Supporting Information

Highly sensitive facile plasmonic scheme for assessment of melamine in raw milk

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1. Characterization of the synthesised nanoparticles

1.1. UV-Visible Study

The UV-Vis absorbance spectrum of the synthesized nanoparticles was obtained using Cary 60 UV-Vis spectrophotometer from Agilent Technologies. From UV-Vis analysis of AgNPs the maximum absorption peak was obtained at 390 nm (Fig. S1(a)). Similarly, the peak was obtained at 530 nm for AuNPs (Fig. S1(b)). This confirms the formation of the desired nanoparticles.

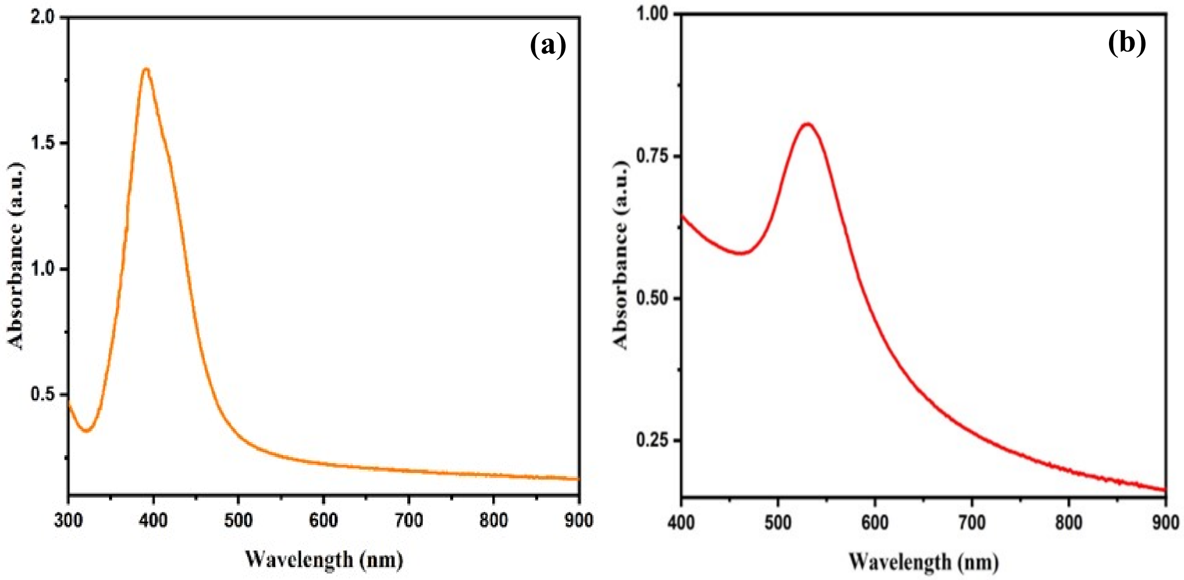


Fig. S1. UV-Visible Spectrum of the synthesised (a) AgNPs and (b) AuNPs.

1.2. Zeta Size Study

To verify the size distribution of the synthesized nanoparticles, a zeta potential study was conducted for both silver nanoparticles (AgNPs) and gold nanoparticles (AuNPs). In the case of AgNPs, the size distribution revealed two distinct peaks at 56.46 nm and 5.734 nm, with the former exhibiting higher intensity. The average zeta size of the AgNPs was determined to be 31.84 nm. Likewise, for AuNPs, a singular peak at 15.50 nm was observed, and the corresponding zeta size was measured at 10.23 nm (Fig. S2).

