Electronic Supplementary Material (ESI) for Analytical Methods.

Electronic Supporting Material

Colorimetric detection of Cr(Ⅵ) using silver nanoparticles functionalized with PVP

1. Optimization of the experimental conditions

In order to achieve high sensitivity of the sensor for Cr(Ⅵ) analysis, the experimental conditions like the ratio of AgNPs and PVP concentration, the pH of PBS buffer, the volume of PBS buffer, the volume of citric acid, and the reaction time of Cr(Ⅵ) were optimized. Fig. S-1A showed the effect of the AgNPs and PVP concentration ratio on the sensing system. It was found that when the concentration ratio of PVP to AgNPs was 1 : 3, $A_{530\ \mathrm{nm}}/A_{390\ \mathrm{nm}}$ reached the maximum. Thus, 1 : 3 was selected as the optimal concentration ratio of PVP to AgNPs.

Fig. S-1B illustrated the effect of pH on the $A_{530\ \mathrm{nm}}/A_{390\ \mathrm{nm}}$ of the system. As seen, it had an mostly effect on the absorbance ratio ($A_{530\ \mathrm{nm}}/A_{390\ \mathrm{nm}}$) when pH was 5.5. Therefore, the pH 5.5 was selected as the optimal condition for subsequent experiments.

Fig. S-1C indicated the effect of the volume of citric acid on the $A_{530\ \mathrm{nm}}/A_{390\ \mathrm{nm}}$ of the system. It was found that a certain concentration of Cd(Ⅱ) also coordinated with the ligand PVP, so it needed to be masked off by citric acid. The changes of $A_{530\ \mathrm{nm}}/A_{390\ \mathrm{nm}}$ reached the maximum when the volume of citric acid (0.1 M) was 20 μL. Hence, 20 μL was chosen as the best volume of citric acid for future experiments.

Fig. S-1D illustrated the effect of reaction time of Cr(Ⅵ) on the A_{390nm}/A_{530nm} of the system. The absorbance ratio $A_{390\ nm}/A_{530\ nm}$ decreased rapidly within 5 min when Cr(VI) was added, and the color changed with visible changes. The absorbance ratio remained basically unchanged at the 10th minute. Therefore, 10 min was chosen for Cr (Ⅵ) reaction.

Fig. S2. illustrated the effect of the others environmentally relevant metal ions on detecting Cr(Ⅵ). The UV-visible spectra were showed that a new absorption peak appeared at the wavelength of 530 nm only when Cr(VI) was added into the PVP-AgNPs system. It can be seen from the inset photographs that all colorimetric tubes (except for Cr(Ⅵ)) demonstrated bright yellow color, indicating only Cr(Ⅵ) can lead to the aggregation of PVP-AgNPs, and the color of PVP-AgNPs changed from bright yellow to orange. So, the detection system was of high selectivity toward Cr(Ⅵ).

Fig. S3. illustrated the effect of coexisting ions on detecting Cr(Ⅵ). It could be concluded that 1000 times of Fe^{2+}, HCO_3^-, Ca^{2+}, 200 times of Al^{3+}, Zn^{2+}, Fe^{3+}, Ag^+, 100 times of SO_3^{2-}, 50 times of NH_4^+, SO_4^{2-}, NO_3^-, 20 times of Mn^{2+}, $C_2O_4^{2-}$, Hg^{2+}, Pb^{2+}, 5 times of Bi^{2+}, Cu^{2+}, K^+, 2 times of Ce^{3+}, Ba^{2+}, Mg^{2+} had no effect on detecting Cr (Ⅵ). Besides, after the addition of citric acid, 1000 times of Mg^{2+}, 200 times of Cd^{2+} and Cr(Ⅲ) also had no effect on detecting Cr(Ⅵ).

