Supporting information

Determination of the binding constant

The binding constant of sensor **1** for FA was calculated by using Benesi-Hindebrand equation. From the equation, the graph is plotted between the inverse of anion concentration against inverse of changes in their respective absorbance (1/ΔA vs. 1/[FA]).The equation is given as follows:

$1/\Delta A = 1/ \{Ka (A_0-A_{max}) [FA]\} + 1/(A_0-A_{max})$

A plot of 1/ΔA vs. 1/[FA] gives the linear graph. From the slope of the plot, the K_a value can be determined.

Determination of limit of detection (LOD)

The detection limit for the detection of FA was evaluated by using the following equation: Detection limit = 3σ/K, where σ is standard deviation and was determined by five blank replicate measurements of compounds, K is the slop of absorbance of synthesized compounds versus FA concentration plot.

Calculation for determining LOD values

(1) LOD value calculation of sensor 1 for FA in ACN

$K= 0.023 \times 10^5$

$\sigma = 0.001789$

$LOD = 3\sigma/K$

$= 2.33 \times 10^{-6}$ M

(2) LOD value calculation of sensor 1 for FA in THF

$K= 0.015 \times 10^5$ M

$\sigma = 0.001155$

$LOD = 3\sigma/K$

$= 2.31 \times 10^{-6}$ M

(3) LOD value calculation of FA sensor 2 for FA in ACN

$K= 0.043 \times 10^5$

$\sigma = 0.001414$

$LOD = 3\sigma/K$

$= 9.86 \times 10^{-7}$ M

(4) LOD value calculation of sensor 2 for FA in THF

$K = 0.95\times10^{5}$ M

$\sigma = 0.000577$

LOD $=3\sigma/K$

$= 1.82\times10^{-8}$ M

Determination of Limit of Quantification (LOQ)

Limit of Quantification (LOQ) is the level of quantitative results which may be obtained with a specified degree of confidence. Mathematically, The LOQ is defined as equal to 10 times the standard deviation of the results for a series of replicates used to determine a justifiable limit of detection **[1]**. LOQ can be calculated at levels approximating according the formula: LOQ =10 σ/S, where, σ = Standard deviation of the response based on either the standard deviation of the blank, the residual standard deviation of the regression line or the standard deviation of y= Intercepts of regression lines and S = Slope of the calibration curve.

Hue

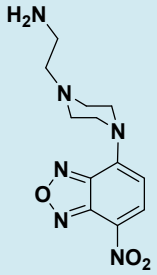
The hue value is calculated for each pixel of the scanning image from the RGB channels. The hue values are calculated by using all the RGB data obtained from inserting the scanning image in software application. Basically,hue is a numerical representation of color**[2]**. The hue value is calculated by using the following equation-

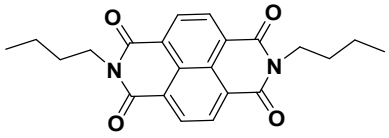
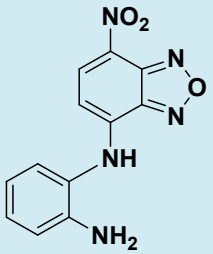
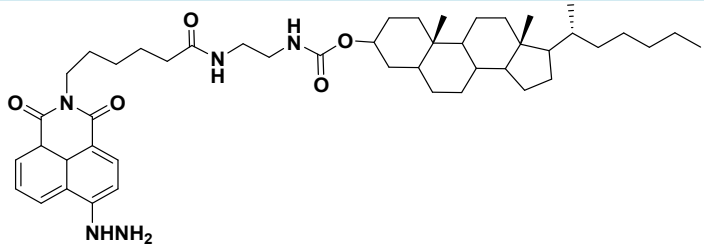
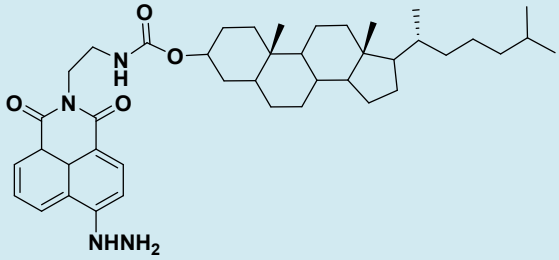
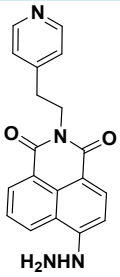
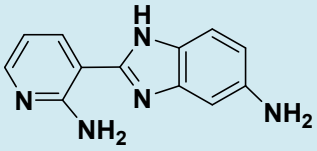
H = (G-B/Max-Min) + 0 / 6; if R is maximum

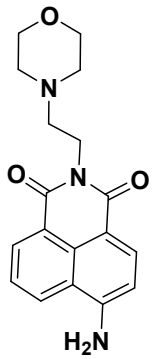
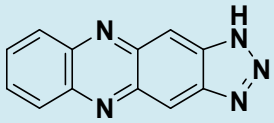
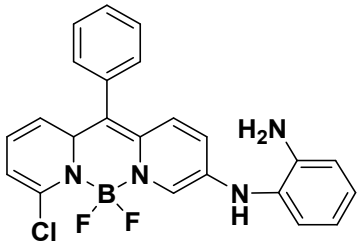
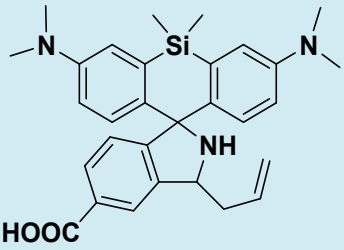
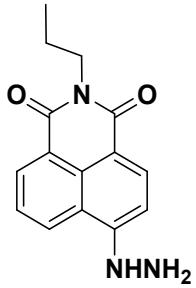
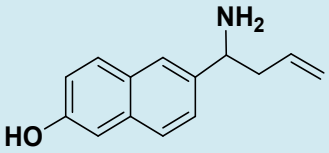
(B-R/ Max-Min) + 2/ 6; if G is maximum

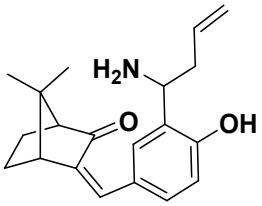
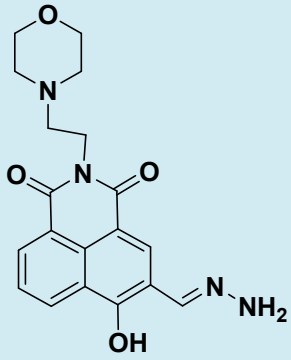
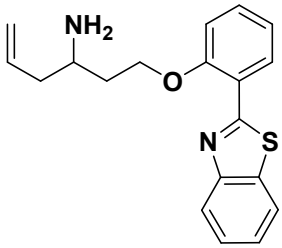
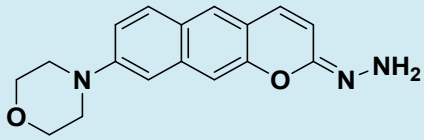
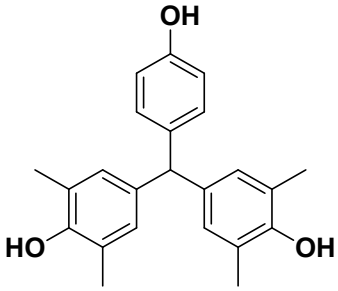
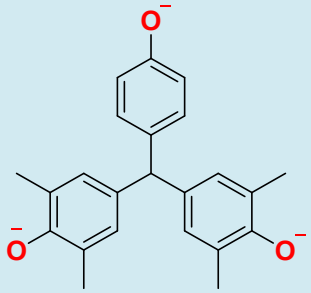
(R-G/ Max-Min) + 4 / 6; if B is maximum

Table S1: List of formaldehyde sensors and their limit of detection value.

Sensor No	Sensing Probes	LOD
S1 [3]		80 nM

S2 **[4]**		1.4 μM
S3 **[5]**		30 μM
S4 **[6]**		66 nM
S5 **[6]**		43 nM
S6 **[7]**		0.3 μM
S7 **[8]**		10 μM

S8 **[9]**		1.77µM
S9 **[10]**		15.54 nM
S10 **[11]**		0.104 µM
S11 **[12]**		5 µM
S12 **[13]**		0.71µM
S13 **[14]**		59.6 µM

S14 **[15]**		2.01 µM
S15 **[16]**		0.95 µM
S16 **[17]**		66 nM
S17 **[18]**		200 µM
1 **[This work]**		2.31 µM
2 **[This Work]**		18.2 nM

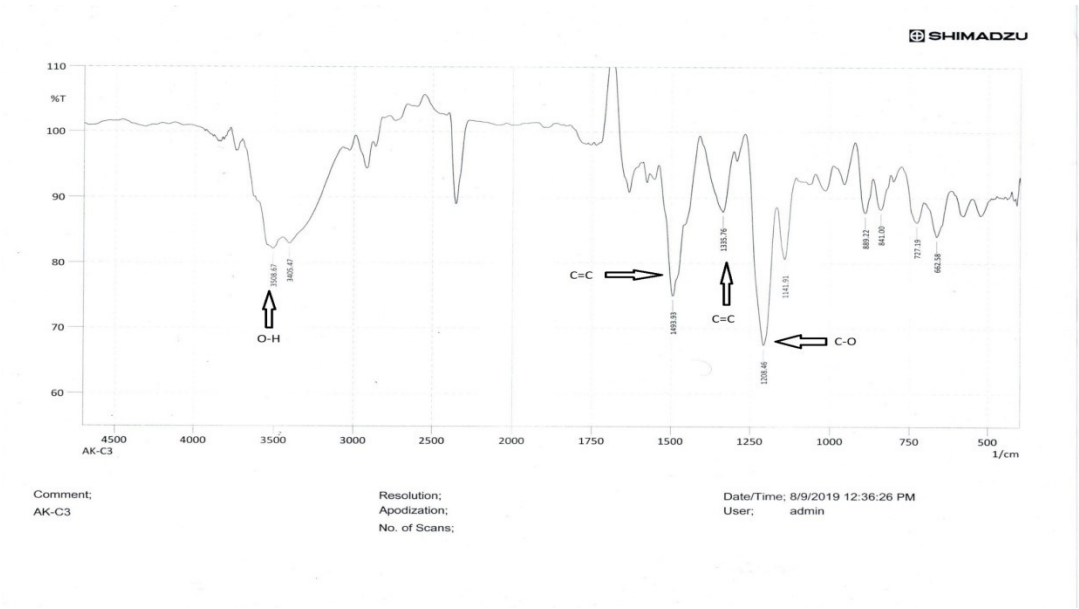


Fig. S1 FTIR spectra of compound **1**.

