

Electronic Supplementary Information

Gold Nanostructures for Sensing of pH in a Smartphone

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S1. XRD pattern of the gold seed S0 and S1 specimens together.

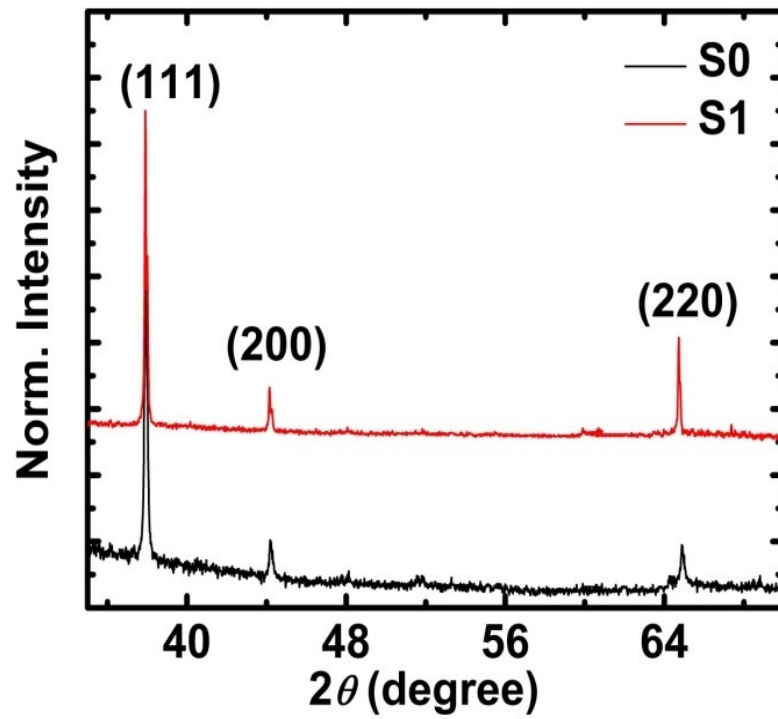


Figure.S1 XRD pattern of the gold seed S0 and (d) S1 specimens.

S2. Absorption spectra of the specimens S1, S2, S3 and S4 at different pH environment.

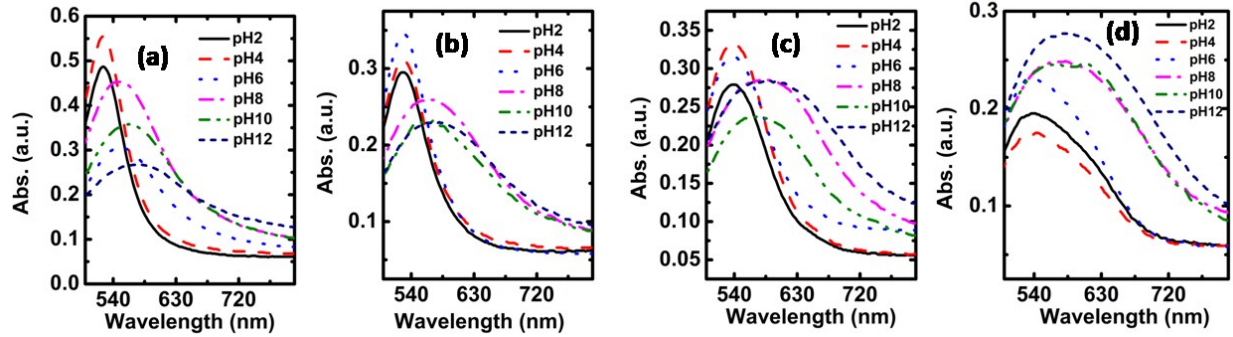


Figure S2. Absorption spectra of the specimens S1, S2, S3 and S4, respectively at different pH environment.

S3. A brief discussion on how to evaluate Euclidean distance between the two colors points (ΔE) from the digital picture of the specimen taken at different pH environment.

We have discussed here briefly the procedure to find out Euclidean distance between the two colors points (ΔE) of the digital picture of the synthesized specimens when dispersed in different pH solutions. However we have given only the results of the specimen S1 in three different pH values. In Table S1 we have provided the RGB values of the color points as captured by the Android application. Digital picture has been captured in identical environment and the RGB values are taken at identical position of the digital pictures.