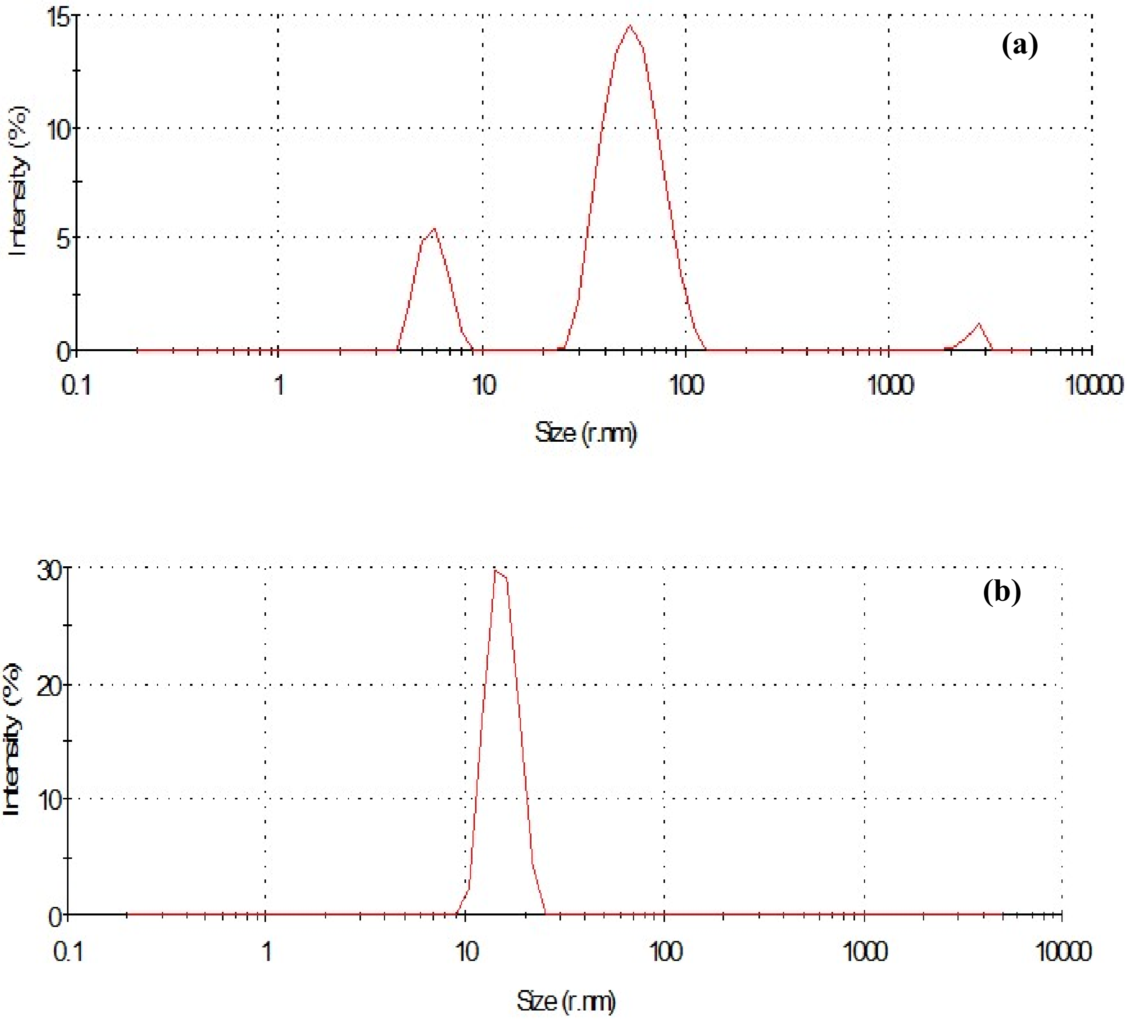


Fig. S2. Size distribution analysis from dynamic light scattering analysis (a) AgNPs and (b) AuNPs.

1.3. Transmission Electron Microscopy Study

To assess the size distribution and morphology of the synthesized nanoparticles, TEM characterization was conducted, yielding detailed images. For AgNPs, most nanoparticles appeared spherical, with some exhibiting slight elongation, and sizes ranging from 2 to 12 nm, with an average diameter of 6.07 nm. In the case of AuNPs, the particles were predominantly spherical, with sizes between 4 and 11 nm and an average diameter of 6.7 nm (Fig. S3).