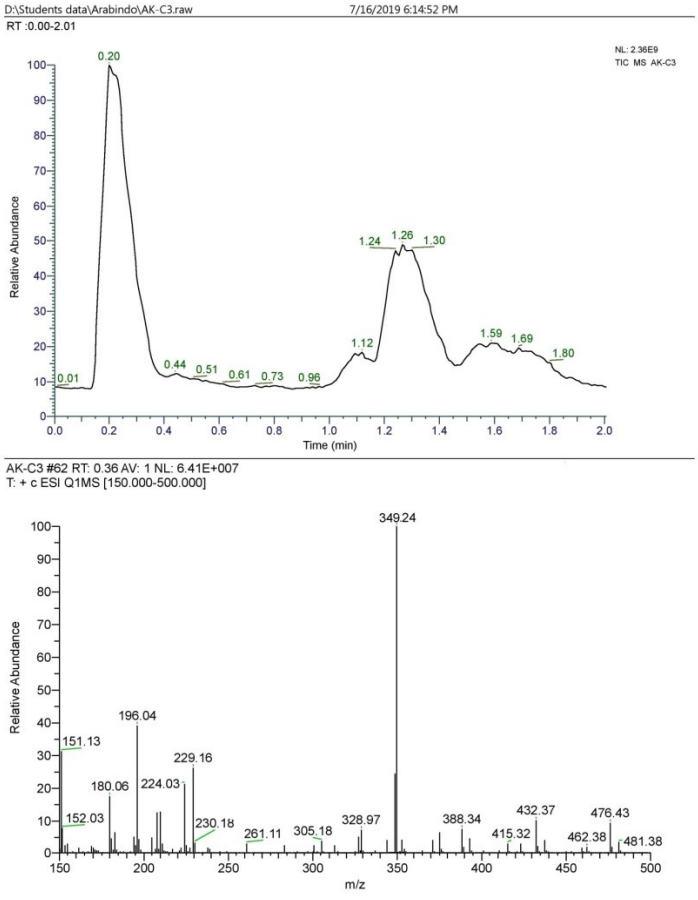


Fig. S2 LC-MS spectra of compound **1**.

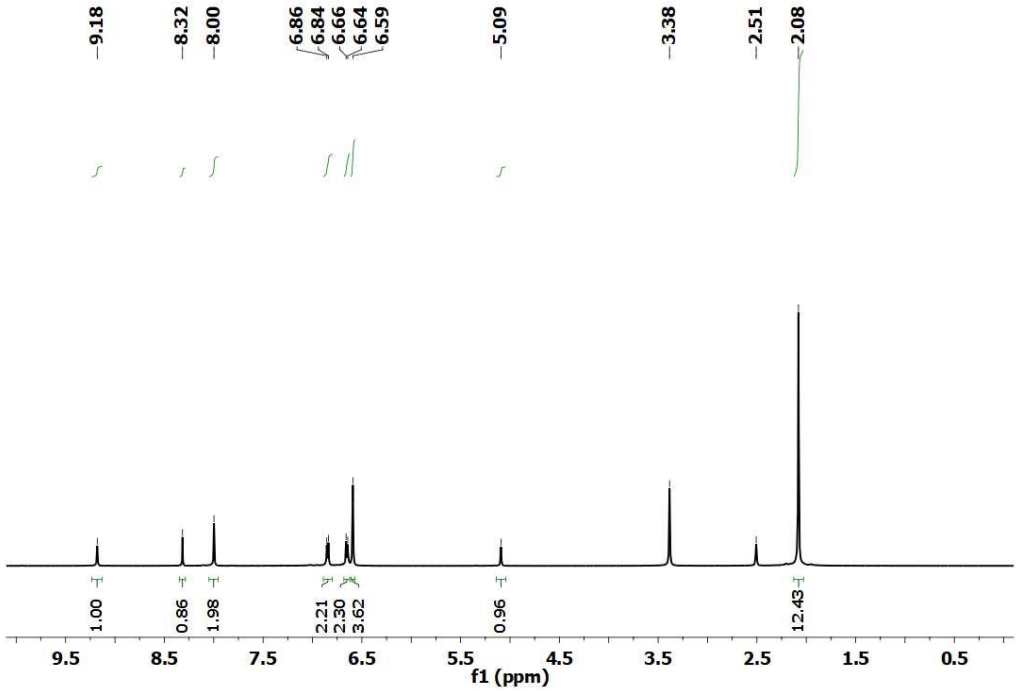


Fig. S3 ^{1}H NMR (500MHz, DMSO-d_6) spectra of compound **1**.

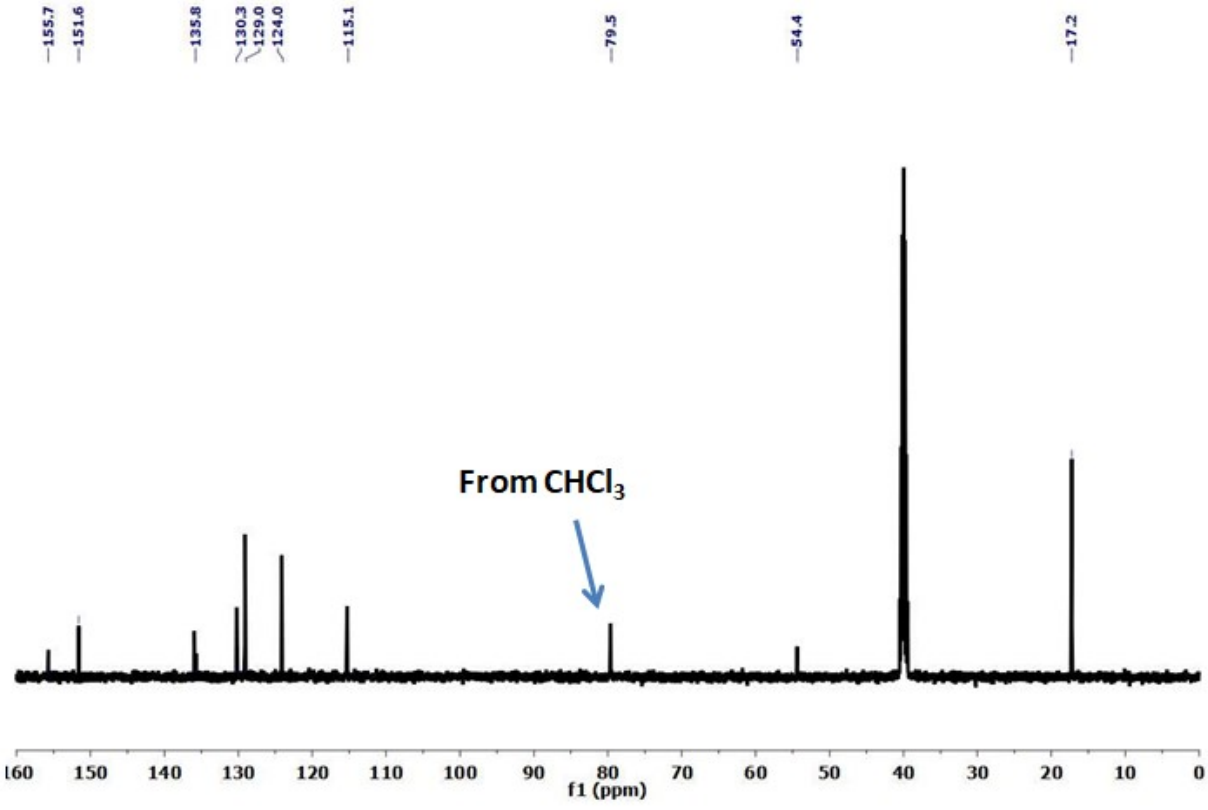
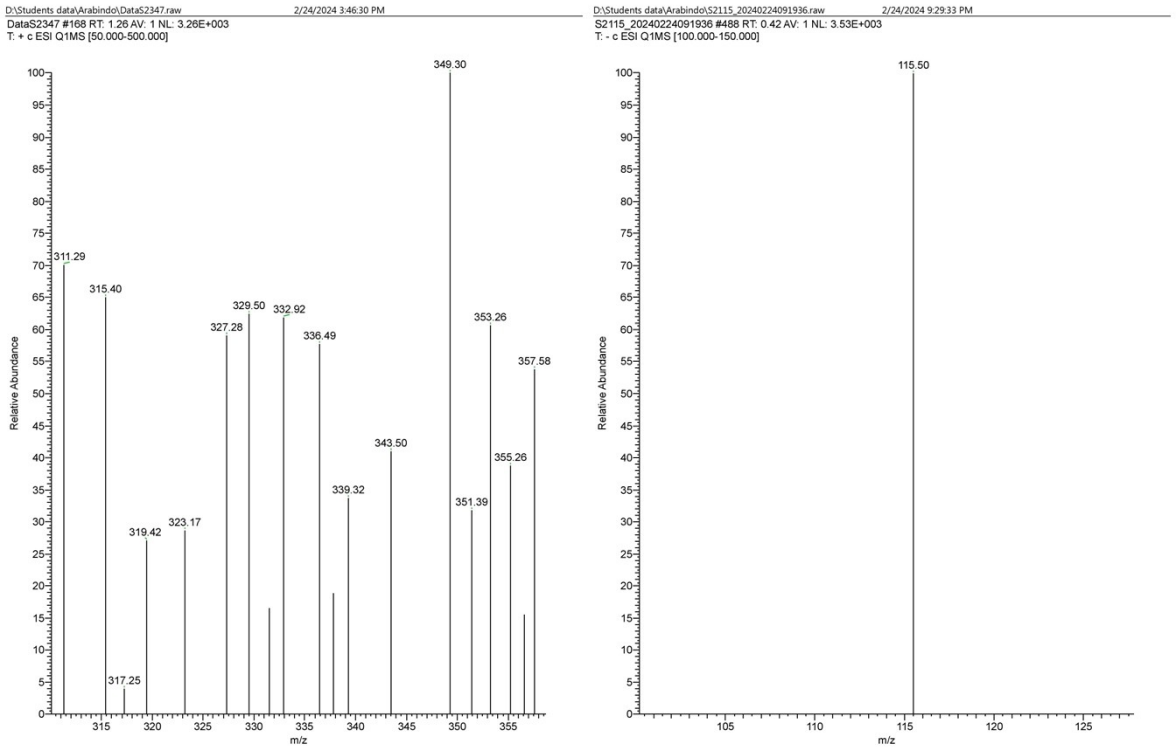


Fig. S4 ^{13}C NMR (126 MHz, DMSO-d_6) spectra of compound **1**.