Table S1. The RGB values as captured by the Android apps for the specimen S1 in different pH environment.

pH values	R	G	B
2	195	151	178
4	184	130	166
6	179	136	163
8	171	148	166
10	153	139	156
12	171	163	178

Now, at pH=2

$$R/X_n = 195/95.02 = 2.05$$

$$G/Y_n = 151/100 = 1.51$$

$$B/Z_n = 178/108.82 = 1.63$$

Using the above values L^* , a^* and b^* can be calculated using the relation 5(a), (b) and (c), respectively.

$$L^* = 116(1.51)^{1/3} - 16 = 117.08$$

$$a^* = 500((2.05)^{1/3} - (1.51)^{1/3}) = 65$$

$$b^* = 200((1.51)^{1/3} - (1.63)^{1/3}) = -6$$

In similar fashion we have calculated the values of L^* , a^* and b^* at pH value 4 and the obtained values are -6.48, 10 and -6, respectively. So the Euclidean distance between the two colors points (ΔE) can be calculated using Eq. 1d and is found to be 13.34.

S4. Technical details of the development of the Android application

An android application is developed to detect the pH of a specimen by detecting the RGB values of the color detected from the specimen. It is written in JAVA using the Android Framework and we have used the tools Android Studio and JAVA. On launching the application screen will appear and it has been depicted below in Figure S3. Here, we can either take a photo of the specimen through camera or pick a photo from the gallery. Then we have to touch on the image

and place the green marker on the region whose RGB (red, green, blue) value we want to detect. Then press the proceed button to move to the programs entry screen.

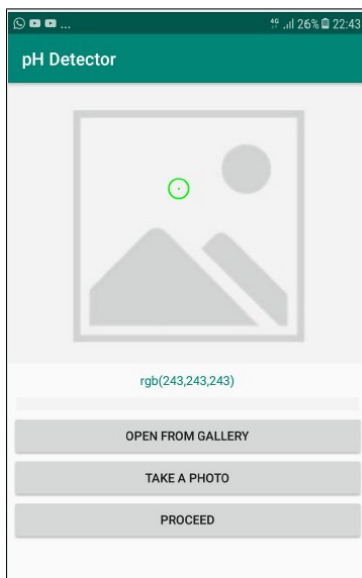


Figure. S3. A screen shot of the first screen of the Android application to detect the pH value from color point

In programs entry screen shown in Figure S4, we have to enter the parameters that are required to calculate the pH from the specimen. The parameters that are required to be entered are:

1. X_n
2. Y_n
3. Z_n
4. Lo^*
5. Ao^*
6. Bo^*

Also, we can enter the value of slope (m) and intercept (c) to use the user supplied graph. Then press the Proceed button to get the pH value.

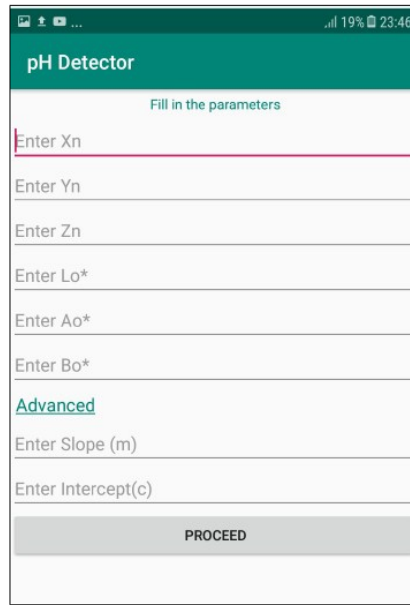


Figure. S4. A screen shot of the second screen of the Android application to detect the pH value from color point

All the data from the frontend is sent to the pH Detector.java class. Then the values of L^* , A^* , B^* are being calculated through these formulas,

$$L^* = 116 * \sqrt[3]{y/yn}$$

$$A^* = 500 * \sqrt[3]{x/xn} - \sqrt[3]{y/yn}$$

$$B^* = 200 * \sqrt[3]{y/yn} - \sqrt[3]{z/zn}$$

Then the value of ΔE is calculated from the values of L^* , A^* , B^* through this formula,

$$\Delta L = L_0^* - L^*$$

$$\Delta A = A_0^* - A^*$$

$$\Delta B = B_0^* - B^*$$

$$\Delta E = \sqrt{(\Delta L)^2 + (\Delta A)^2 + (\Delta B)^2}$$

Hence we get ΔE from here. These are implemented as two functions in codebase to find out the values of L^* , A^* , B^* and the value of ΔE , respectively.

We define two arrays X and Y. RGB Values given: (195, 151, 178), (184, 130, 166), (179, 136, 163), (171, 148, 166), (153, 139, 156), (171, 163, 178)

The pH values recorded on the basis of the RGB Values are:

[2.0, 4.0, 6.0, 8.0, 10.0, 12.0]-Array Y

Now, for each of these RGB values we find out the ΔE and append it to the Array X.

