Supporting Information

Surface Modulation of solution processed Organolead Halide Perovskite Quantum Dot to Large Nanocrystals integrated with silica Gel G

Parul Bansal[a], Yusuf Khan[b] and Gaurav Kumar Nim[a], Prasenjit Kar*[a]

[a] Department of Chemistry
Indian Institute of Technology Roorkee, Uttarakhand, India

[b] Department of metallurgical and materials engineering

Indian Institute of Technology Roorkee, Uttarakhand, India

Corresponding Email address: kar.prasen@gmail.com, prkarfcy@iitr.ac.in

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S1. Experimental Section

Chemical Reagents

All the chemicals and solvents were procured from commercial sources were used as received. Lead(II) Bromide (99%), Methylamine solution (33wt% in absolute ethanol) and oleylamine are purchased from sigma adrich . Other reagents like Chloroform (Rankem), N,N-dimethylformamide(Thomas baker), oleic acid, Silica Gel G(Merck) and hydrobromic acid (48wt % in water, SRL) were ordered from local purchase.

S2.Synthesis of SiO_2 - $CH_3NH_3PbBr_3$ Perovskite quantum dots Nanocomposite

In this procedure, 250mg of Silica Gel G had been weighed in small glass tube and 500µL of 3ml prepared perovskite quantum dot solution is injected on it. Silica Gel G will show blue fluorescence but suddenly disappeared then again 500µL of perovskite solution was injected and kept for drying. Addition of 1ml of more solution to the above dried silica will start giving light green fluorescence and after few minutes , we added 1.5ml of more perovskite solution to above glass tube and kept as it is. After few minutes we will observe green fluorescenct silica gel and light cream color under daylight.

S3. Instrumentation details

1.UV absorption and photoluminiscence Spectroscopy

The electronic absorption and emission spectral measurements were performed on UV-vis spectrophotometer at room temperature. Shimadzu UV-Vis 2450 spectrophotometer was used for recording UV-Vis absorption spectra in the range of 200-650 nm. Photoluminescence spectra were taken by Horiba scientific Fluoromax-4C spectrophotometer. A quartz cuvette of 10 mm path length and volume 3.0 ml was used for collecting the spectras. Solid state fluorescence has been recorded using solid probe. The excitation and emission slit widths and step size were 2.0, 2.0 and 1.0nm respectively.

2. TCSPC studies

Fluorescence lifetime decay measurements were recorded on 1cm quartz cell on a Horiba Jobin Yvon ," Fluorocube Fluorescence Lifetime System" equipped with NanoLEDs and LDs as the excitation source and an automated polarization accessory (Model 5000 U-02).

3. Fourier Transform Infrared Spectroscopy (FTIR)

Infra red spectra (IR) of CNs were recorded by using Thermo scientific Nicolet 6700. The use of the spectral subtraction provided reliable and reproducible results.

4. UV- Diffusion Reflectance Spectroscopy

The DRS spectra were recorded at room temperature on a Shimadzu UV-2450 UV-Vis spectrophotometer equipped with an integrating sphere using BaSO4 as the reference. The sample powders were mixed and ground well with BaSO4 powder, with the sample to BaSO4 weight ratio of about 1:1.

5. Field Emission Scanning Electron Microscopy (FEI-SEM) SEM images, EDX and mapping had been done on model FE-SEM Quanta 200 FEG.

6.Transmission Electron Microscopy (TEM)

TEM study was carried out by TEM TECHNAI G2 20 S-TWIN. A drop of highly diluted CNs solution was placed on Carbon coated Copper grid. Again a drop was added before drying it. Drying was carried at ambient temperature.

7. Atomic Force Microscopy (AFM) was performed on model NT-MDT-Integra on tapping mode.

8. Powder XRD was carried out on Bruker -D8 Advance having Target Cu and accelerating voltage 40kV from 5 to 50˚ at the rate of 2˚/min. Thin film samples were prepared on silica glass.

