Cannabis Sativa derived carbon dots with N-S co-doped: highly efficient nanosensors for temperature and vitamin B$_{12}$

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**SUPPORTING INFORMATION**

**Fig. S1** Excitation and emission spectrum of N-S@CsCD.

**Fig. S2** Deconvoluted XPS peak of N-S@CsCD (a) C1s (b) O1s (c) N1s (d) S2p.

**Fig. S3** FTIR spectra of N-S@CsCD.

**Fig. S4** Fluorescence stability of N-S@CsCD with (a) number of days (b) Salt concentration (c) pH (d) fluorescence intensity of N-S@CsCD in varying fluids (e) fluorescence life time decay of N-S@CsCD in varying fluid.

**Fig. S5** Temperature dependent life time value of N-S@CsCD experimental data are shown in black solid lines and circles exhibit fitting data (a) Temperature=15°C (b) Temperature=20°C (c) Temperature= 25°C (d) Temperature= 30°C (e) Temperature= 40°C (f) Temperature= 50°C (g) Temperature= 60°C.

**Fig. S6** Polynomial calibration curve for N-S@CsCD life time value with temperature.

**Fig. S7** Effect of temperature (a) Quantum yield (b) Radiative and non radiative recombination rates.

**Fig. S8** Temperature dependent fluorescence changes in N-S@CsCD with varying fluid (a) water (b) PBS (c) DMEM.

**Fig. S9** Temperature dependent fluorescence changes in N-S@CsCD (a) emission wavelength (b) fwhm (c) relative integrated fluorescence intensity.

**Fig. S10** Vitamin sensing with N-S@CsCD with varying fluid (a) water (b) PBS (c) DMEM.

**Fig. S11** Sensing response time of N-S@CsCD with VB<sub>12</sub>.

**Fig. S12** Sensing response time of N-S@CsCD with T=15°C+ VB<sub>12</sub>.

**Fig. S13** Effect of interfering species.

**Fig. S14** Real sample analysis (a) Fluorescence intensity of N-S@CsCD and with VB<sub>12</sub> injection (b) Fluorescence intensity of N-S@CsCD and with VB<sub>12</sub> injection at temperature=15°C.

**Fig. S15** Phototoxicity of N-S@CsCD.

**Fig. S16** Intracellular imaging of N-S@CsCD.
Fig. S17. (a) Plot of integrated Fluorescence intensity (excited at 360 nm) against absorbance values at 360 nm of N@VRCD. (b) Plot of integrated Fluorescence intensity (excited at 345 nm) against absorbance values at 345 nm of quinine sulfate (QS).

Table S1. Deconvoluted fluorescence spectra with temperature increment.

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Table S1. Deconvoluted fluorescence spectra with temperature increment.

<table>
<thead>
<tr>
<th>Sl no</th>
<th>Temp(°C)</th>
<th>FWHM</th>
<th>Peak1(nm)</th>
<th>Peak2(nm)</th>
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Method: Quantum yield measurement

Quantum yield of N-S@CsCD was calculated using five-point method. The absorbance of N-S@CsCD and standard (Quinine sulphate) was fixed 0.02, 0.04, 0.06, 0.08 and 0.1. Results were summarized in table S2. The average quantum yield was found to be ~14.38%.

![Plot of integrated Fluorescence intensity (excited at 360 nm) against absorbance values at 360 nm of N@VRCD.](image)
![Plot of integrated Fluorescence intensity (excited at 345 nm) against absorbance values at 345 nm of Quinine sulphate(QS).](image)

Table S2. Quantum yield calculated using steady-state comparative method.

<table>
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<tr>
<th>S.No.</th>
<th>Absorbance</th>
<th>Quantum yield</th>
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<td>5.</td>
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