(a) (b)

Fig. S5 LC-MS spectra of sensor 2 (a) and ESI (+), m/z = 349.30 (b) ESI (-), m/z =115.50

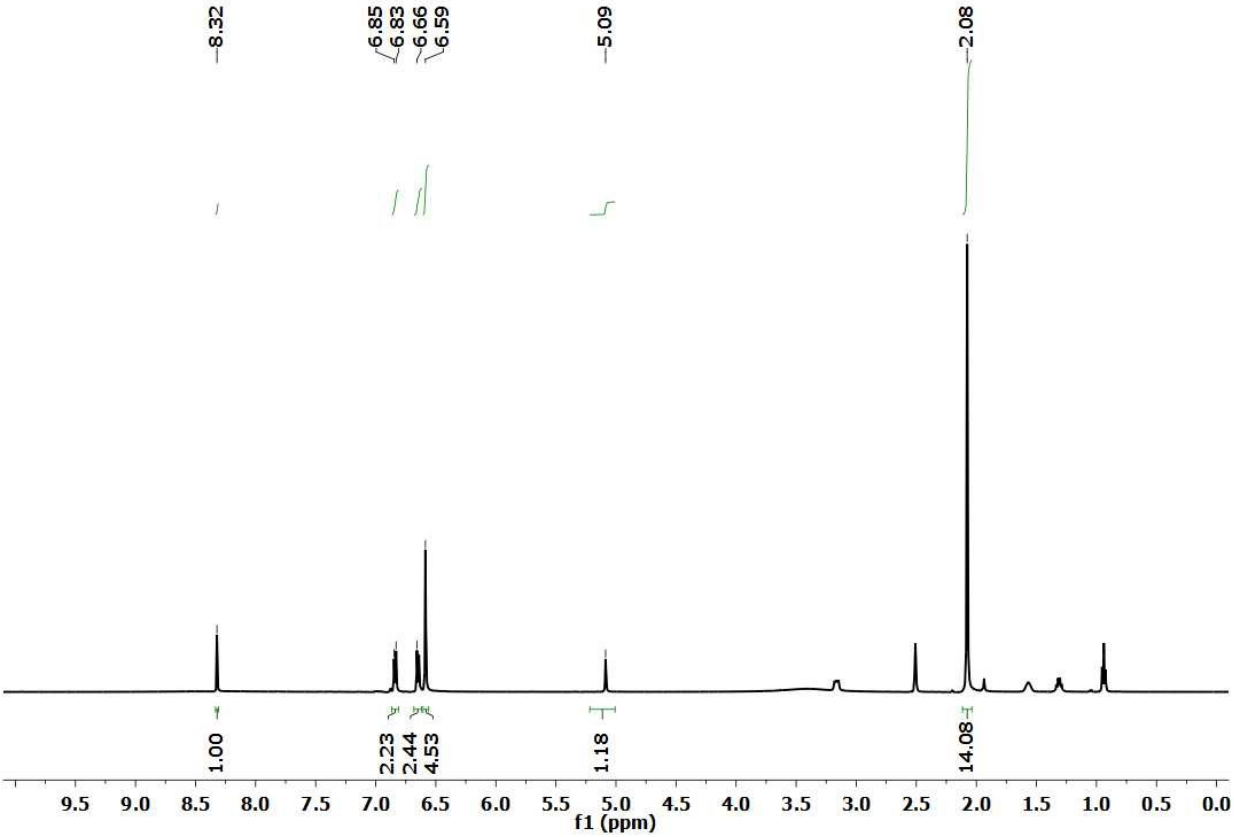


Fig. S6 ^{1}H NMR (500MHz, DMSO-d_6) spectra of compound **2**.

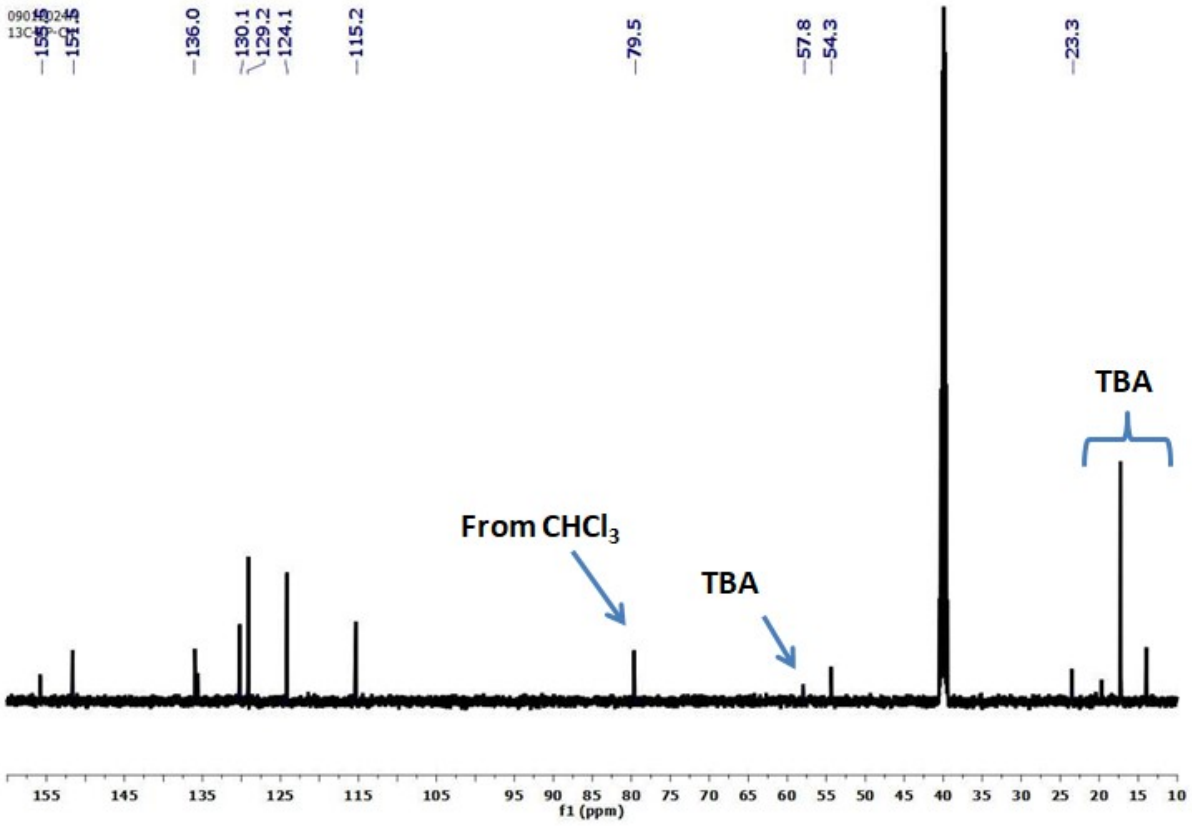


Fig. S7 ^{13}C NMR (126 MHz, DMSO-d_6) spectra of compound **2**.

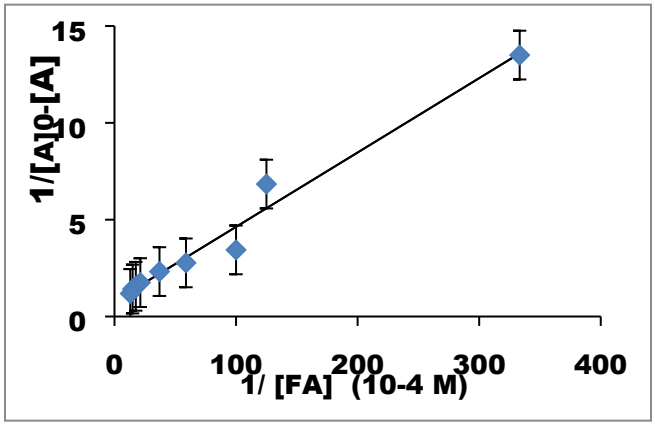


Fig. S8 Binding constant plot of **1** with FA.

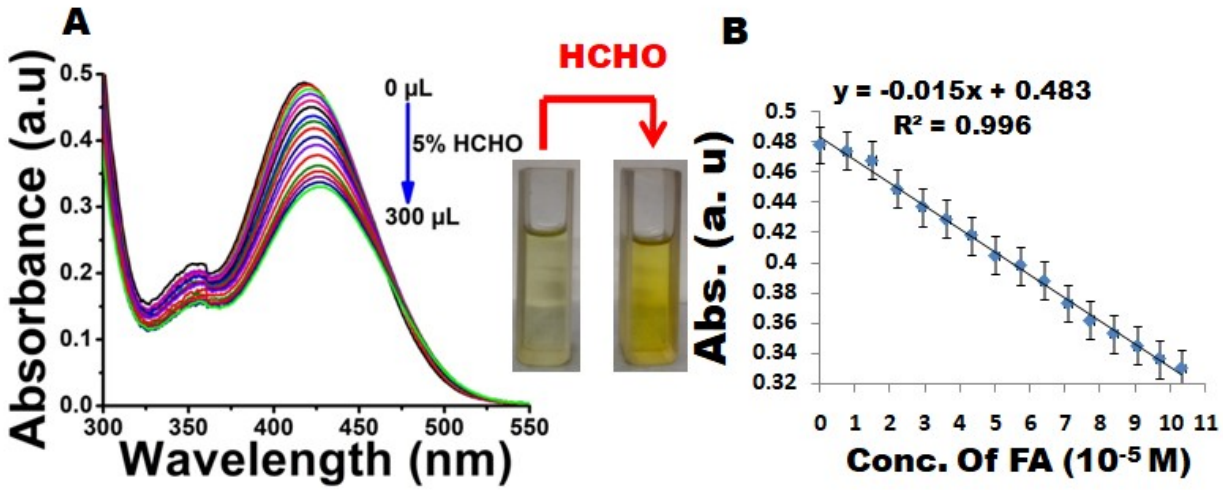


Fig. S9 (A) Absorption of **1** (10^{-4}M in THF) upon aliquot addition of 5% (V/V) FA solution in THF; (B) LOD plot of **1** (10^{-4} M in THF) on addition of 5% (V/V) FA in THF.

