Development of Immunochromatographic Assays Based on Photon-Upconversion Nanoparticles

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Lateral flow immunoassays (LFIAs) are analytical tools used in many areas, especially in point-of-care diagnostics, and are best known as pregnancy tests and COVID-19 antigen tests. Conventionally, LFIAs use gold nanoparticles to detect an analyte in a sample. However, gold nanoparticles typically do not allow for quantitation and may not provide sufficient sensitivity. Therefore, other nanomaterial labels could be used to enhance the analytical performance of LFIAs. One alternative is photon-upconversion nanoparticles (UCNPs), which enable a substantial reduction in the optical background of the assay. In this project, a UCNP-based LFIA was developed and optimized to detect human serum albumin (HSA), a biomarker of kidney malfunction in diabetic patients. Early detection of elevated HSA in urine is crucial for preventing chronic diabetes-related complications. Optimization focused on drying time, blocking method, preincubation time, and conjugate concentration. Once fully optimized, the method was successfully tested on a spiked urine sample to detect HSA. The analytical performance of UCNPs was compared with that of conventional gold nanoparticles. The limit of detection for UCNPs was 0.8 ng/mL, a fourfold improvement over that of gold nanoparticles. These results show that UCNPs enhance LFIA sensitivity and are suitable for diagnosing albuminuria. Moreover, the method could be easily adapted to a range of other analytes.

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