9. Quantum yield Absolute quantum yield is measured directly by using Edinburgh instruments FLS 980 . We have prepared a highly diluted solution of CNs and measured the absolute quantum yield.

10 NMR ^{1}H NMR spectra were recorded on Jeol 400 MHz and Bruker 500 MHz spectrometer.

Table S1 IR Band assignments for corresponding silica and $CH_3NH_3PbBr_3$ perovskite quantum dots

Sr. No.	Wavenumber (cm^{-1})	Assignments
1	3435.4	Broad peak of N-H stretching
2	2936.4	Symmetric vibrations of CH_2
3	2860.5	Asymmetric vibrations of CH_3
4	1649.0	COO^- modes
5	1126.2	Asymmetric stretching vibration of Si-O-Si

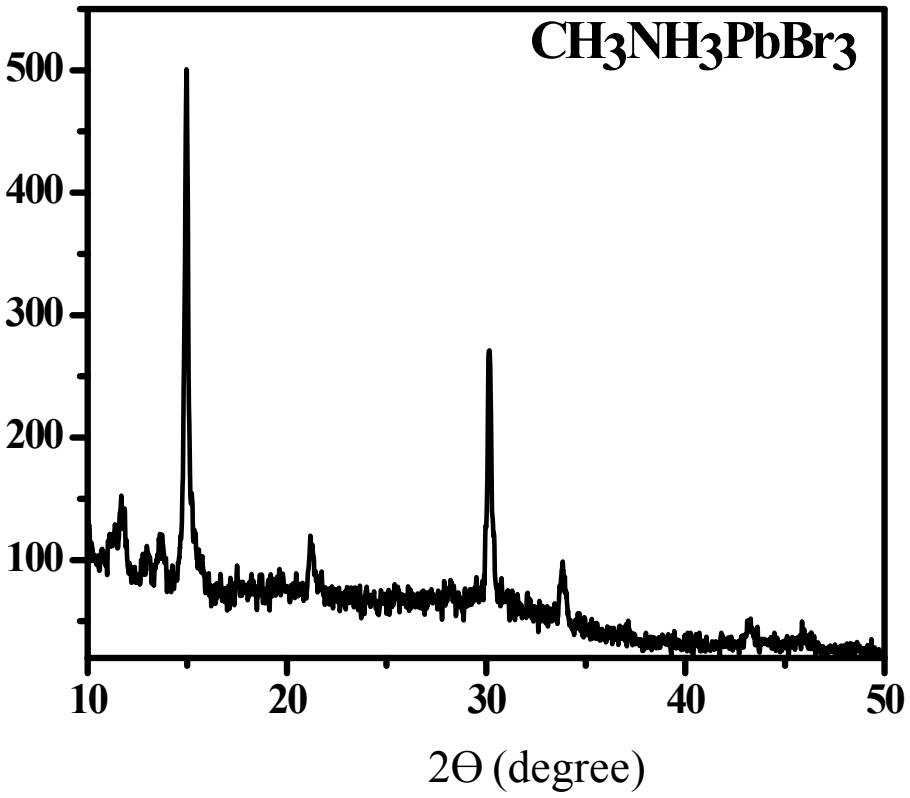

Figure S4. X-Ray diffraction Patterns of $CH_3NH_3PbBr_3$ Perovskites

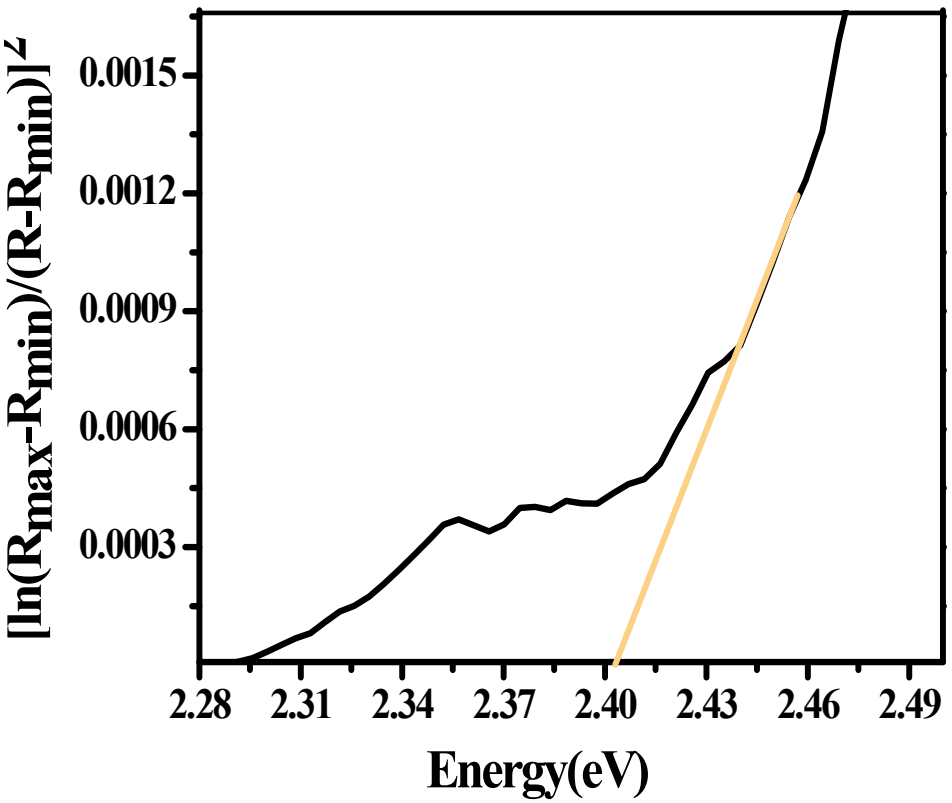

Figure S5 Energy band gap of Silica + $CH_3NH_3PbBr_3$ Nanocomposite .