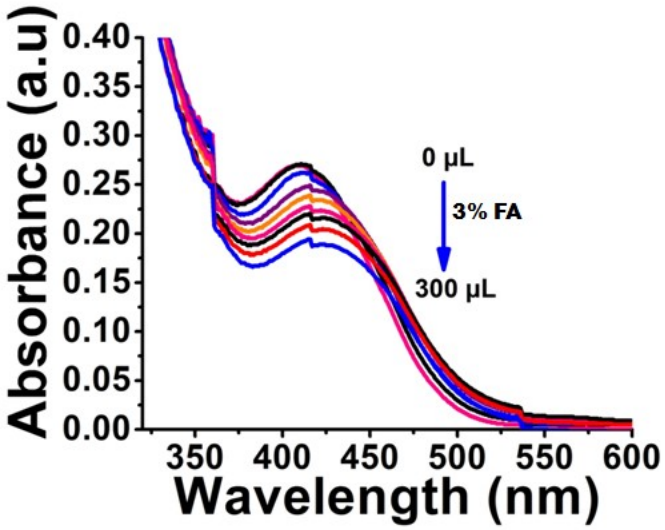


Fig. S10: Absorption spectra of **1** (10^{-4}M in THF) upon aliquot addition of 5% (V/V) FA solution in ethyl acetate

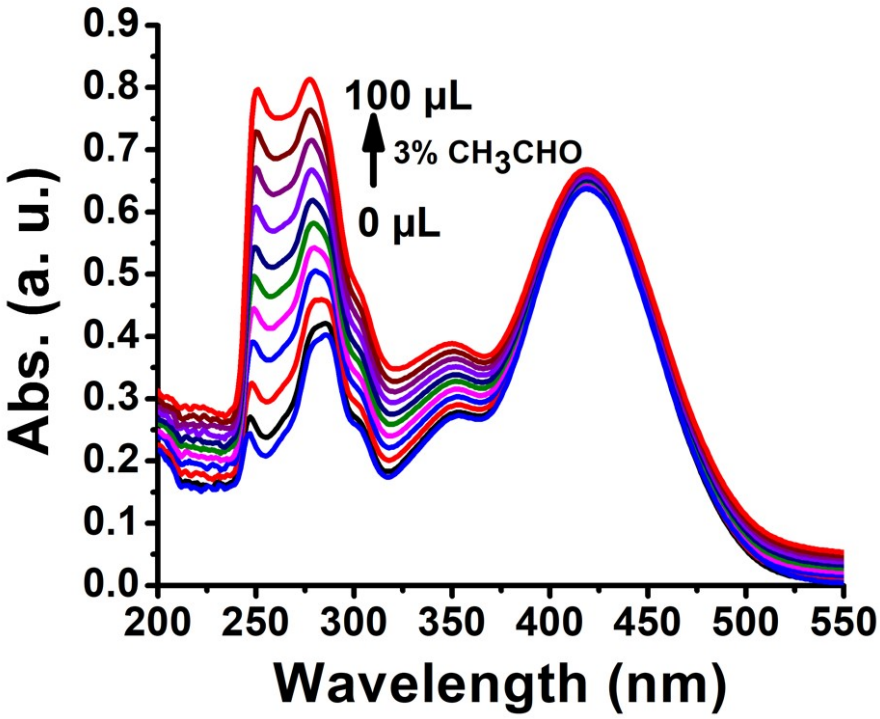


Fig. S11: Absorption spectra of sensor 1 in presence of Acetaldehyde

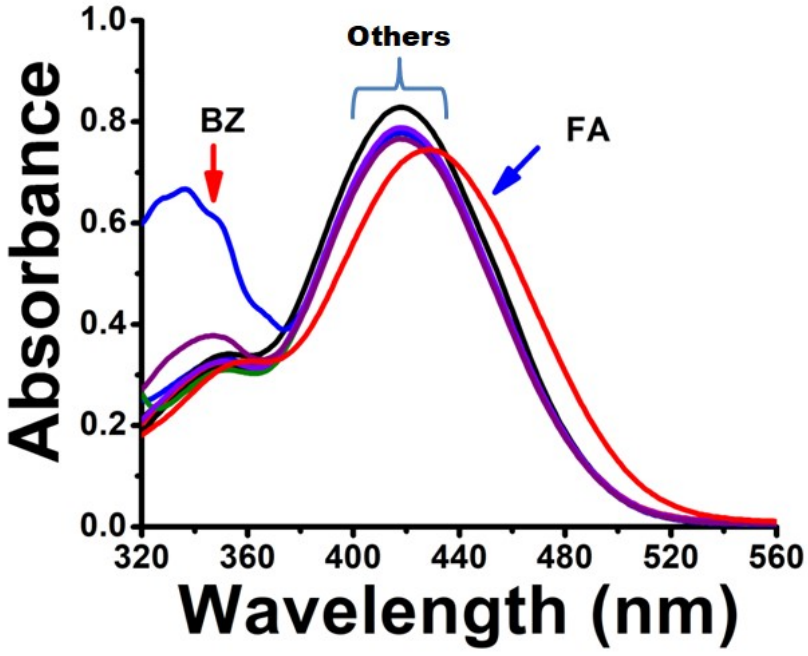


Fig. S12 Absorption spectra of sensor 1 in presence of FA and others

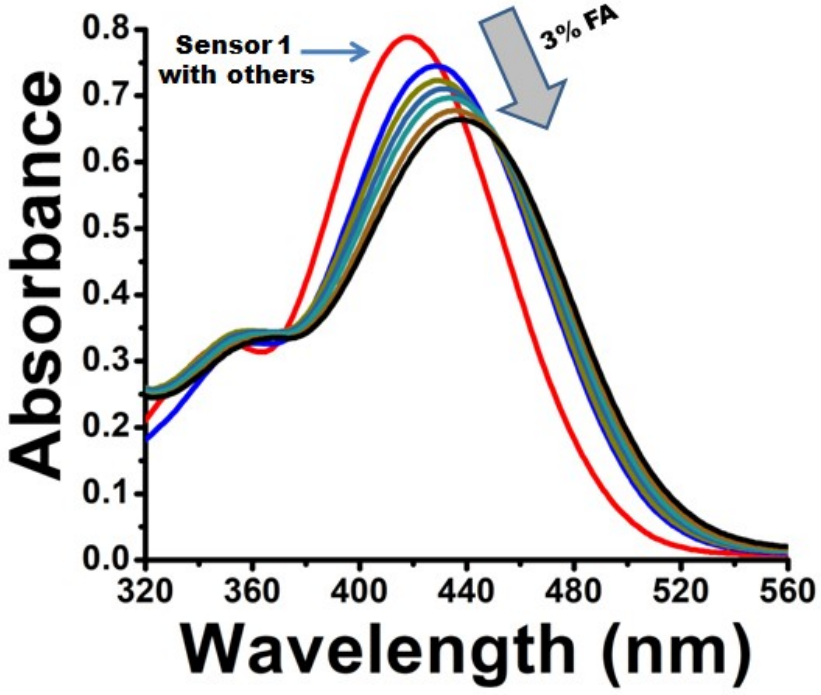


Fig S13 Interference spectra of sensor 1 with FA in the presence of others

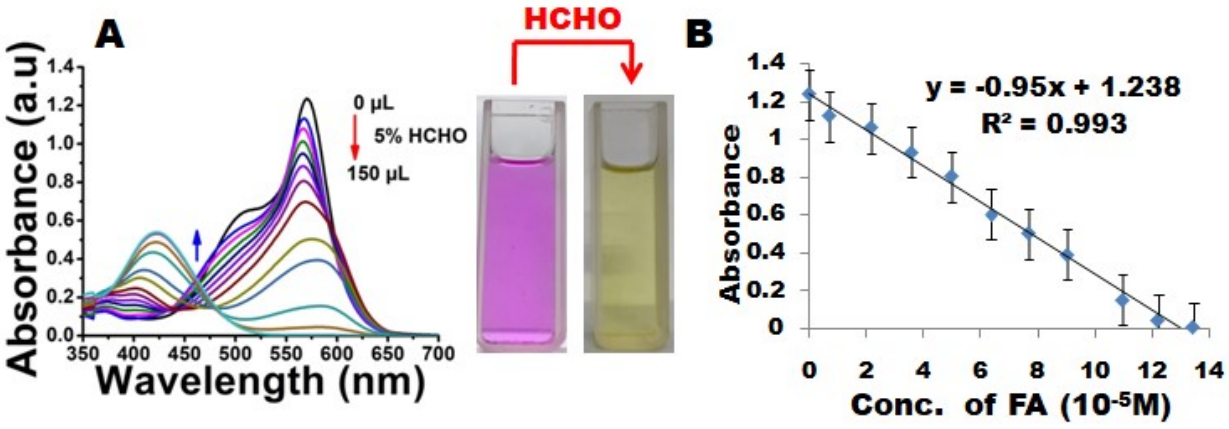
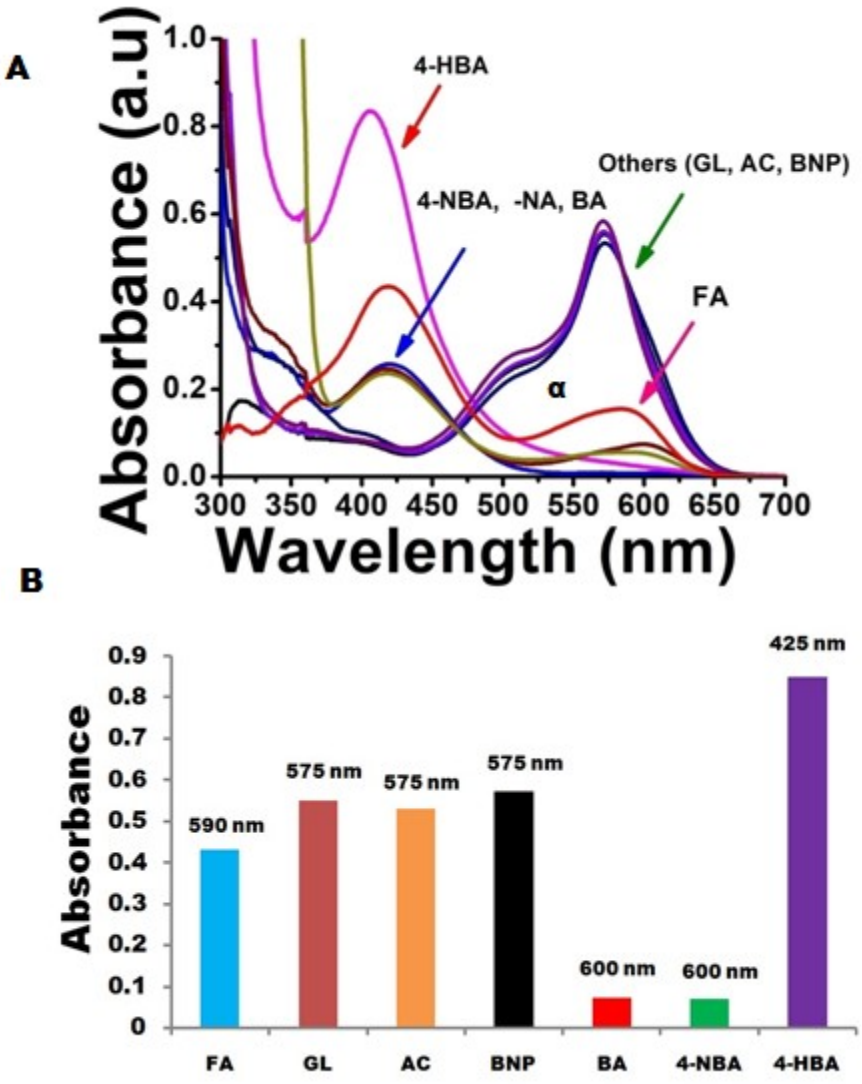


Fig. S14 (A) Absorption of **2** (10^{-4}M in THF) upon aliquot addition of 5% (V/V) FA solution in THF; (B) LOD plot of **2** (10^{-4} M in THF) on addition of 5% (V/V) FA in THF.


