Highly-sensitive C-reactive protein detection based on the selective aggregation of aptamer-conjugated silver nanoparticles

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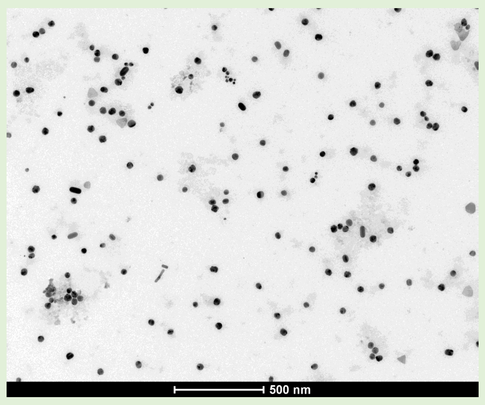
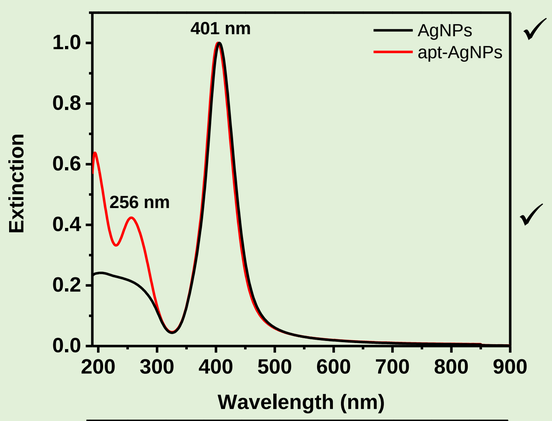
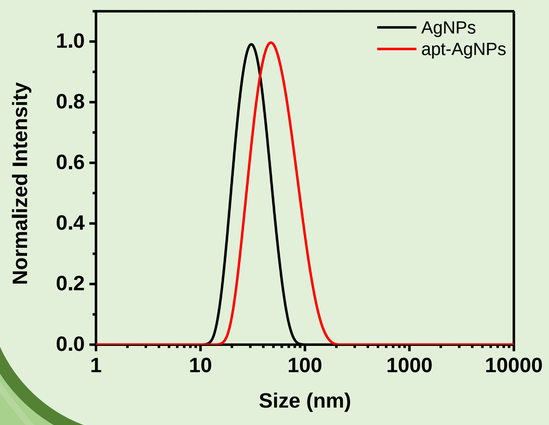
Introduction

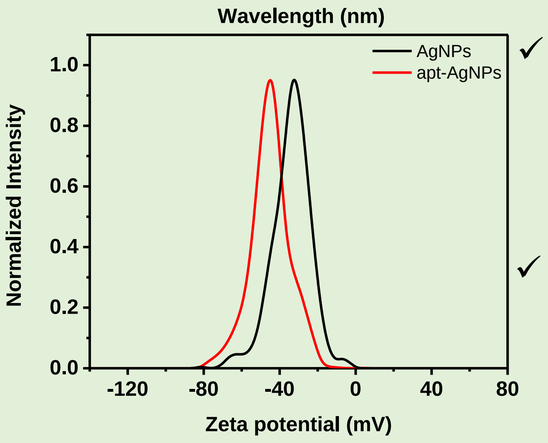
C-reactive protein (CRP) is an annular pentameric protein produced by the liver and is one of the earliest indicators of infectious and inflammatory conditions related to diseases such as sepsis, viral infections and even autoimmune diseases [1]. More importantly, when CRP levels chronically stay below 5 mg/L indicate the possibility of developing coronary heart disease, ischemic stroke and acute myocardial infarction. Therefore, the development of fast and cheap sensing platforms for the selective and highly-sensitive detection of CRP is extremely necessary in order to timely predict the development of these diseases. In this work, we present a high-sensitivity sensor for the selective detection and quantification of CRP based on the aggregation of silver nanoparticles conjugated with a CRP-specific aptamer (apt-AgNPs). Initially, the yellow colloidal solution of apt-AgNPs presents one narrow localized surface plasmon resonance (LSPR) band located at 401 nm. After the interaction of apt-AgNPs with different CRP concentrations in the presence of sodium chloride, a change in color of the colloidal solution takes place that can be observed even by the naked-eye. After the UV-Vis evaluation, the addition of CRP in the colloidal solution resulted in the appearance of a second LSPR band that was assigned to aggregated NPs. Furthermore, by monitoring the ratio between the absorption of aggregated and non-aggregated NPs, the concentration of CRP can be precisely determined. Taking into consideration the aforementioned characteristics, the apt-AgNPs represent a promising candidate as a rapid and cheap sensing platform for the selective detection and highly sensitive quantification of low-CRP concentrations.

