

## Electronic Supporting Information (ESI)

### **Direct Synthesis of Highly Stable Nitrogen Rich Carbon Dots toward White Light Emission**

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#### **Experimental section**

*Materials used:* Ethylenediamine, phosphorous pentoxide, quinine sulphate and dialysis bags were brought from Sigma Aldrich. Nitric acid was purchased from Merck specialties, India. All aqueous solutions were prepared using double distilled water.

*Synthesis NCDs:* The nitrogen rich carbon dots were prepared by carbonizing the precursor molecule ethylenediamine using phosphorous pentoxide in the presence of water. Briefly, a mixture containing 0.6 mL of ethylenediamine and 0.5 mL of water were introduced to a beaker containing 1.25 g of phosphorous pentoxide. The spontaneous heat produced due to the exothermic reaction between P<sub>2</sub>O<sub>5</sub> and H<sub>2</sub>O subsequently boils ethylenediamine. The color of the reaction mixture changes to dark brown in 2 min indicates the successful carbonization reaction. The dark slurry was diluted to 5 mL using distilled water. The crude NCDs were centrifuged three times (10,000 rpm) and supernatant was dialyzed using dialysis sacks (2000 MWCO) for 24 hour and collected for further analysis. pH of the purified solution of NCDs were found to be around 2. XPS spectra of NCDs recorded before and after the purification shows significant decrease in intensity of Phosphorous peak corresponding to the binding energy 134.5 eV, which indicates the effectiveness of the purification process.

*Characterization:* UV-Visible spectra were recorded using a Carry-100 UV-Visible spectrometer. Infrared studies were performed using a Spectrum 100T Perkin-Elmer FT-IR spectrometer. For collecting FTIR spectra, samples were lyophilized for 2 days at -30 °C and the IR spectra of NCD and ethylenediamine were recorded in attenuated total internal reflection (ATR) mode (number of scans-32).

All steady state fluorescence measurements (excitation and emission) were carried out using Fluoro Max-4C Spectrofluorometer (Horiba Instruments, USA). Excitation and emission slit width were fixed at 3 nm with an integration time of 0.1 ns. Time resolved fluorescence measurements were performed using time-correlated single-photon counting (TCSPC). For TCSPC measurements, excitation wavelength is fixed at 330 nm and decay profile were collected at 400, 450, 500 and 600 nm (laser pulse width <370 ps). Quantum yield of NCDs were calculated using quinine sulfate ( $\phi = 0.54$ ) as standard at 400 nm excitation according to previously reported procedure.<sup>[7]</sup> Photostability experiments were

carried out by irradiating aqueous solution of NCDs under 360 nm UV lamp (48 W power) and fluorescence spectra of photoirradiated sample were recorded in the specified time interval. Solid state fluorescence measurements of NCDs were performed by dropcasting as prepared NCDs over the polymeric film and dried. Steady state fluorescence spectra of the resulting film is recorded at various excitation wavelength.

Raman spectral analysis were carried out using WiTec alpha 300R Confocal Raman Microscope with 785 nm laser. Transmission electron microscopy (TEM) images were recoded using JEOL 3010 UHR instrument by assembling NCDs on Cu grid coated with ultrathin amorphous carbon film. Atomic microscopy (AFM) images were obtained from Agilent 5500 scanning probe microscope and the obtained images were further processed using WSxM software. X ray Photoelectron Spectroscopic (XPS) studies of NCDs were performed using Omicron ESCA probe spectrometer with unmonochromatised Mg K $\alpha$  radiation. EUTECH instruments' pH meter was used for pH measurements. Thermo gravimetric analysis (TGA) were done using TA instruments Q50. Heating rate were maintained at 10 °C/min in an inert atmosphere.

**Calculation of quantum yield:** Quantum yield of the NCDs were calculated using quinine sulfate in 0.1 M H<sub>2</sub>SO<sub>4</sub> as a standard (literature quantum yield of the quinine sulphate,  $\phi_o=0.54$ ) at the excitation wavelength 360 nm according to:

$$\phi_c = \phi_o \times \frac{I_c}{I_o} \times \frac{A_o}{A_c} \times \frac{\eta_c^2}{\eta_o^2}$$

Where,

$\Phi_o$  and  $\Phi_c$  are the photoluminescence quantum yield of the standard (quinine sulfate) and sample (NCD), respectively.