A
Absorbance (a.u)
Wavelength (nm)
4-HBA
4-NBA, -NA, BA
Others (GL, AC, BNP)
FA
α
B
Absorbance
590 nm
575 nm
575 nm
575 nm
600 nm
600 nm
425 nm
FA
GL
AC
BNP
BA
4-NBA
4-HBA

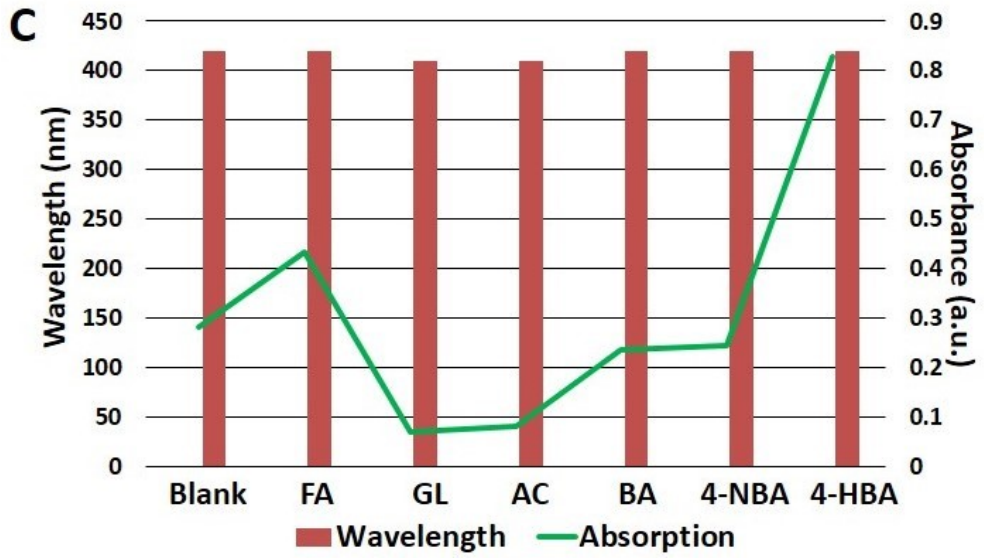


Fig. S15 (A) Absorption of solution of **2** (10^{-4} M in THF) in the presence of 4-HBA, 4-BA, BA, FA, α-NA, GL, AC and BNP. Bar diagram (B) in the wavelength range 500-650 nm (C) in the wavelength range 350-450 nm.

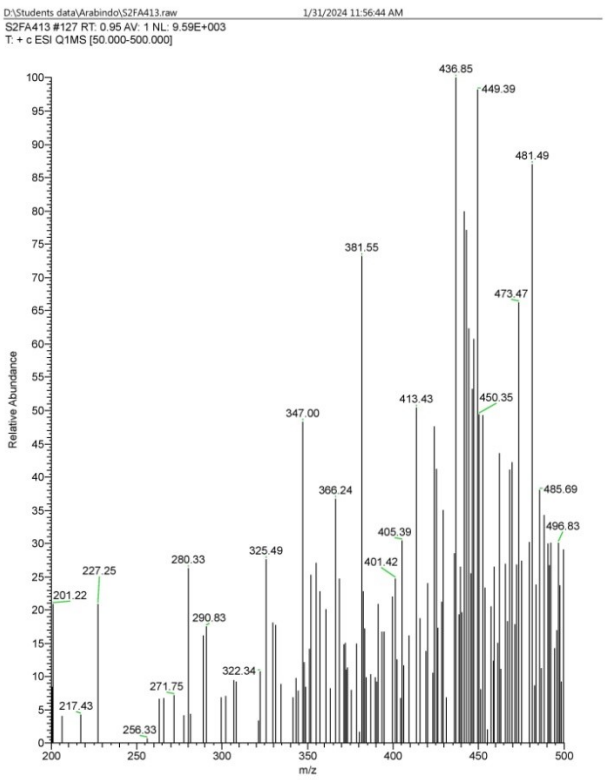


Fig. S16 LC-MS spectra of sensor 2 after adding formaldehyde (1:3 molar ratio), (m + 1) peak: 436.85

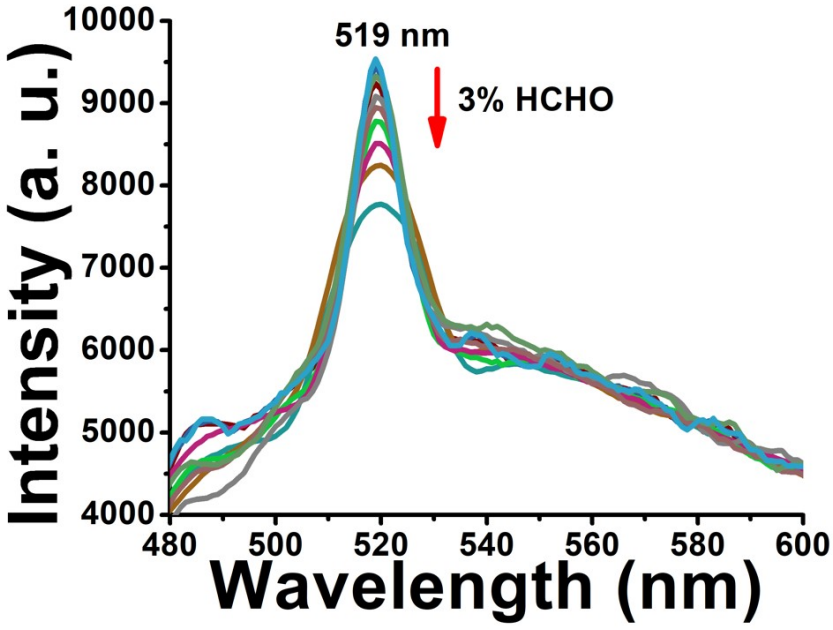


Fig. S17 PL spectra of **1** (10^{-4} M in THF) upon aliquot addition of 3% (V/V) FA solution in THF

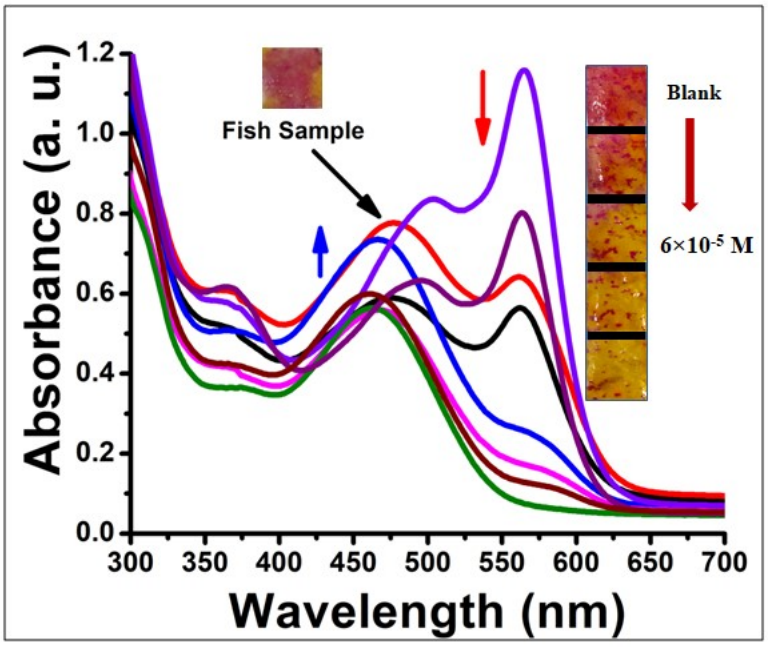


Fig. S18 Solid state absorption spectra of the composite film before and after treatment with FA. (inset: colour of the composite film).

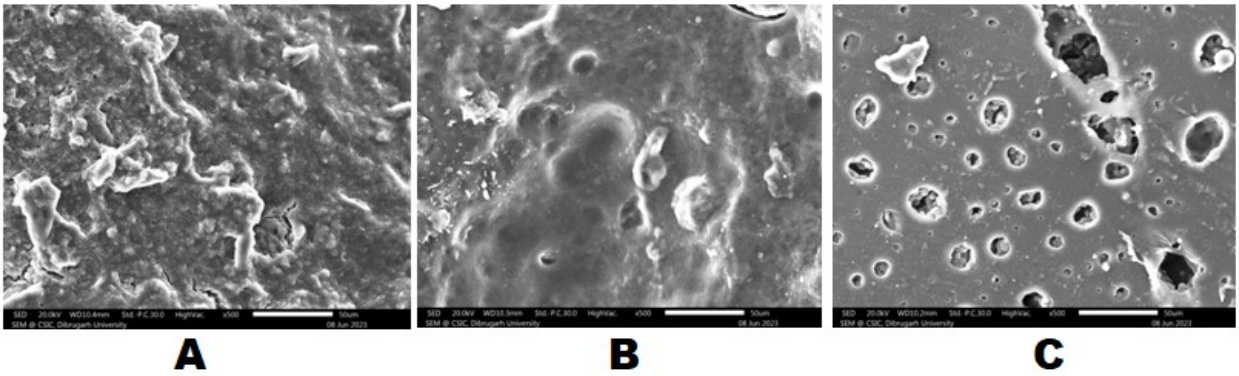


Fig. S19 SEM image (X500 magnification) of (A) **1**@SP, (B) **2**@SP composite films and (C) **2**@SP composite films after treatment with FA solution.

