Colorimetric Hormone Sensing with Gold Nanoparticles and DNA Aptamers

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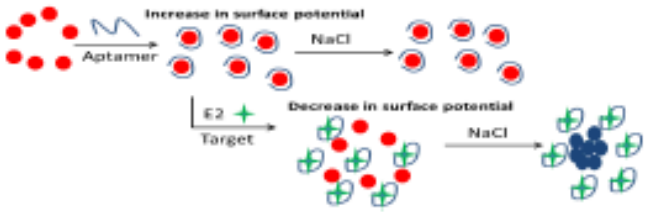
Single stranded (ss) DNA aptamers [1,2] are generated *via* a combinatorial process starting from a pool of random and synthetic ssDNAs (~ 10^{15} molecules). They have demonstrated considerable promise for sensing applications due to their stability in non-physiological conditions, ease of synthesis, modification and surface coupling. A 75-mer aptamer capable of binding the hormone 17β-estradiol (E2) was isolated in our group [1]. This study reports the use of gold nanoparticles (AuNPs) in the construction of a simple colorimetric sensor for E2 in water samples at sub-nanomolar levels as well as a simple means to evaluate the structural modification of the aptamer towards better sensing and specificity.

1) Concept Behind Sensing

AuNPs have a great affinity to the nitrogen bases on the ssDNA aptamer backbone which leads to a stable dispersion of ssDNA-coated AuNPs in moderate salt concentrations. Binding of the target molecule (E2) induces a conformational change in the ssDNA aptamer which reduces its affinity to AuNPs and thereby destabilizes the dispersion towards salt. At an optimum ionic strength, presence of the target is identified by the colour change resulting from aggregation of AuNPs that are no longer protected by aptamers. The degree of aggregation is sensitive to the concentration of the target molecule (E2) and this can be quantified by UV-vis absorption but is also evident to the naked-eye.

Scheme 1. Schematic depiction of colorimetric aptasensing of E2



2) Nanomolar Colorimetric E2 Sensing with the 75-mer Aptamer

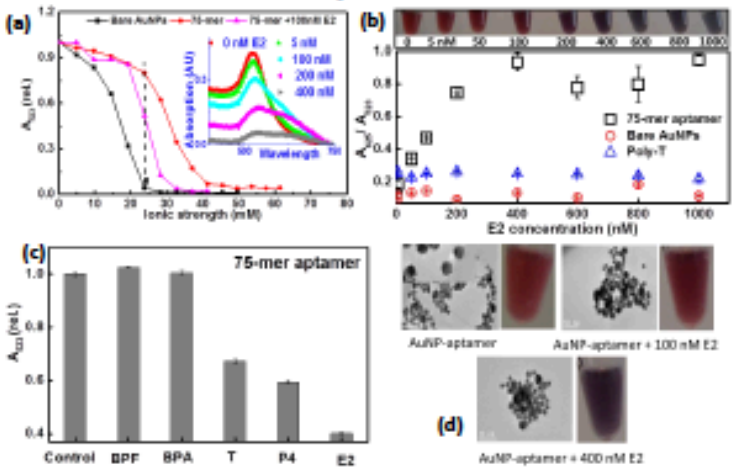


Figure 1.

a) Confirmation of adsorption of the 75-mer aptamer and determination of the optimal [NaCl] for E2 sensing.

b) Nanomolar colorimetric E2 detection using AuNP-75-mer aptamer compared with bare AuNPs and AuNP-poly-T controls (photograph in the top panel).

c) Specificity examinations of interfering molecules (chemical structures shown in Figure 3d).

d) TEM images and photographs for AuNPs-75-mer aptamer and E2 sensing samples.

3) Truncation of the 75-mer Aptamer

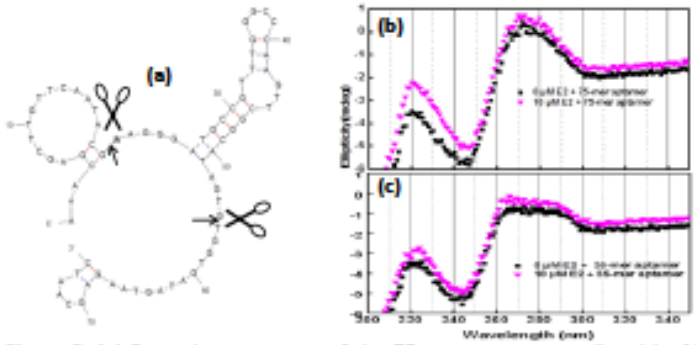


Figure 2. (a) Secondary structure of the 75-mer aptamer predicted by M-fold program, indicating the truncation positions. Circular dichroism (CD) spectra for (b) the 75-mer and (c) the 35-mer aptamers showing both aptamers are capable of binding to E2 with a new 3D (G-quadruplex) feature seen for the 35-mer aptamer.

4) Enhanced Specificity and Sub-nanomolar Sensing with the 35-mer Aptamer

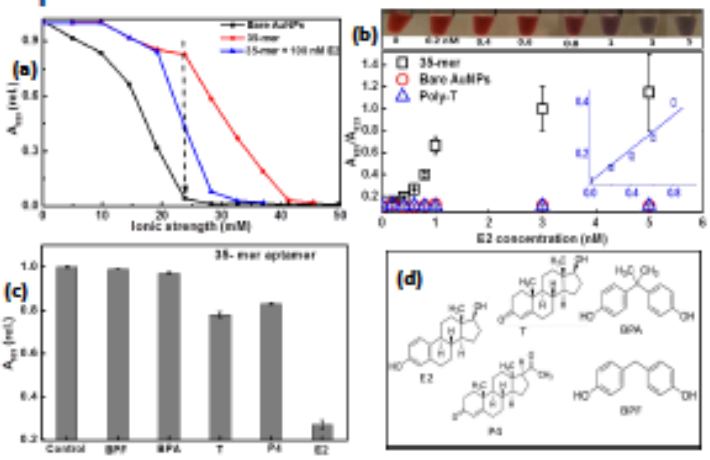


Figure 3.

a) Adsorption conformation of the 35-mer aptamer and determination of the optimal [NaCl] for sensing.

b) Sub-nanomolar colorimetric response and Improvement of E2 detection using the AuNP-35-mer aptamer compared with bare AuNPs and AuNP-poly-T controls (photograph in the top panel) .

c) Enhanced Specificity towards E2 over interfering molecules using the AuNP-35-mer aptamer

d) Molecular structures of the detected compounds.

(References): *[1] Tuerk, C., Gold, L., 1990. Science (80-.). 249, 505–510. [2] Ellington, A.D., Szostak, J.W., 1990. Nature 346, 818–22. [3] Alsager, O. A, Kumar, S., Willmott, G.R., McNatty, K.P., Hodgkiss, J.M., 2014. Biosens. Bioelectron. 57C, 262–268.*

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