$I_o$  and  $I_c$  are the integrated emission intensity of the standard and sample, respectively

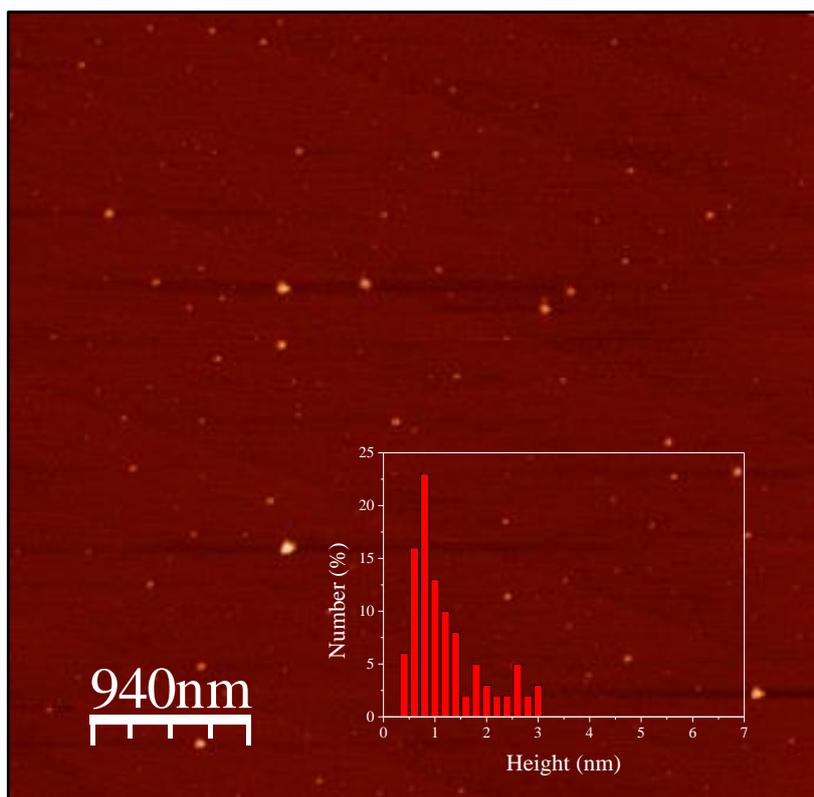
$A_o$  and  $A_c$  are the absorbance of the standard and sample, respectively

$\eta_o$  and  $\eta_c$  are the refractive index of the reference and sample solutions, respectively

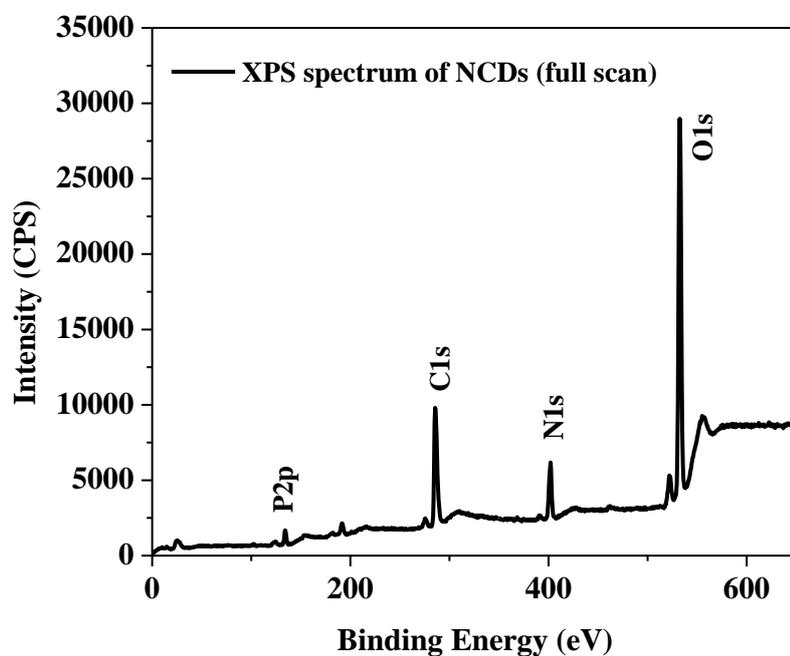
Exc. $\lambda$ (nm)	$\phi_o$	$A_o$	$I_o$	$\eta_o$	$A_c$	$I_c$	$\eta_c$	$\Phi_c$
360	0.54	0.0503	$1.7 \times 10^8$	1.35	0.398	$7.1 \times 10^8$	1.35	0.285

**Table S1.** Showing various photo-physical parameters such as lifetime ( $\tau$ ), amplitude (A),  $\chi^2$  values measured at various emission wavelengths ( $\lambda_{em}$ ).