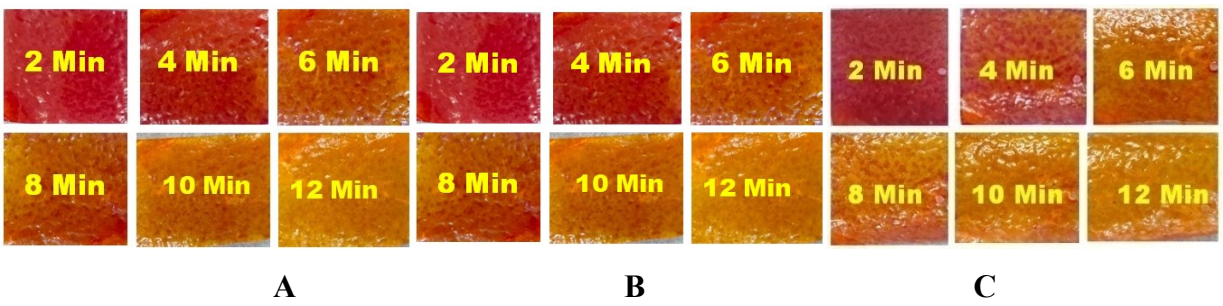


Fig. S20 Changes in colour of **2**@SP composite film with the time of exposure of FA vapour from (A) 1%, (B)2% and (C) 3% (V/V in hexane) solution.

Table S2: The RGB content vs time of exposure of FA vapour from 5 % (V/V in hexane) solution.

Sl No.	Expo. Time (Min.)	Red	Green	Blue
1	2	187.78	10.01	118.27
2	4	168.78	33.25	92.38
3	6	190.28	46.19	11.26
4	8	171.20	57.52	11.17
5	10	188.73	80.94	4.27
6	12	204.89	115.27	1.25

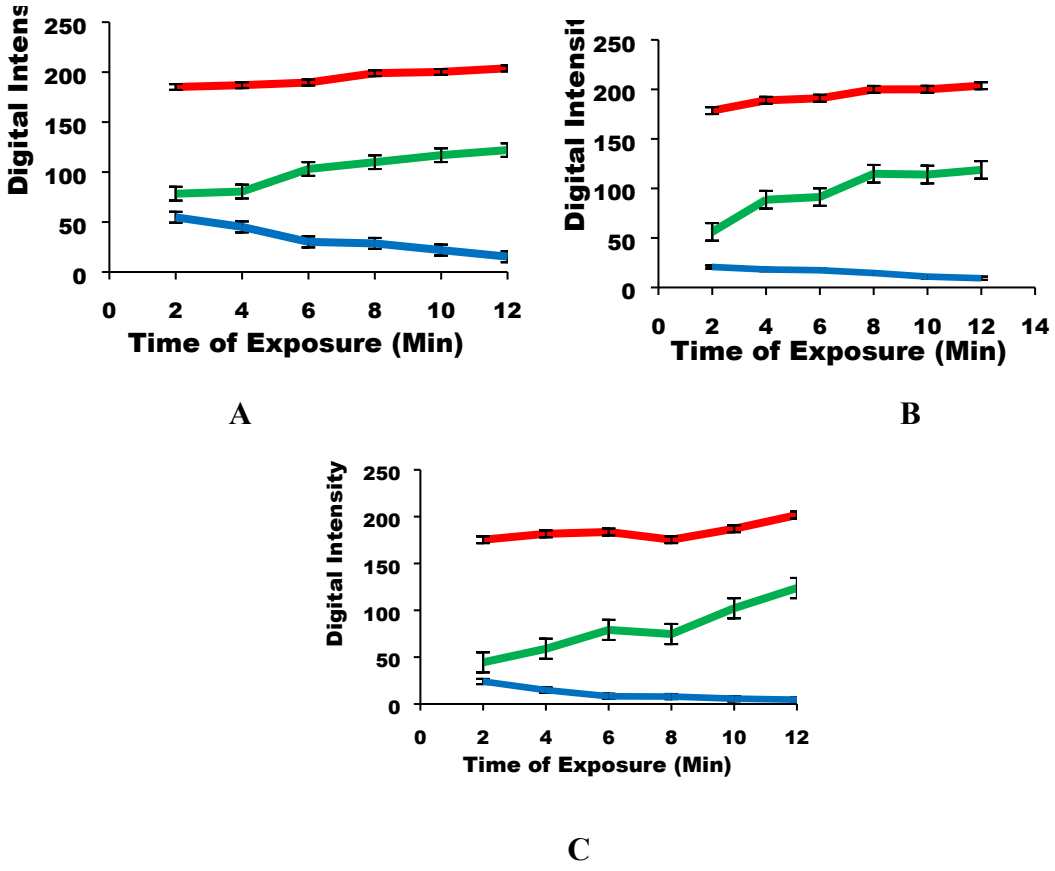


Fig. S21 The of RGB content composite film *vs* time of exposure of FA vapour Linear regression curve (A) 1%, (B)2% and (C) 3% (V/V in hexane) solution.

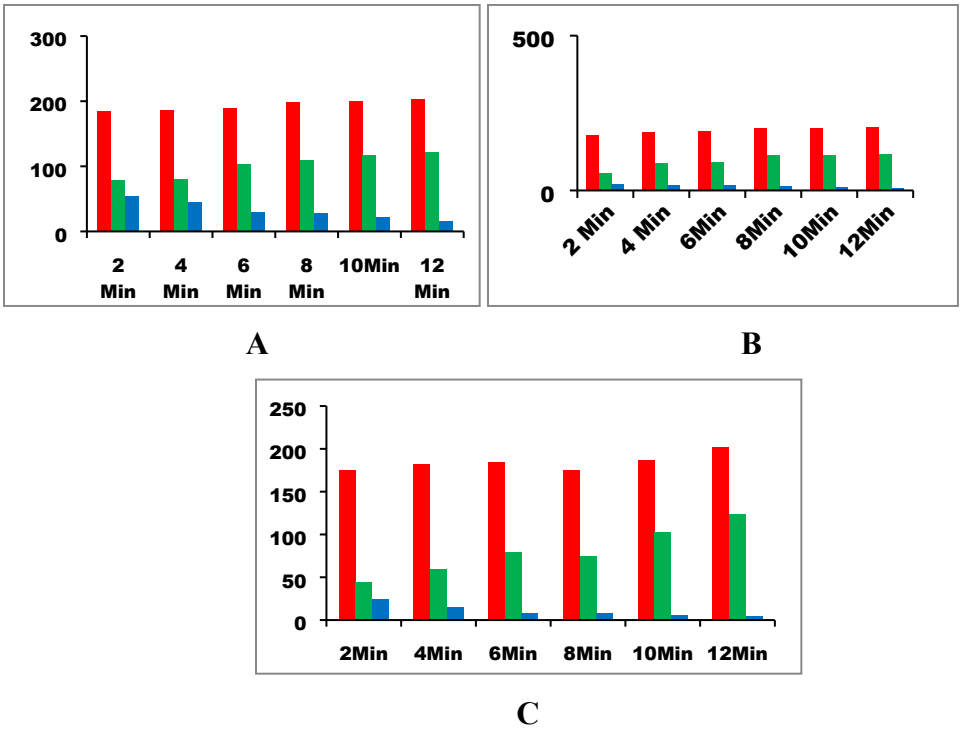


Fig. S22 The bar diagram of RGB content composite film *Vs* time of exposure of FA vapour bar diagram (A) 1%, (B)2% and (C) 3% (V/V in hexane) solution.

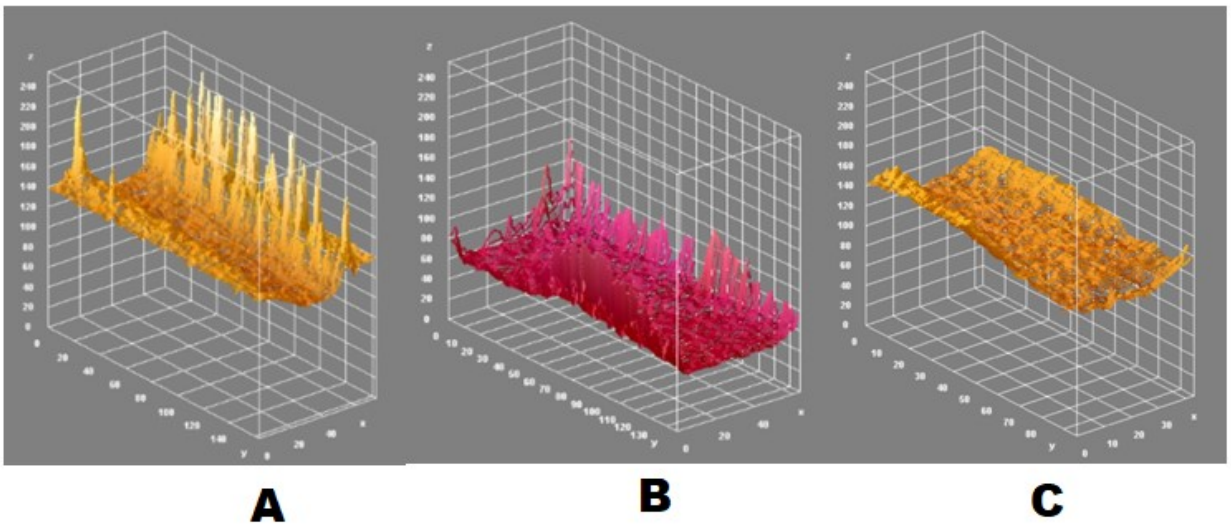


Fig. S23 Interactive 3D surface plot of (A) **1**@SP, (B) **2**@SP and (C) **2**@SP after treatment with FA solution (5% V/V in hexane).