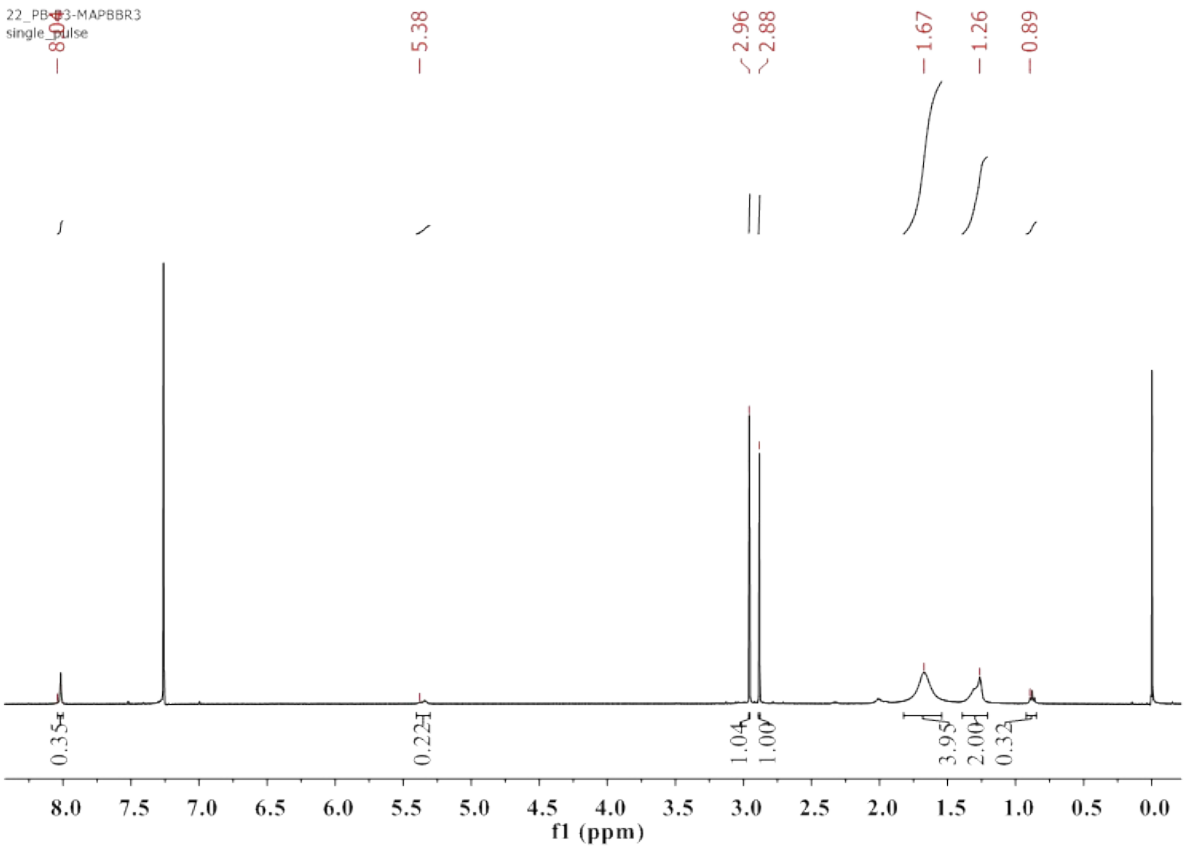

Figure S6 ^{1}H-Proton (CDCl3)NMR of Ligand capped $CH_3NH_3PbBr_3$ perovskite quantum dot

NMR of perovskite QDs has been taken on centrifuging and drying the nanoparticles. Peaks in aliphatic region is attributed to the presence of oleic acid and oleylamine. Predictable signature in between 2.82ppm-2.95ppm is for $MAPbBr_3$ [1,2].