$\lambda_{em}$	$\tau_1$ (ns)	$A_1$ (%)	$\tau_2$ (ns)	$A_2$ (%)	$\langle \tau \rangle = \frac{\sum (A_1 \tau_1^2)}{\sum (A_1 \tau_1)}$ (ns)	$\chi^2$
<b>400</b>	1.59	54.21	6.3	45.79	5.21	1.24
<b>450</b>	1.58	37.22	6.5	62.78	5.88	1.27
<b>500</b>	1.98	31.63	7.18	68.37	6.59	1.07



**Fig. S1** AFM image of NCDs. The histogram shows height distribution. High profiles shows a range within 2 nm.



**Fig. S2** Survey scan XPS spectra of nitrogen rich carbon dots (NCDs).

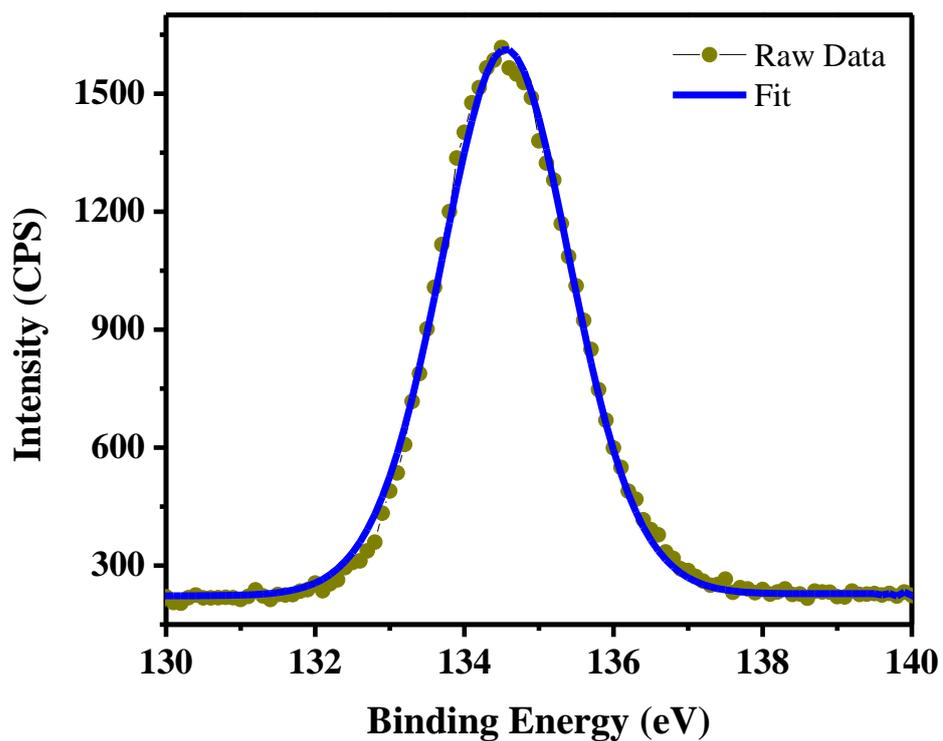


Fig. S3 High resolution P2p XPS spectrum of NCDs.