Synthesis and characterization



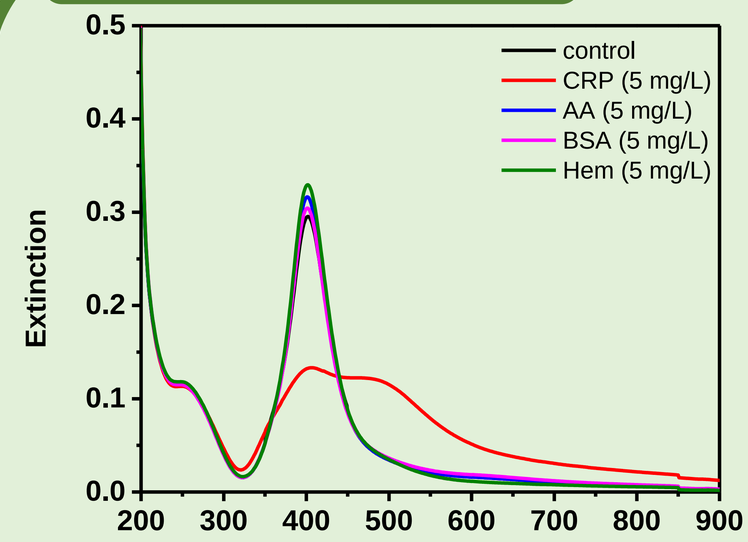


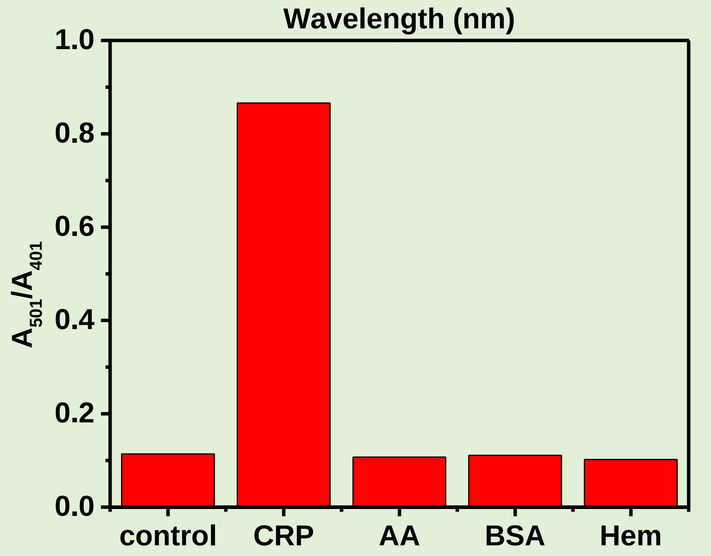




- ✓ **Excellent monodispersity** of AgNPs confirmed by transmission electron microscopy;
- ✓ The extinction spectrum of **apt-AgNPs** present both the **plasmonic** and **CRP specific aptamer** responses;
- ✓ The **hydrodynamic size increase** of apt-AgNPs proves the presence of **the CRP specific aptamer on the surface of AgNPs;**
- ✓ The CRP specific **aptamer improves the stability of AgNPs** as confimed by zeta potential measurements;