Then we plot the graph between x and y, find the best fit line through it using Linear Regression. Linear Regression is being implemented in the Linear Regression Classifier java class in codebase.

The equation is of the form $pH = m(\Delta E) + c$

After this, we take the inputs and find the ΔE and using the best fit line and this ΔE we get the pH. In case when, the equation of the line is also supplied we just put the value of the calculated ΔE in the equation and get the value of pH.

The third screen depicted in Figure S5 shows the pH value of the specimen from the color that was detected from the selected region of the image.

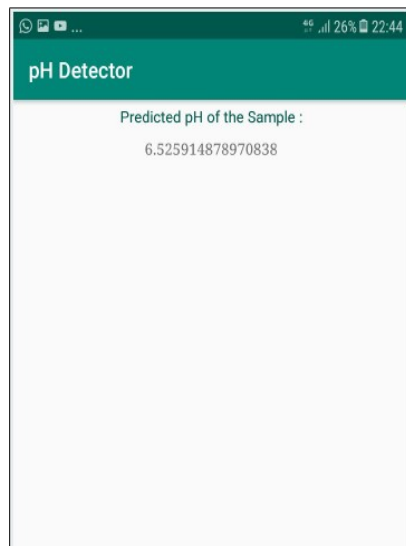


Figure. S5. A screen shot of the second screen of the Android application to detect the pH value from color point

S5. Trisimulus values for S4 in different pH environment in the chromaticity diagram.

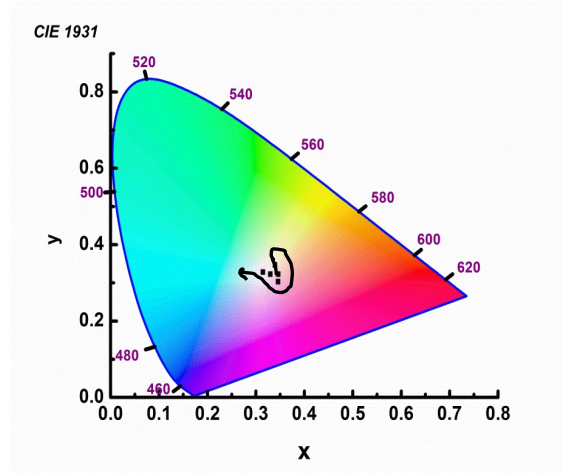


Figure. S6. Show the trisimulus values for S4 in different pH environment in the chromaticity diagram.

S6. Digital photograph of the specimen when dispersed in a solution of unknown pH and absorption spectra of the specimens in solution of unknown pH.

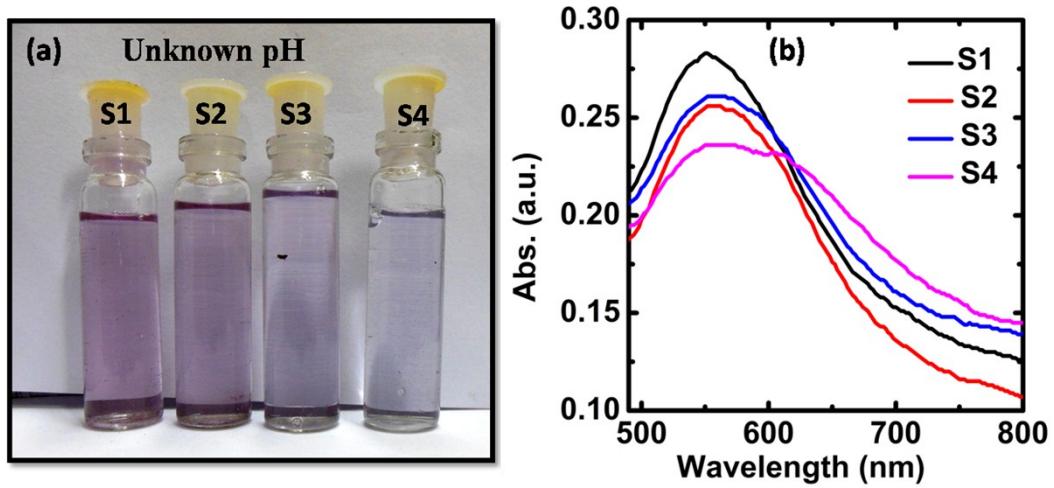


Figure. S7.(a) Digital photograph of the specimens when dispersed in a solution of unknown pH.
(b) Absorption spectra of the specimens in solution of unknown pH.