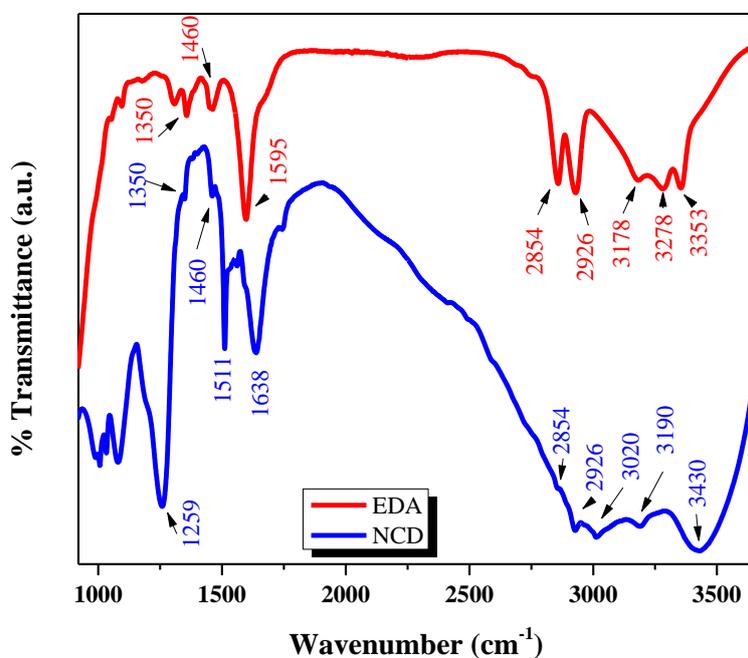


Fig. S4 IR spectra of ethylenediamine (red trace) and nitrogen rich carbon dots (blue trace)

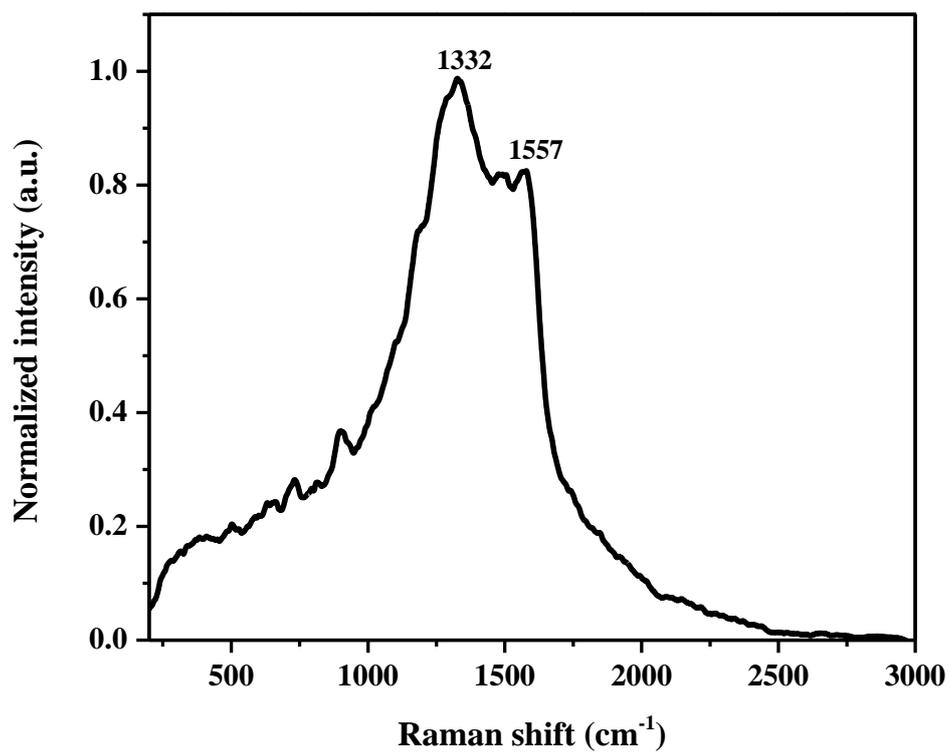


Fig. S5 Raman spectrum of NCDs. Excitation wavelength was 785 nm.