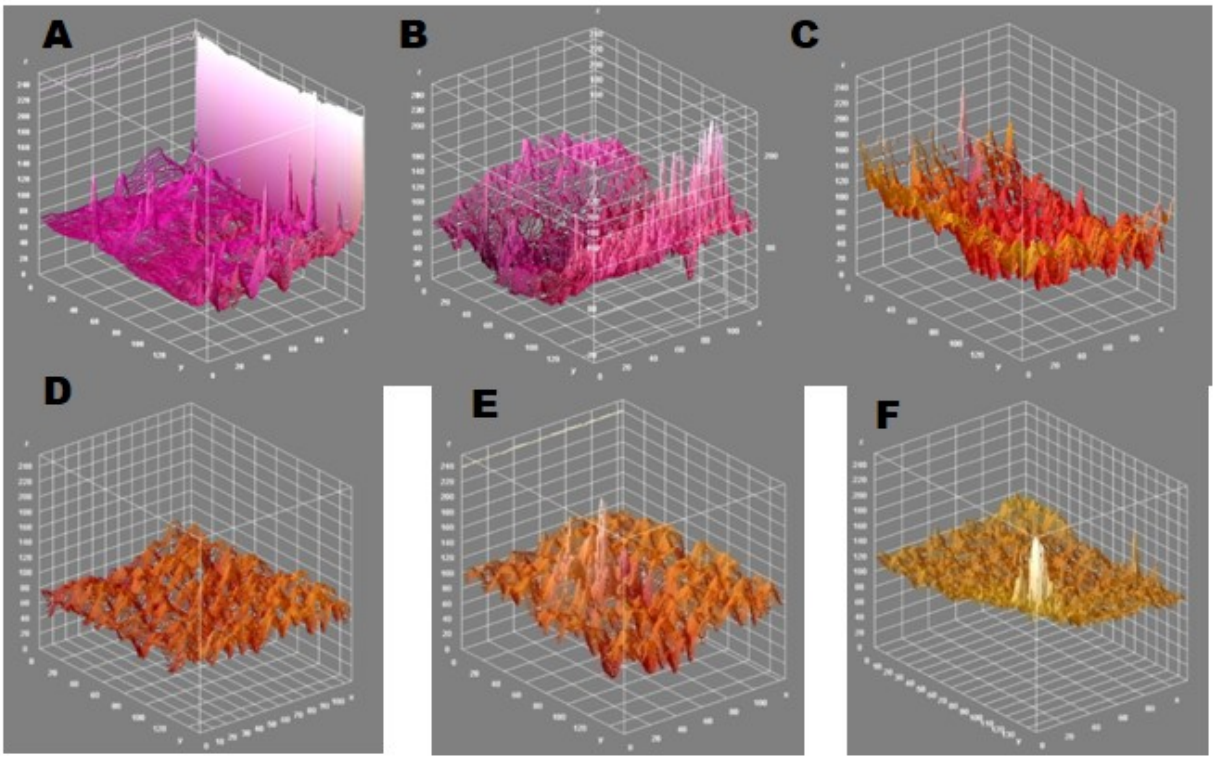


Fig. S24 Interactive 3D surface plot of **2**@SP on exposure of vapour from 5% (V/Vin hexane) FA solution for (A) 2 Min, (B) 4 Min, (C) 6 Min, (D) 8 Min, (E) 10 Min and (F) 12 Min.

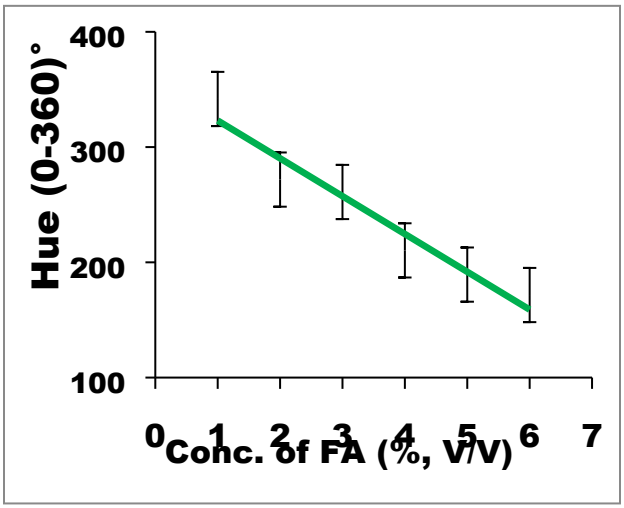


Fig. S25 The standard linear curve obtained from hue vs conc. of FA vapour due to exposure of 3% (V/V in hexane) solution.

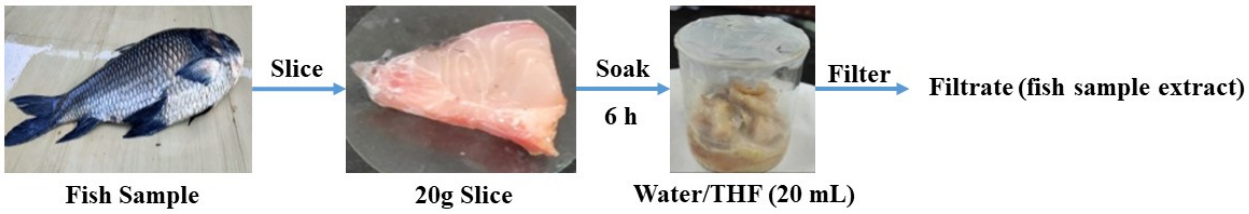


Fig. S26 Flow chart of steps involved in fish sample preparation.

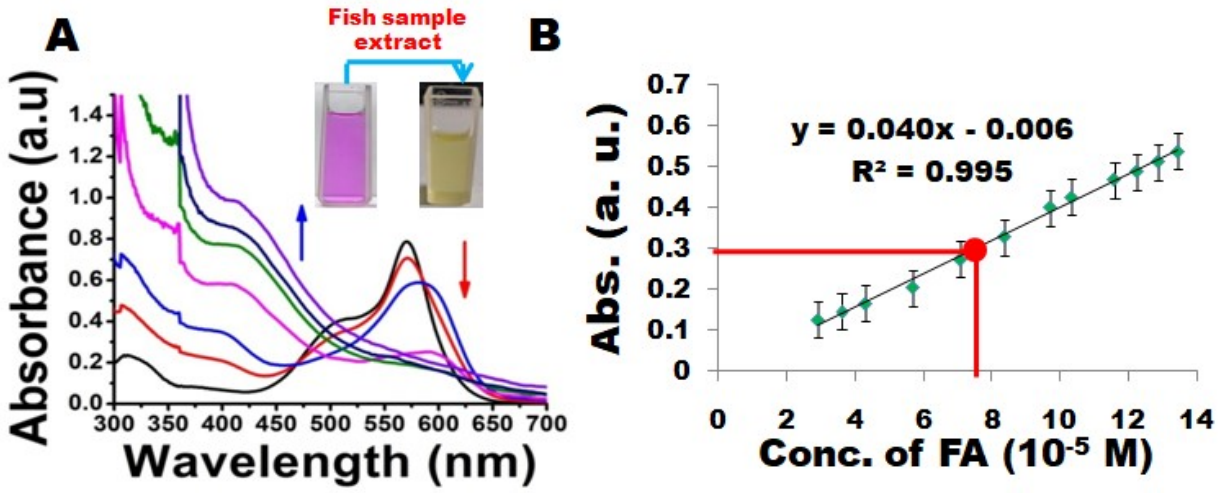


Fig. S27 (A) The absorption of solution of **2** (10^{-4} M in THF) on aliquot addition of fish sample extract (*labeo catla)* (B) Estimation of concentration of FA in fish samples (*labeo catla)* extract from the standard absorbance *Vs* Conc. curve.

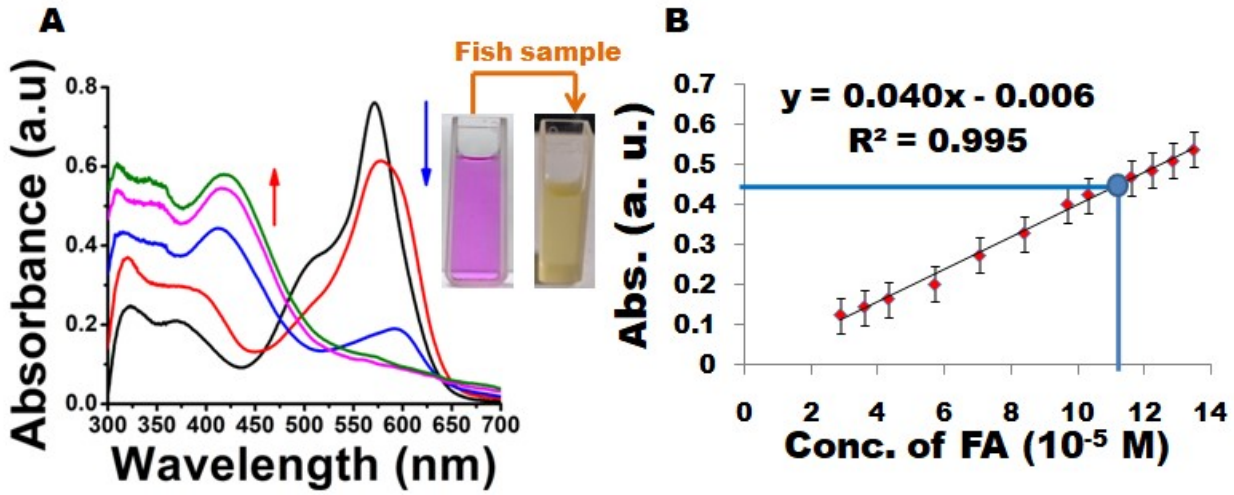


Fig. S28 (A) Changes in the absorption spectra due to addition of fish sample solution (*Pangasius bocurti)* to the solution of **2** in THF, (B) Estimation of unknown concentration of formaldehyde in fish samples (*Pangasius bocurti)* from the standard absorbance curve.

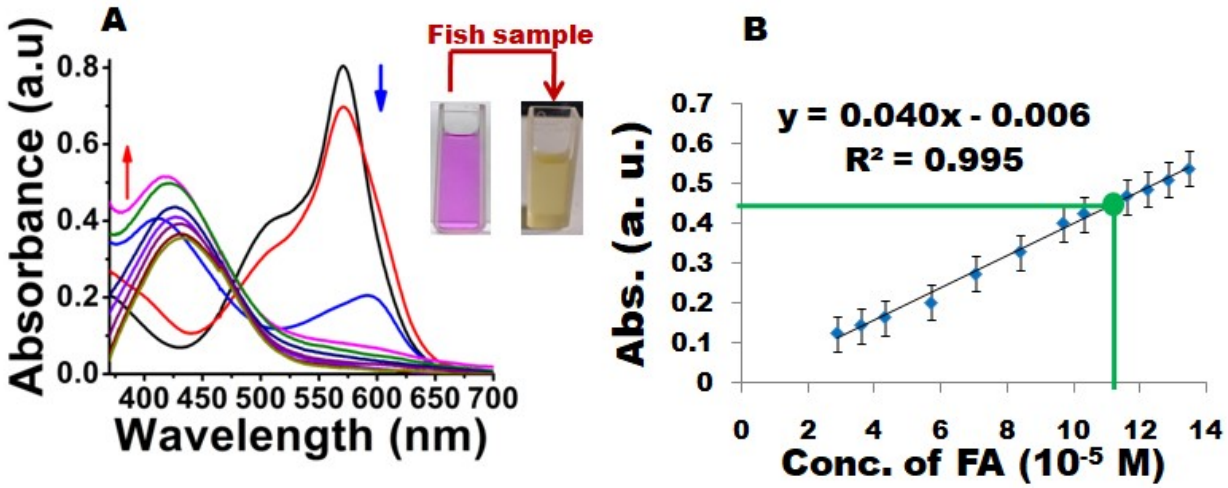


Fig. S29 (A) Changes in the absorption spectra due to addition of fish sample solution (*Plural rupchanda)* to the solution of **2** in THF, (B) Estimation of unknown concentration of formaldehyde in fish samples (*Plural rupchanda)* from the standard absorbance curve.