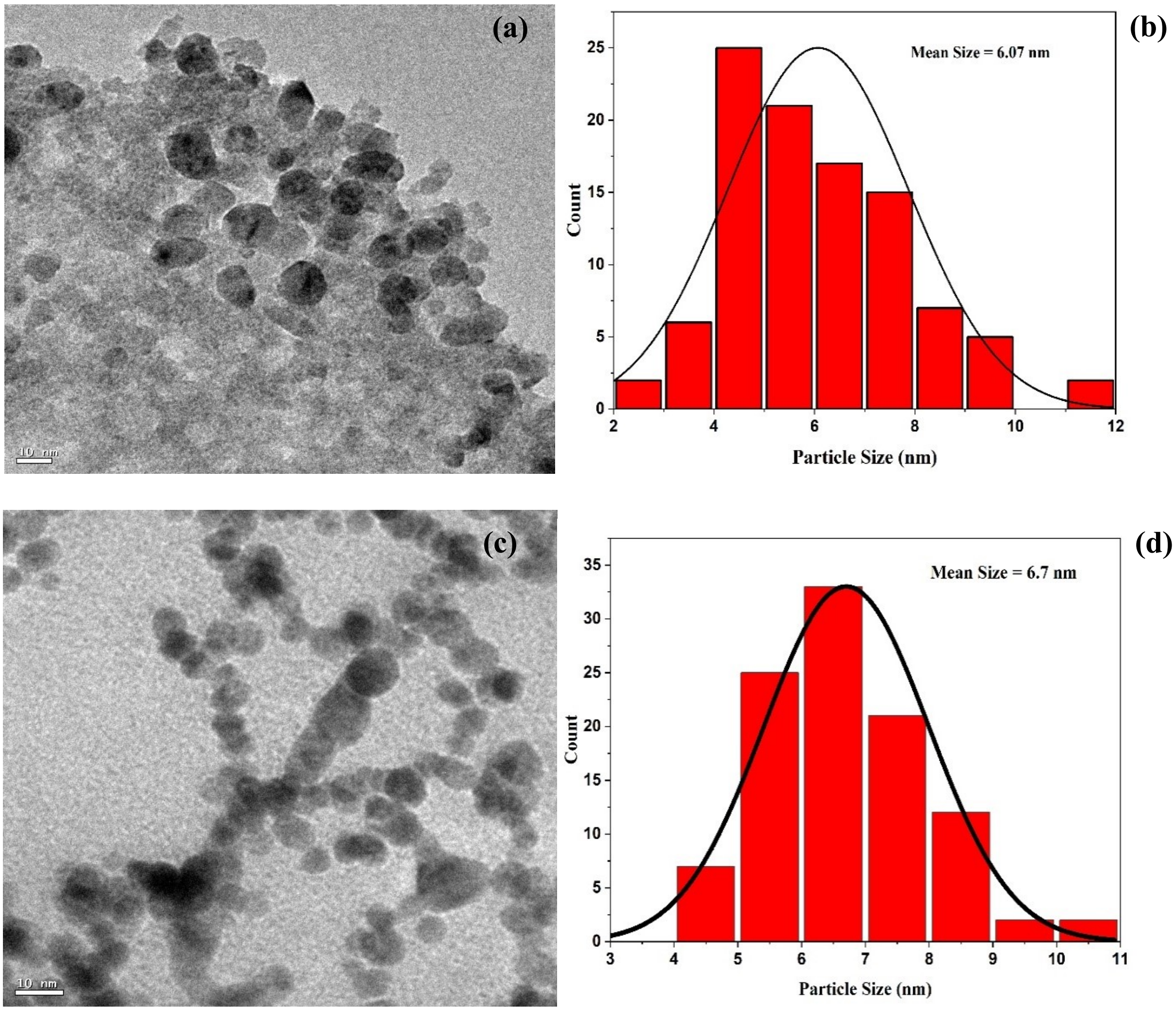


Fig. S3. (a) TEM image, and (b) Size distribution of synthesised AgNPs; (c) TEM image, and (b) Size distribution of synthesised AuNPs.