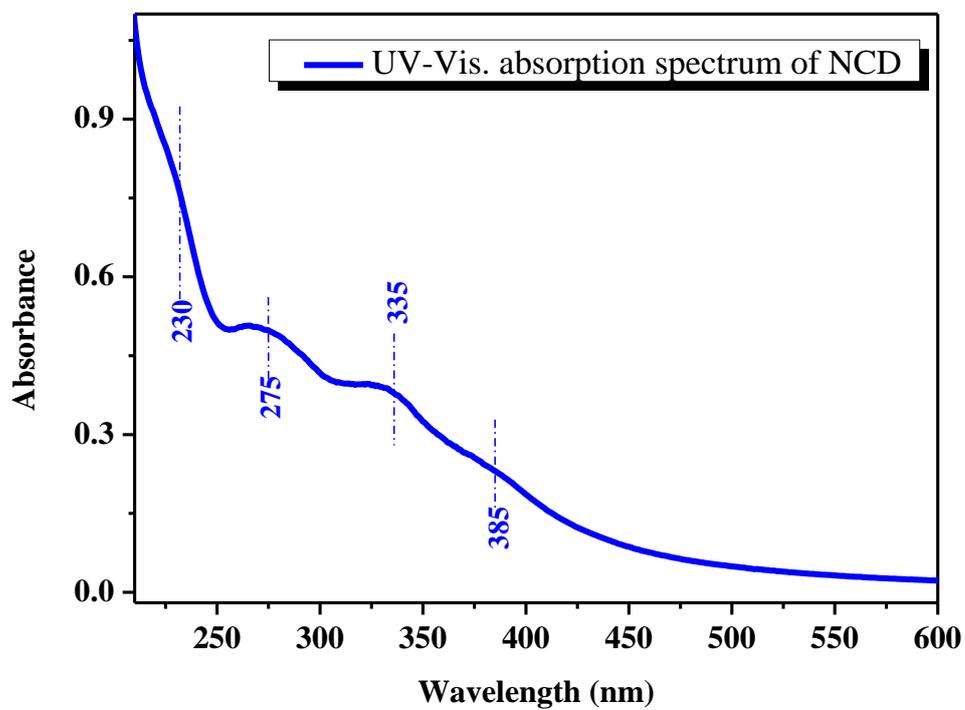
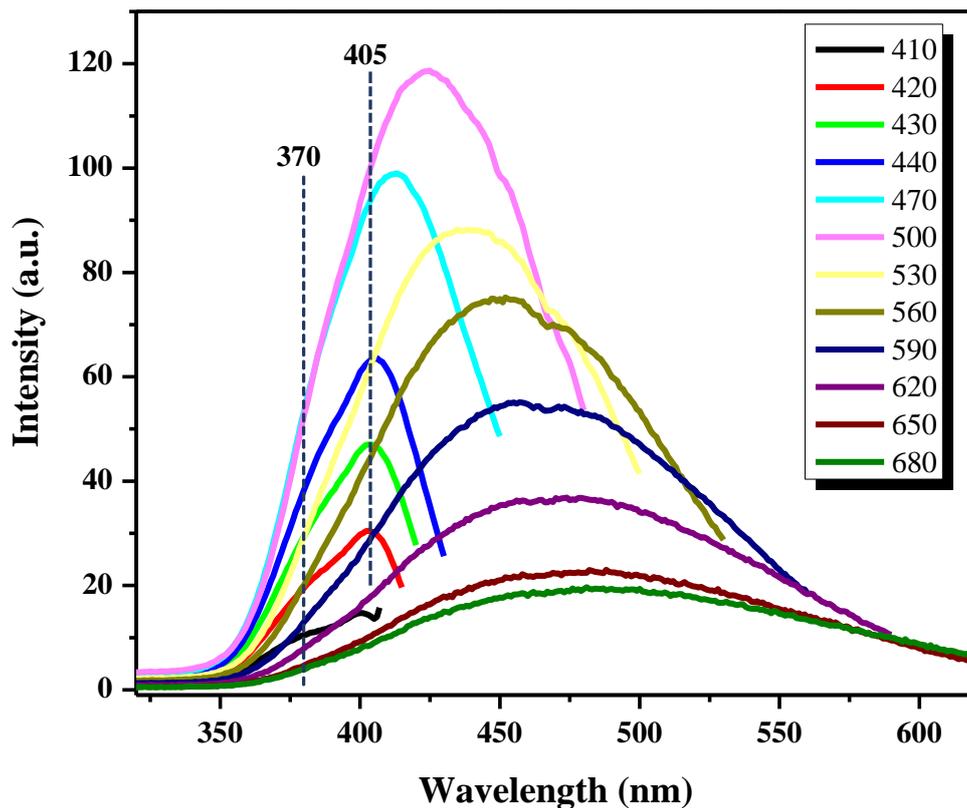
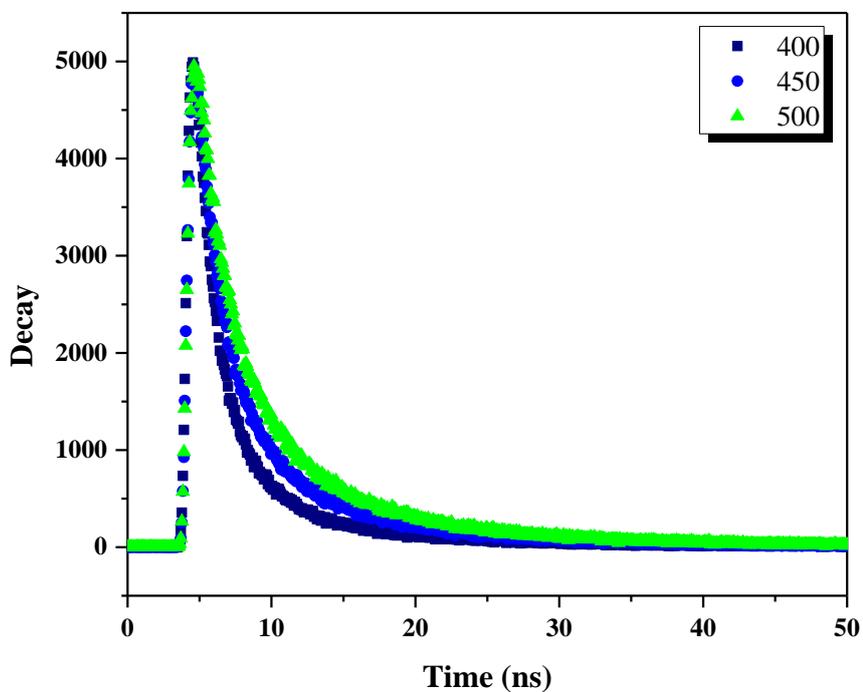