Table S3: Estimated FA concentration in fish samples.

Fish sample	Conc. Of**2** (10^{-4} M)	Fish Extract taken(µL)	Conc. Of FA (M)
Labeocatla	2 mL (0.1mM)	50 µL	7.36×10^{-5}
Pangasiusbocurti	2 mL (0.1mM)	50 µL	11.2×10^{-5}
Plural rupchanda	2 mL (0.1mM)	50 µL	11.3×10^{-5}

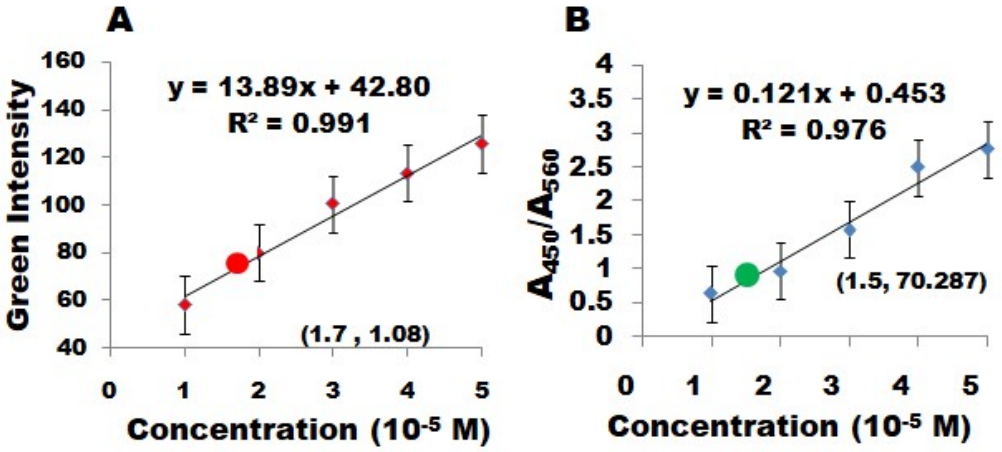


Fig. S30 Estimation of unknown concentration of formaldehyde in fish samples (*labeo catla)* from the (A) RGB standard standard linear curve and (B) standard absorbance curve of the film samples.

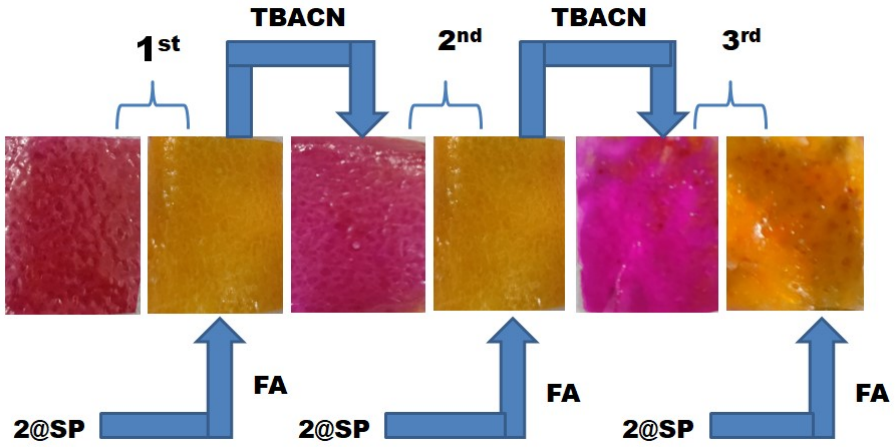


Fig. S31 Photographs of color changes of composite film during of reversibility test.

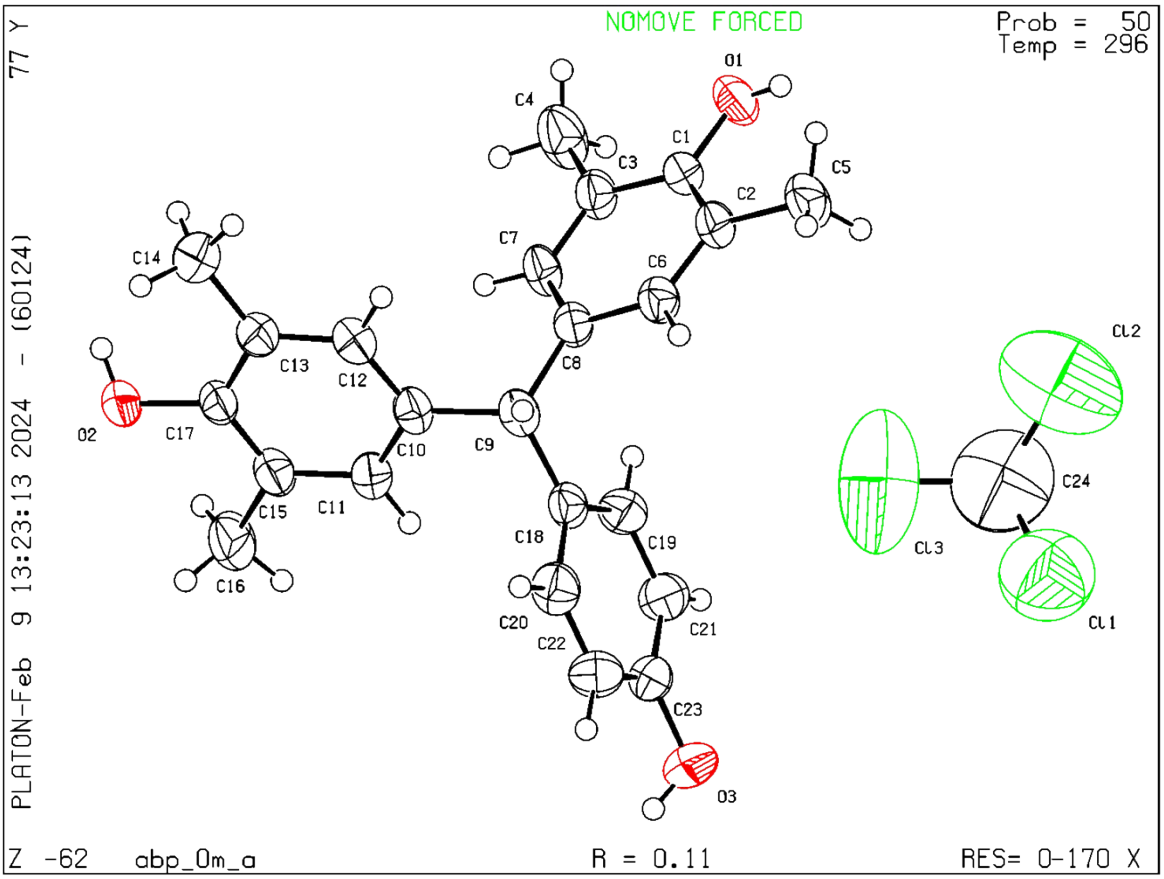


Fig. S32 Crystal structure of sensor 1

Reference:

1 M. Taleuzzaman, *O. M. C. I. J.*, 2018, **7**, OMCIJ.MS.ID.555722.

2 K. Cantrell, M. M. Erenas, I. de Orbe-Paya and L. F. Capita´ n-Vallvey, *Anal. Chem.*, 2010, **82**, 531–542.

3 A. Gangopadhyay, K. Maiti, S. S. Ali, A. K. Pramanik, U. N. Guria, S. K. Samanta, R. Sarkar, P. Datta , A. K. Mahapatra, *Anal. Methods.* 2018, **10**, 2888-2894.

4 S. Saha and P. Sahoo, *Bioorganic Med. Chem. Lett.*, 2021, **49**, 128287.

5 K. Wechakorn, S. Supalang and S. Suanpai, *Tetrahedron*, 2020, **76**, 131411.

6 Y. Sun, Y. Zhang, Y. Song, Y. Liu, X. Zhang, *Dyes Pigm.,* 2021, **193**, 109546.

7 A. Nasirian, A. F.Tikum, M. M. Fortibui, S. Lee and J. Kim, *Dyes Pigm.*, 2021, **188**, 109156.

8 W. Zhou, H. Dong, H. Yan, C. Shi, M. Yu, L. Wei and Z. Li, *Sens. Actuators B: Chem.*, 2015, **209**, 664-669.

9 T. Cao and H. Ma, *RSC Adv.*, 2022, **12**, 18093-18101.

10 T. B. Wei, L. R. Dang, J. P. Hu, Y. Jia, Q. Lin, H. Yao, B. Shi, Y. M. Zhang and W. J. Qu, *New J. Chem.*, 2022, **46**, 20658-20663.

11 T. Cao, D. Gong, S. C. Han, A. Iqbal, J. Qian, W. Liu, W. Qin and H. Guo, *Talanta*, 2018, **189**, 274-280.

12 T. F. Brewer and C. J. Chang, *J. Am. Chem. Soc.*, 2015, **137**, 10886−10889.

13 Y. Tang, Dr. X. Kong, A. Xu, Dr. B. Dong and Prof. W. Lin, *Angew. Chem. Int.*, 2016, **55**, 3356–3359.

14 L. He, X. Yang, Y. Liu, X. Kong and W. Lin, *Chem. Comm.*, 2016, **52**, 4029-4032.

15 Y. Liang, Y. Zhang, M. Li, Z. Meng, S. Gong, W. Du, Y. Yang, Z. Wang and S. Wang, *Microchem. J.*, 2022, **177**, 107305.

16 H. Du, H. Zhang, Y.Fan, Y. Zheng, S.Yuan, T-T. Jia, M. Li, J.Hou, Z. Li, Y. Li, Z. Ma, Y. Wang, H. Niu and Y.Ye, *Food Chem.*, 2023, **411**, 135483.

17 T. Quan, Z. Liang, H. Pang, G. Zeng and T. Chen, *Analyst*, 2022, **147**, 252–261

18 Y. Han and X. Li, *Anal. Chem.* 2022, **94**, 1308–1317.