S7. PL emission spectra of Rh-6G ($0.4 \mu\text{M}$) in the presence of S0 to S3 specimens with increasing concentration of GNPs from $0\text{-}12\mu\text{M}$.

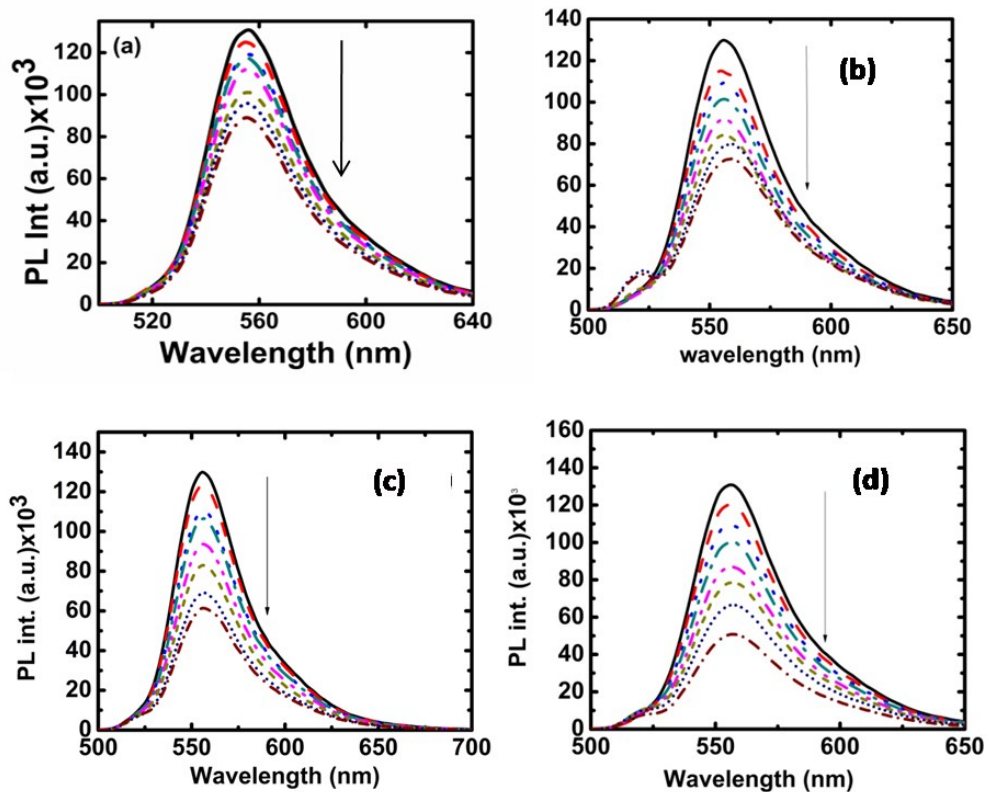


Figure. S8 PL emission spectra of the Rh-6G ($0.4 \mu\text{M}$) in the presence of the specimens S0 to S3 are depicted in (a) to (c), respectively with increasing concentration of GNPs from $0\text{-}12\mu\text{M}$.

S8. Absorption spectra of S1 and S4 for increasing concentration of Rh-6G.

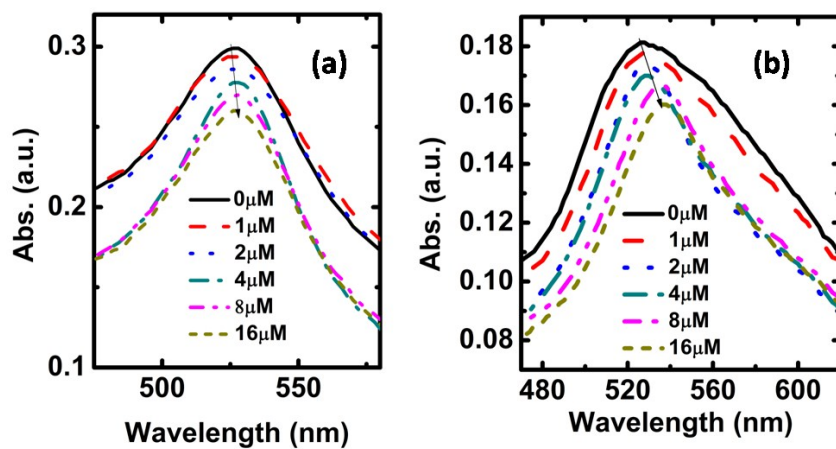


Figure. S9. Absorption spectra of S1 (a) and S4 (b) for increasing concentration of Rh-6G.