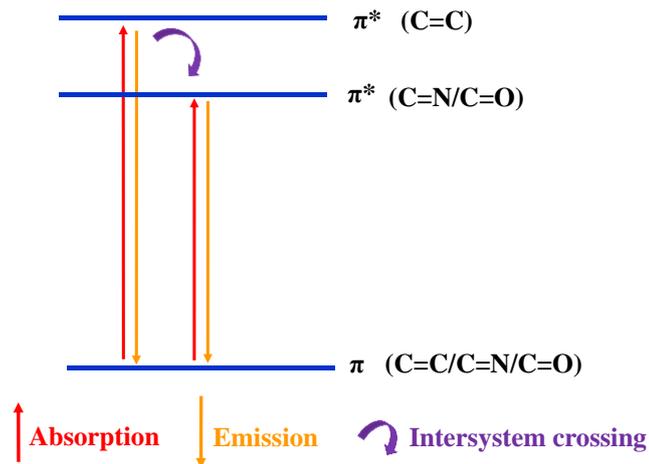
Fig. S6 UV-Visible absorption spectrum of NCDs.



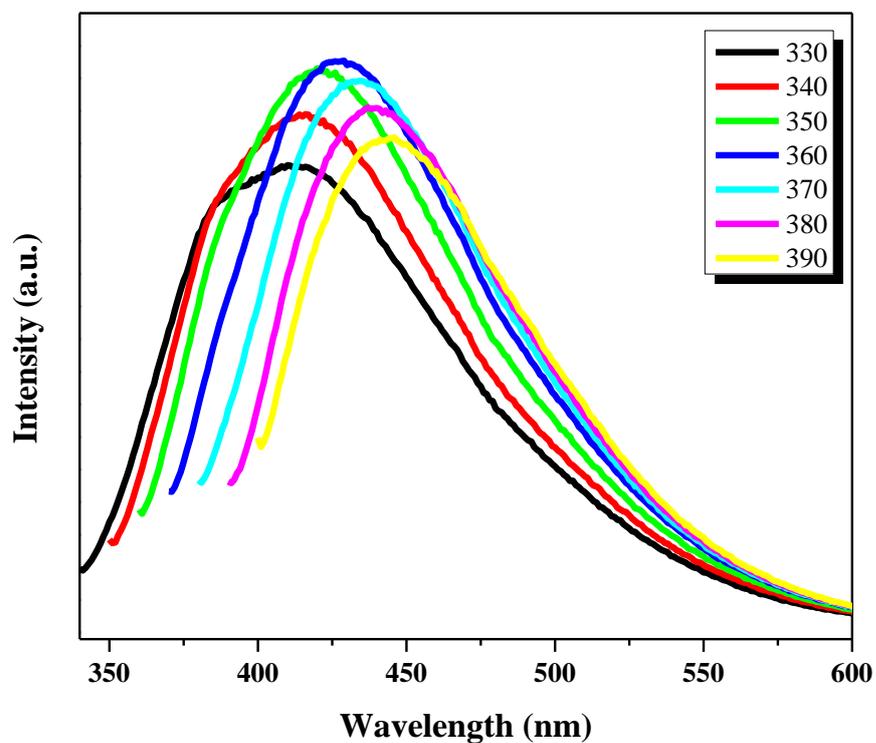
**Fig. S7** Photoluminescence excitation (PLE) spectra of NCDs measured at various emission wavelengths.