2. Sensitivity and Interference analysis

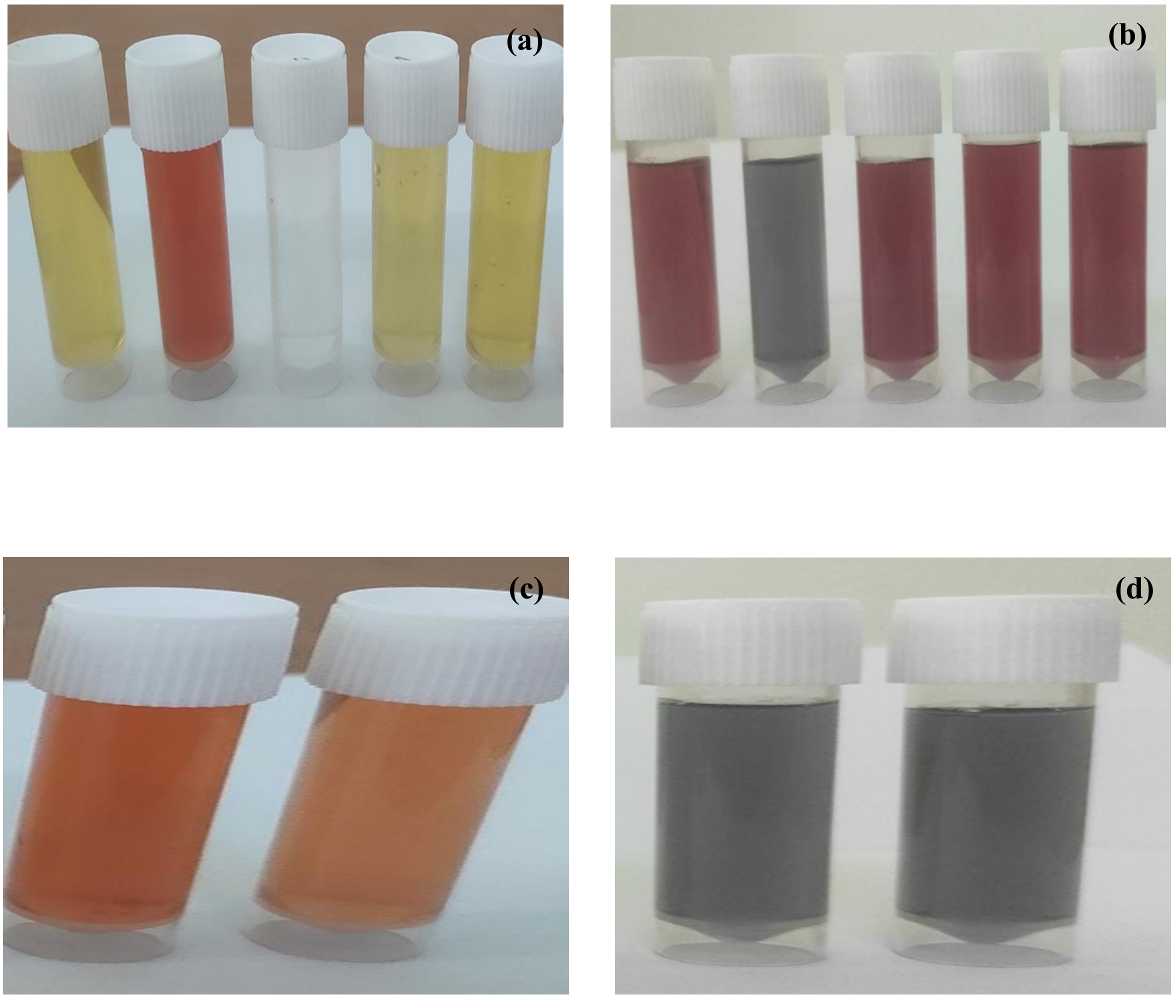
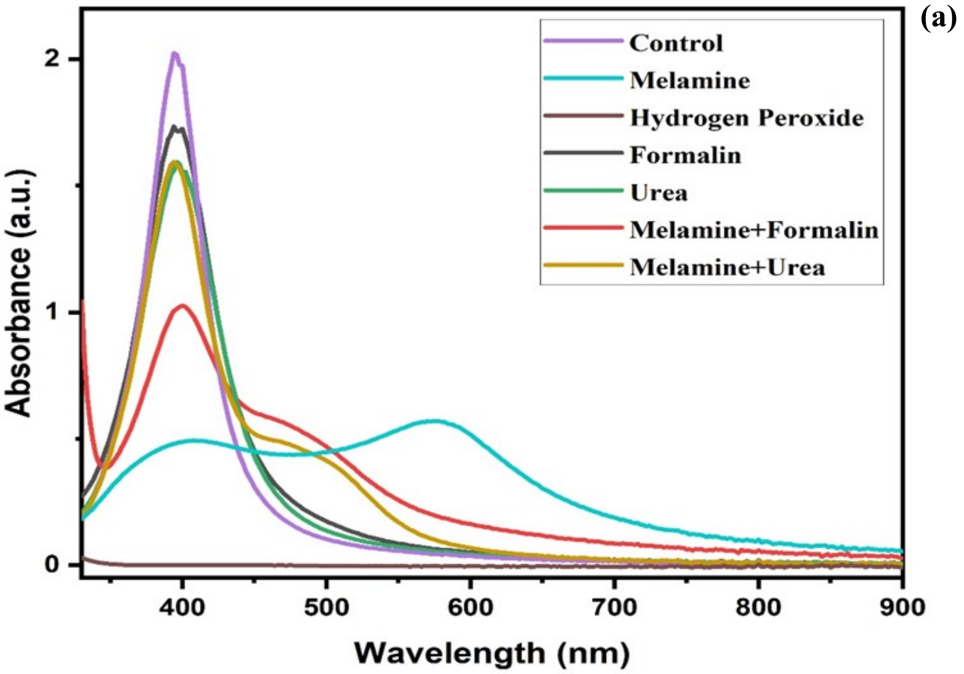


