addition or Schiff base reaction. Recent studies highlights the integration of PDA in LFAs with various functional structures: bare PDA[1], core–shell hybrid platforms (Core@PDA)[2] integrating magnetic or optical cores, fluorescence quenchers[3] for Turn-On/Turn-Off assays and catalytic/SERS scaffolds[4] to enhance signal amplification for the detection of mycotoxin, bacteria, viruses or diagnostic biomarkers in complex matrices.

In this work, we investigate and compare the sensitivity in LFA of bare PDA and Fe_3O_4@PDA nanoparticles (NPs) using human transferrin as a model target. Dynamic Light Scattering (DLS) was used to characterize the nanosystem, confirming both anti-transferrin bioconjugation and casein passivation. Transmission Electron Microscopy (TEM) analysis confirmed the morphology, while High-Resolution TEM (HRTEM) verified the crystalline structure of the magnetite core.

Both NPs were tested on LFA with a transferrin calibration range between 0 and 1000 ng/mL. At the same optical density (OD_{600nm} = 1), Fe_3O_4@PDA NPs demonstrated a lower Limit of Detection (LOD) and a higher Signal-to-Noise Ratio (SNR) compared to PDA NPs. This enhancement is driven by the higher intrinsic optical density of the iron component, as confirmed by UV-Vis spectra.

Future work will focus on optimizing core–shell synthesis, exploiting magnetic pre-concentration to lower detection limits, and applying PDA coatings to other types of particles to develop new multifunctional materials.

(1) Liang J. et al. *High extinction coefficient material combined with multi-line lateral flow immunoassay strip for ultrasensitive detection of bacteria,* Food Chemistry, **2023**
(2) Dong T. et al. *Multifunctional Co3O4@PDA Nanocomposite-Based Sensitive Dual-Mode Lateral Flow Immunoassay for the Simultaneous Detection of Two Antibodies* against Respiratory Tract Pathogens, Analytical Chemistry, **2025**
(3) Zheng Z. et al. *Dual-signal lateral flow immunoassay for rapid detection of ochratoxin A based on polydopamine nanoparticles and gold nanocluster,* Journal of Food Composition and Analysis, **2025**
(4) Liu X. et al. *Multifunctional Nano-Sunflowers with Color-Magnetic-Raman Properties for Multimodal Lateral Flow Immunoassay,* Analytical Chemistry, **2021**