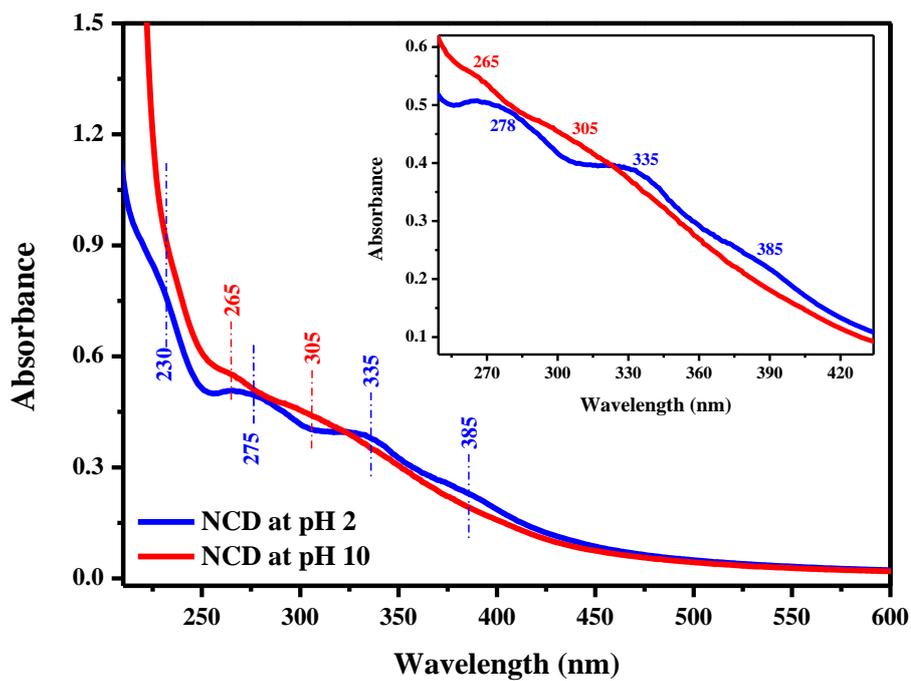
**Fig. S8** Time resolved fluorescence spectra of NCDs collected at 400 (violet), 450 (blue) and 500 (green). Excitation wavelength was fixed at 330 nm with laser pulse width <math><370</math> ps.