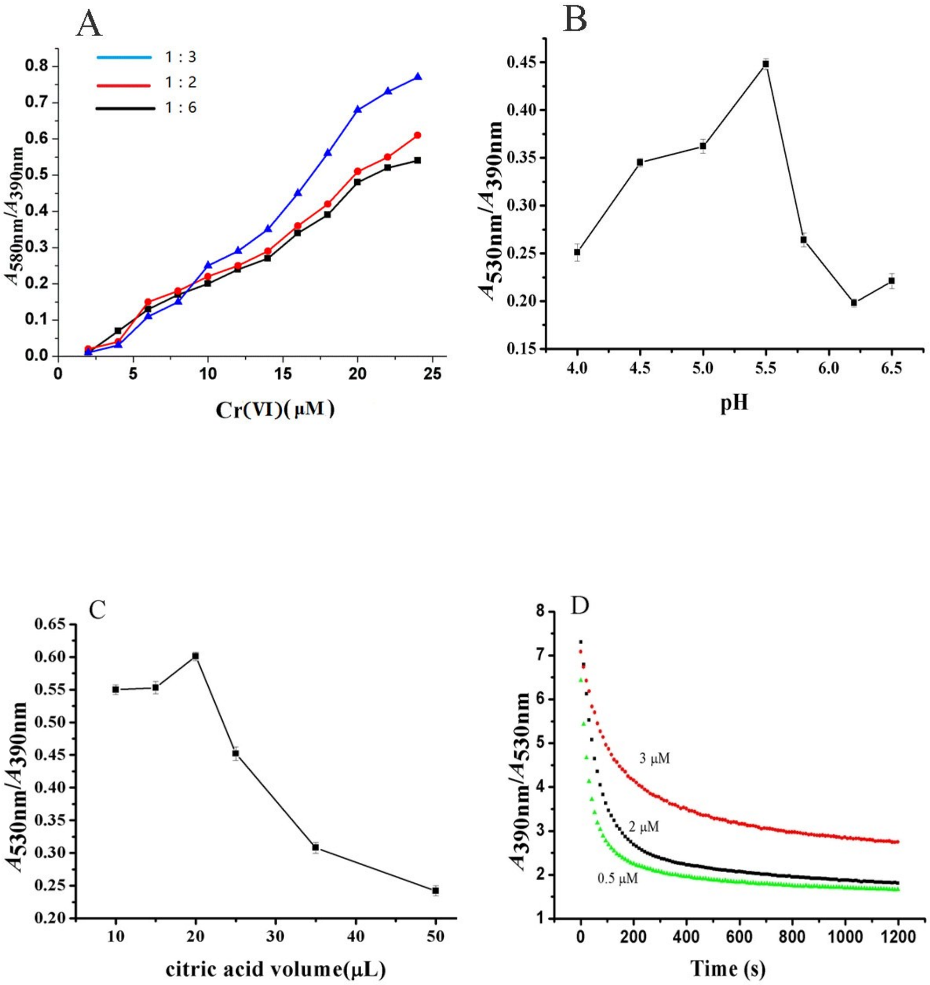

Fig. S1. Effect of the ratio of AgNPs and PVP concentration (A), the pH of PBS buffer (B), the volume of citric acid (C), and the reaction time of Cr(Ⅵ) (D) on the sensing system.

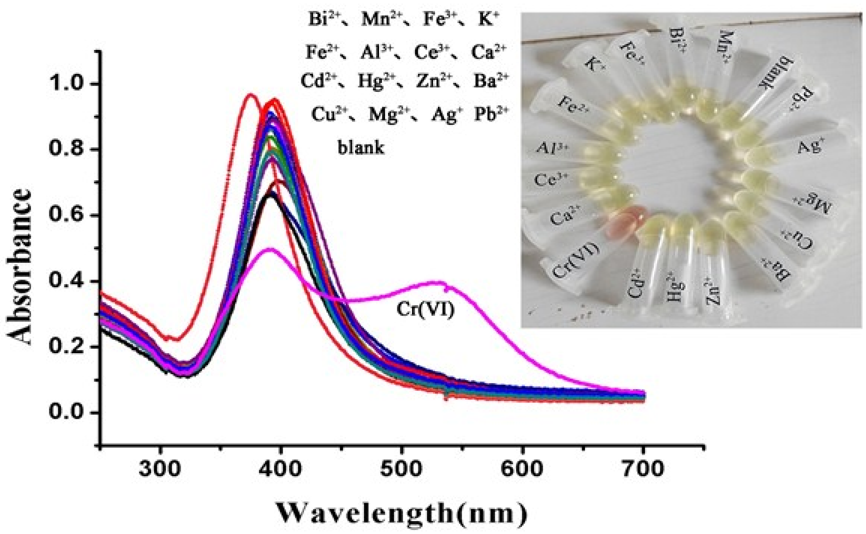

Fig. S2. UV-visible spectra and photographs (inset) of the PVP-AgNPs upon the addition of 2.0 μM of various metal ions in 90 μL PBS buffer (pH 5.5).

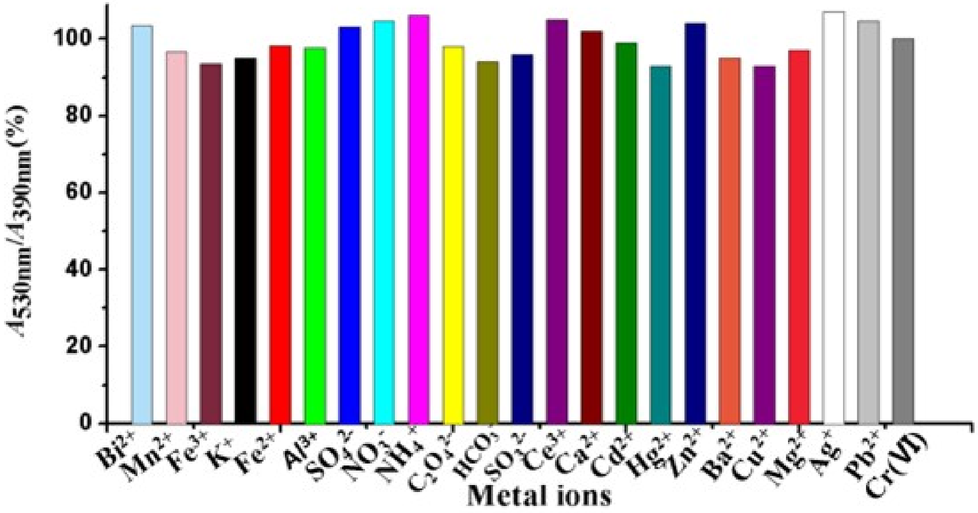

Fig. S3. The effect of interfering ions on detecting Cr(VI) (2.0 μM). The concentrations of possible interferences are 2.0 mM Fe^{2+}, HCO_3^-, Ca^{2+}, 0.4 mM Al^{3+}, Zn^{2+}, Fe^{3+}, Ag^+, 0.2 Mm SO_3^{2-}, 0.1mM NH_4^+, SO_4^{2-}, NO_3^-, 40μM Mn^{2+}, $C_2O_4^{2-}$, Hg^{2+}, Pb^{2+} and 10 μM Bi^{2+}, Cu^{2+}, K^+, 4.0μM Ce^{3+}, Ba^{2+}. After the addition of citric acid, the concentrations of possible interferences are 2.0 mM Mg^{2+}, 0.4 mM Cd^{2+} and Cr(Ⅲ).