Fig. S4. Colorimetric response of (a) Citrate-capped silver nanoparticles in Control, Melamine, Hydrogen Peroxide, Formalin, and Urea, (b) Citrate-capped gold nanoparticles in Control, Melamine, Hydrogen Peroxide, Formalin, and Urea, (c) Citrate-capped silver nanoparticles in Melamine + Formalin, and Melamine + Urea, (d) Citrate-capped gold nanoparticles in Melamine + Formalin, and Melamine + Urea.



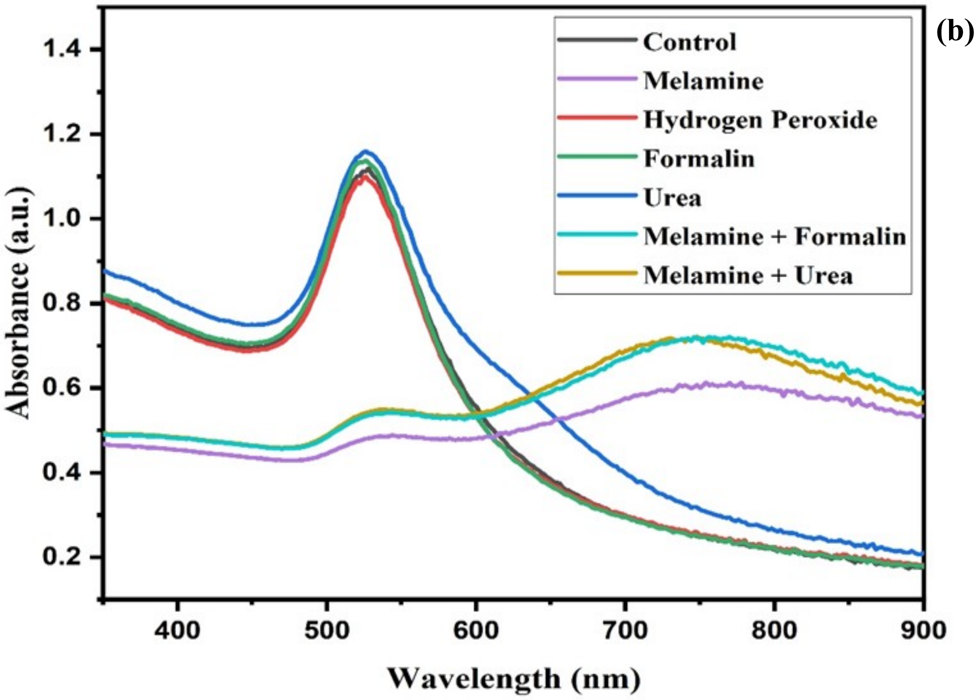


Fig. S5. UV-Vis study of (a) Citrate-capped silver nanoparticles in presence of Control, Melamine, Hydrogen Peroxide, Formalin, Urea, Melamine + Formalin, and Melamine + Urea, and (b) UV-Vis Study of Citrate-capped gold nanoparticles in presence of Control, Melamine, Hydrogen Peroxide, Formalin, Urea, Melamine + Formalin, and Melamine + Urea.