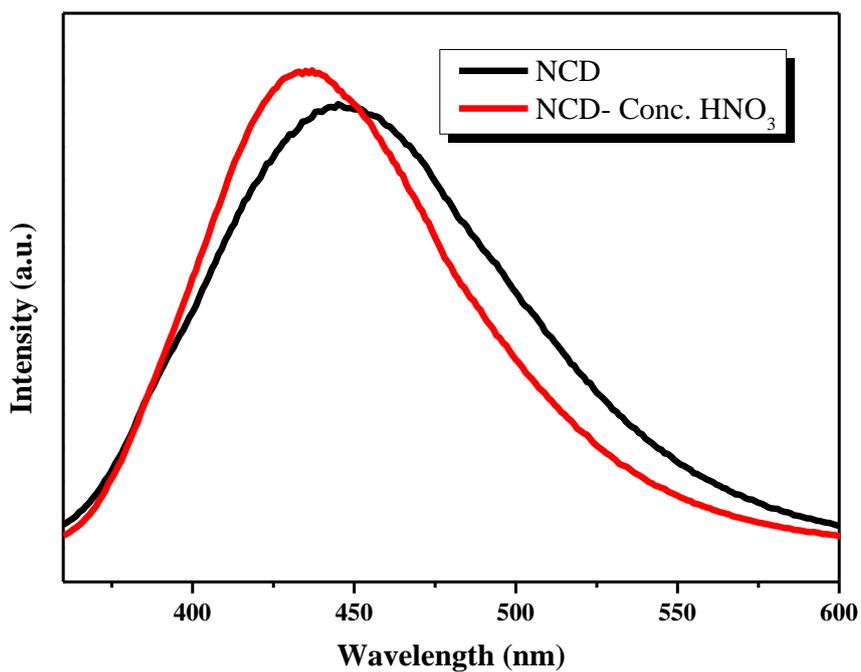
**Fig. S9** Plausible electronic transitions that leads to white light emission in NCDs.



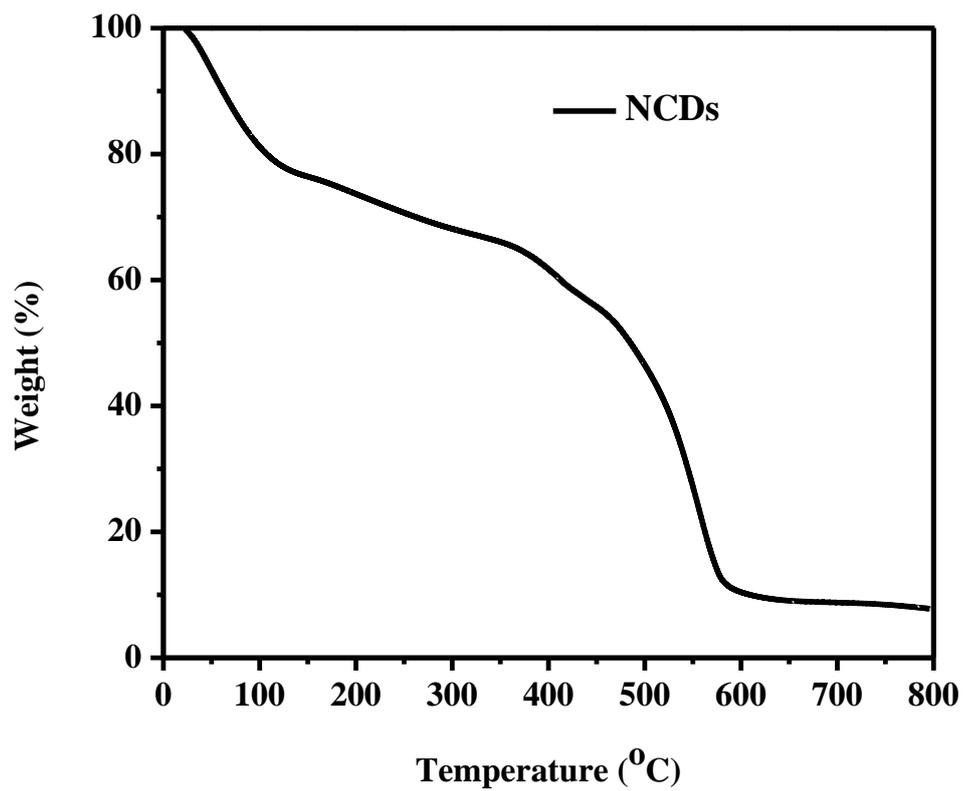
**Fig. S10** Photoluminescence spectra of NCDs coated on a polymer (PVA) surface at various excitation wavelengths.



**Fig. S11** Absorption spectra of NCDs at pH 2 (blue trace) and pH 10 (red trace). An enlarged view of 350 to 440 nm region is shown as inset.



**Fig. S12** Photoluminescence spectra of NCDs before (black trace) and after (red trace) the treatment of conc.  $\text{HNO}_3$ .



**Fig. S13** Thermogravimetric (TGA) curve of the NCDs.