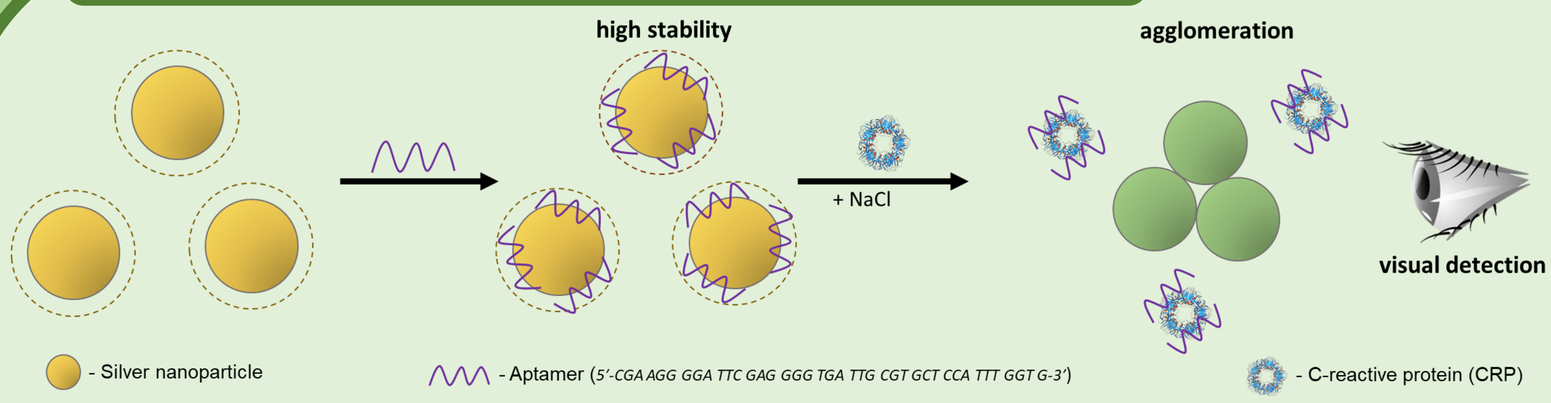
Selectivity

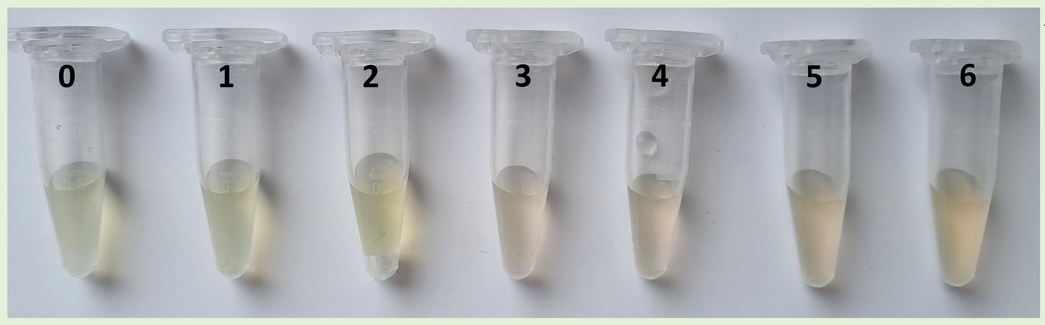


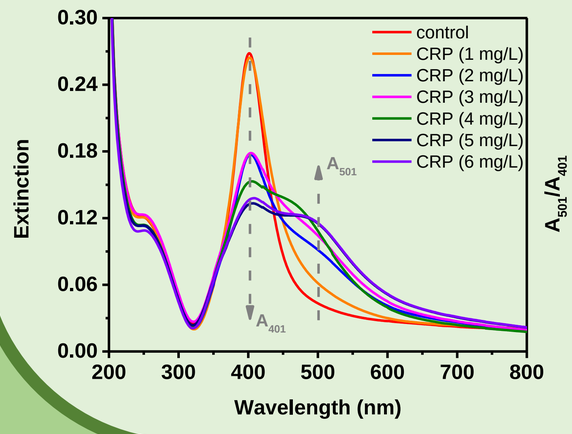


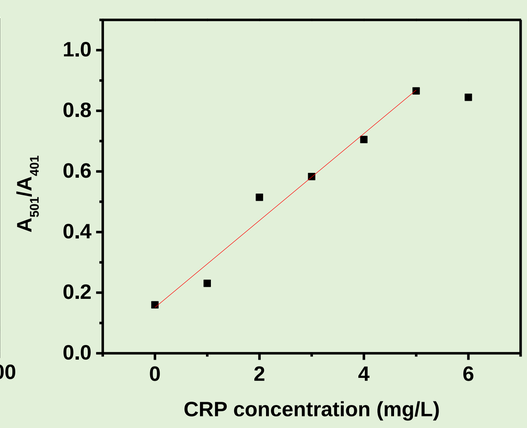
- ✓ The apt-AgNPs-based sensor presents **high selectivity towards CRP detection** compared to other analytes

Visual detection of CRP









- ✓ The **sensing mechanism** is based on the **gradual agglomeration of unprotected AgNPs** in the presence of a **saline solution** after the **aptamer detaches and bonds to the CRP protein**
- ✓ **Gradual color changes** were observed after interaction with CRP concentration between 0-6 µg/mL;
- ✓ The absorbance ratio (A501/A401) was in **good linear relationship** with the CRP concentration ranging from **0-5 mg/L**. The **limit of detection** was calculated to be **0.85 mg/L**;

Conclusion

- ✓ The **aptamer functionalized citrate-capped silver nanoparticles** represent a **promising candidate** as a **rapid and cheap sensing platform** for the **visual detection of low-CRP concentrations,** as the colloidal solution gradually changes color with the increase of CRP concentration**.** Moreover, the **highly sensitive quantification** of the **low-volumes of CRP** was achieved by **monitoring the agglomeration grade** *via* UV-Vis spectroscopy.

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Reference

[1] T. Nagy-Simon et al. J. Mol. Struct., 1246, 131178, (2021).