3. Calibration of the device

The amount of light transmitted to the sensor is dependent on the absorbance of light within the sample. The absorbance increases with increase in concentration of nanoparticles and consequently the amount of transmitted light decreases. This is given by the Beer-Lambert law which states that the concentration of an absorbing material in a solution determines the absorbance or absorptive capacity of the solution. If A is the absorbance of the solution, l is the optical path length and c is the concentration of the absorbing material, then mathematically $A= \varepsilon lc$, where ε is a constant termed as the molar extinction coefficient. If we consider l to be constant along with ε, then the absorbance of light by the sample will be directly proportional to the concentration of the nanoparticles.

3.1. Calibration (LDR Based Setup)

With increase in concentration of nanoparticles in the sample, absorbance increases, which results in decrease of transmittance. This decrease in transmittance results in increase in resistance of the LDR as well as increase in voltage drop across it, this indicates that the sensor output must vary directly with the concentration of nanoparticles. For calibration purpose, the transmitted light intensity falling on the sensor was analysed for varying concentrations of AuNPs and AgNPs. From the UV-Vis absorbance spectrum of the citrate capped nanoparticles shown in fig. 1 the surface plasmon peak for the AuNPs is obtained at 530 nm and for the Ag NPs at 390 nm. Therefore, green LASER source was used for the AuNPs while blue LASER source was used for the AgNPs. The sensor output variation for increasing nanoparticle concentration is shown in (Fig. S6).

(a)

