A Centrifugation-Assisted Lateral Flow Assay Platform for Bioassay Sensitivity and Visualization Enhancement

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ABSTRACT

This study presents a centrifugation-assisted lateral flow assay (CLFA) platform that addresses the limited sensitivity and uncontrollable incubation time of traditional lateral flow assays (LFA). The CLFA platform generates a centrifugal force by controlling the motor to improve the flow rate controllability and optimize incubation time at the test line (T line). As a proof-of-concept, human chorionic gonadotropin (hCG) was chosen for quantification to validate the sensitivity and visualization enhancements. The centrifuged experiment group exhibits better linearity (R^2=0.9795) with the logarithm of the concentration (0-2000 mIU/mL) than the uncentrifuged control group. And the T line intensity enhances by an average of 8.23%. Our CLFA platform potentially improves early screening and advances point-of-care testing development.

INTRODUCTION

- **Lateral flow assay (LFA) is one of the most promising techniques for point-of-care testing (POCT) due to its user-friendliness and cost-effectiveness [1].**
- **Limited sensitivity and uncontrollable incubation time are the main challenges of LFA [2, 3].**
- **We developed a simple centrifugation-assisted LFA (CLFA) platform to improve flow rate controllability and optimize incubation time.**
- **We demonstrated the low-level human chorionic gonadotropin (hCG) quantification on this platform to validate the improved sensitivity and visualization.**

RESULTS

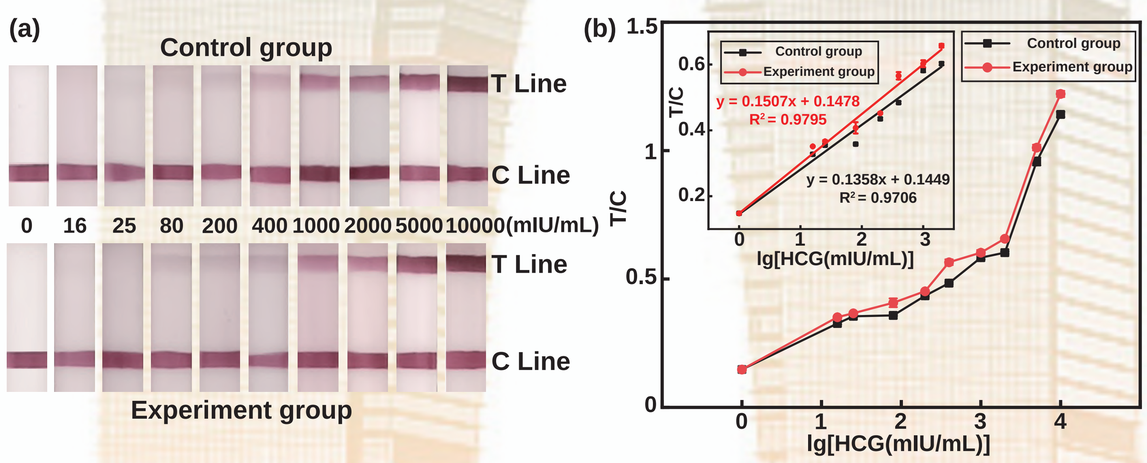

Figure 2. The results of hCG test strips with different concentrations (n=5).

- **Test strip results:**
  - **Fig. 2(a) shows the test strip results of the control and experiment groups taken by the smartphone.**
  - **Fig. 2(b) shows the ratio of the mean grayscale of the T line to that of the C line.**
- **Better linear relationship:**
  - **The centrifuged experiment group indicates a better linear relationship with the logarithm of the concentration from 0 to 2000 mIU/mL (R^2=0.9795) than the uncentrifuged control group.**
- **Visualization enhancement:**
  - **The experiment group demonstrates an average increase of 8.23% in the T line intensity at the same hCG concentration.**

METHODS

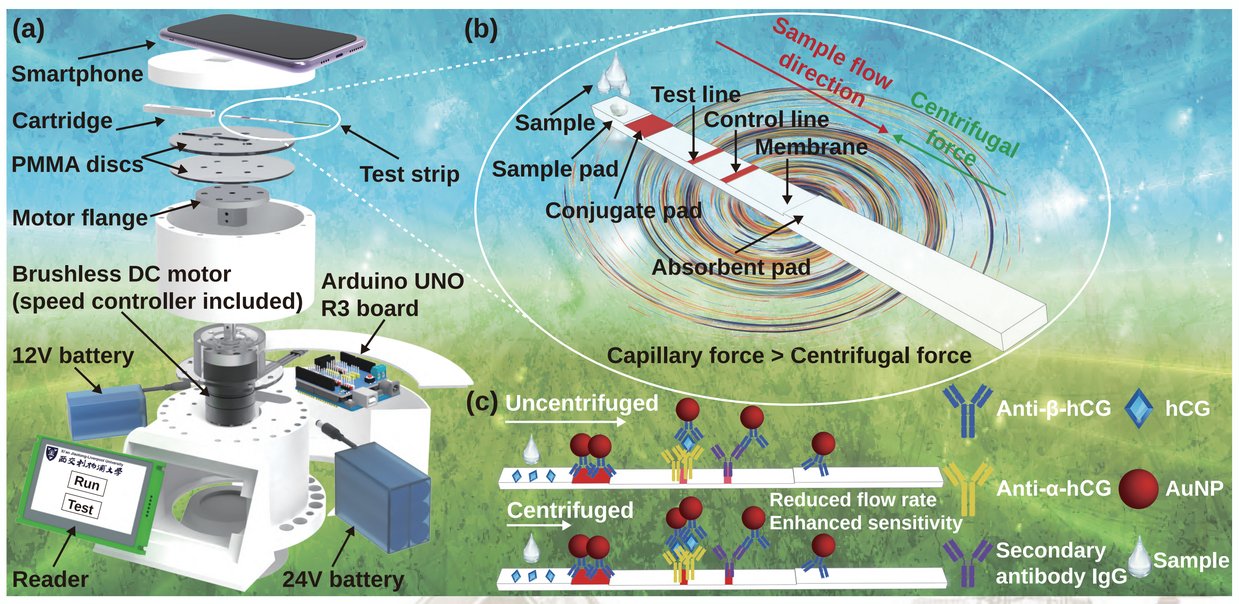

Figure 1. Schematic diagram of CLFA platform and working principle.

- **CLFA platform design:**
  - **Fig. 1(a) shows the CLFA platform we developed, which can provide different rotation speeds for precise control of flow rates.**
  - **The detected results can be displayed on the reader.**
- **Working principle of CLFA:**
  - **Figs. 1(b) and 1(c) show the structure of LFA test strips and the working principle of CLFA.**
  - **The CLFA platform achieves flow rate control by generating a controlled centrifugal force radially opposite to the capillary force.**
- **Optimization of incubation time:**
  - **The CLFA platform enables the reduction of hCG liquid sample flow rate, optimizing the incubation time at the test line (T line).**
  - **The optimized incubation time allows the gold-labeled probe (Anti-β-hCG-AuNP) with hCG antigen to form a sandwich structure more fully with the Anti-α-hCG. This provides a higher intensity of the T line.**

CONCLUSION

We developed a CLFA platform that enhances the sensitivity and visualization of quantitative bioassays, potentially improving early screening and advancing POCT development.

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