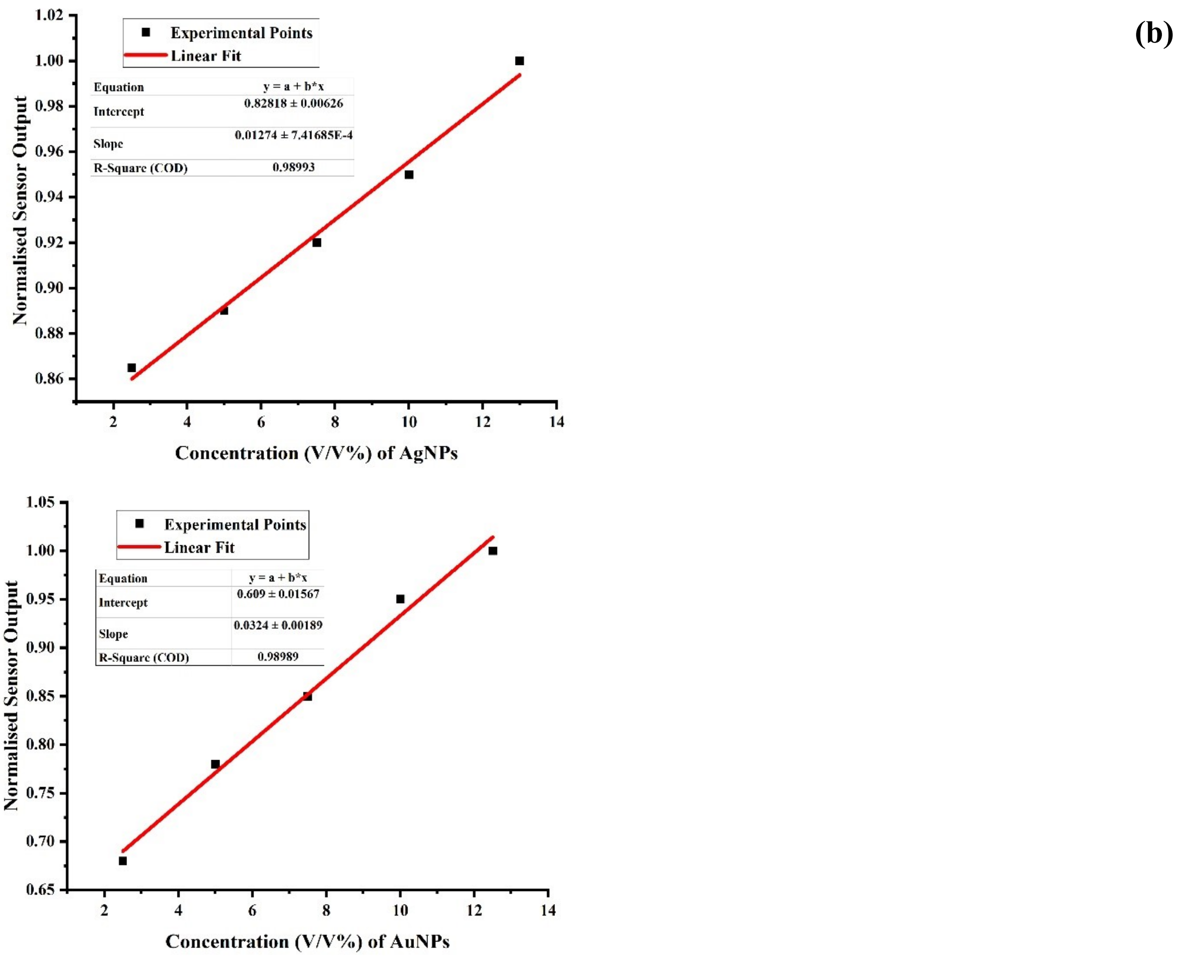


Fig. S6. Sensor output (LDR) vs. concentration of (a) AgNPs and (b) AuNPs (in V/V%).

3.2. Calibration (Ambient Light sensor Based Setup)

This sensor works reversely, when the intensity of transmitted light which falls on the sensor decreases, its output also decreases. As transmittance is inversely proportional to absorbance thus, as absorbance increases with increase in concentration of nanoparticles, output decreases. This indicates that the sensor output must vary inversely with the concentration of nanoparticles. For calibration purpose, the transmitted light intensity falling on the sensor was analysed for varying concentrations of AuNPs and AgNPs. As analysed from the UV-Vis absorbance spectrum of the citrate capped nanoparticles shown in fig. 1 the surface plasmon peak for the AuNPs is obtained at 530 nm and for the AgNPs at 390 nm. Therefore, green LED source was used for the AuNPs while blue LED source was used for the AgNPs. But it was observed that for green LED no linear correlation was observed between concentration of nanoparticles and sensor output in case of AuNPs while blue LED could display a linear variation of sensor output with respect to change in concentration of nanoparticles. This suggests that this sensor could only be used for detecting melamine by use of silver nanoparticles only by using LEDs as the light source. The sensor output variation for increasing silver nanoparticle concentration is shown in (Fig. S7).

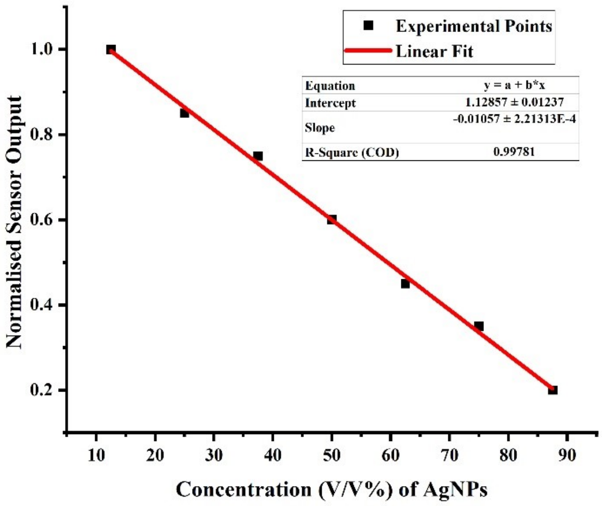


Fig. S7. Sensor output (ALS) vs. concentration of (a) AgNPs (b) AuNPs (in V/V%).