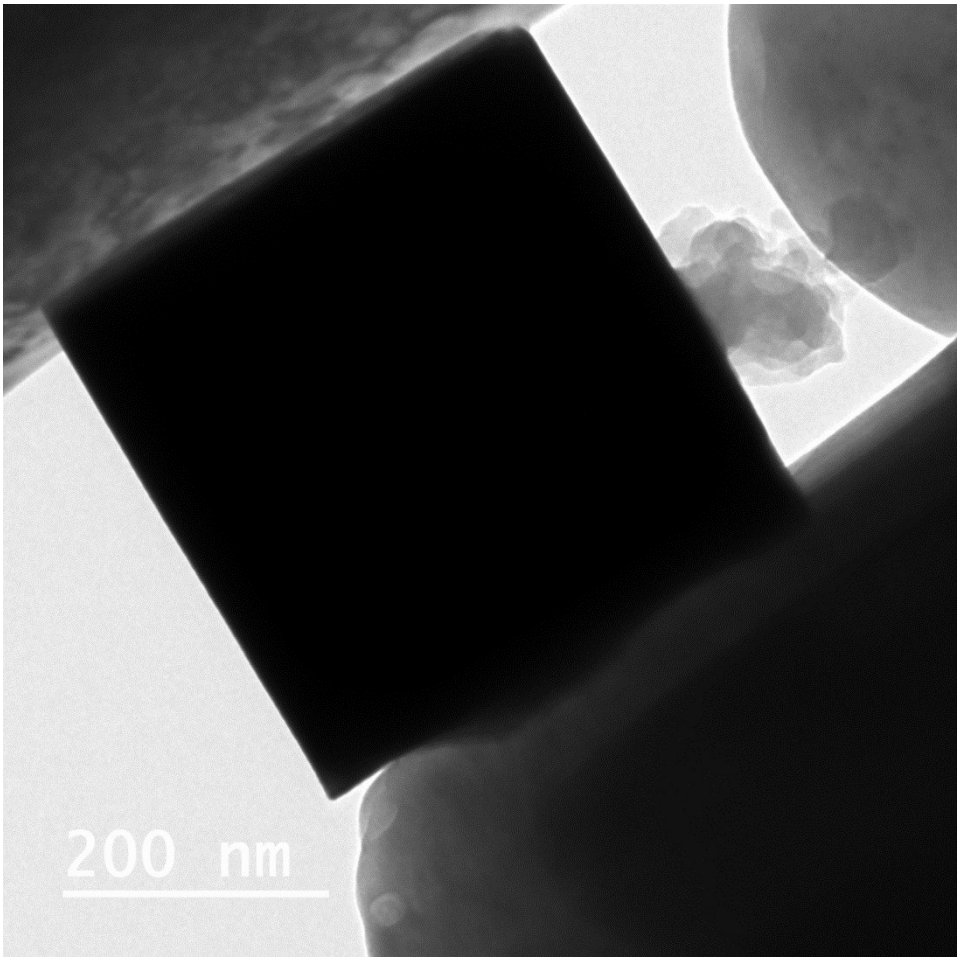

Figure S7 TEM image of Silica embedded nanocrystal formed at scale bar 2nm

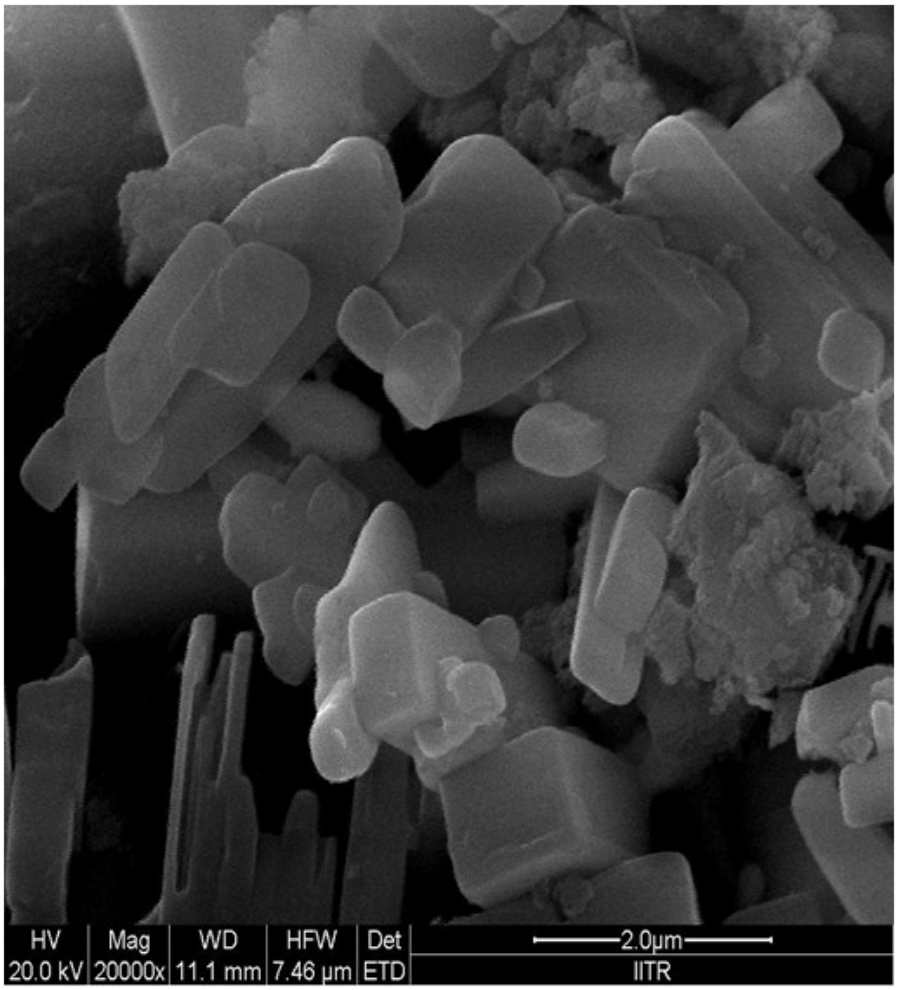

Figure S8 FEI-SEM image of Silica embedded nanocrystal formed at scale bar 2µm

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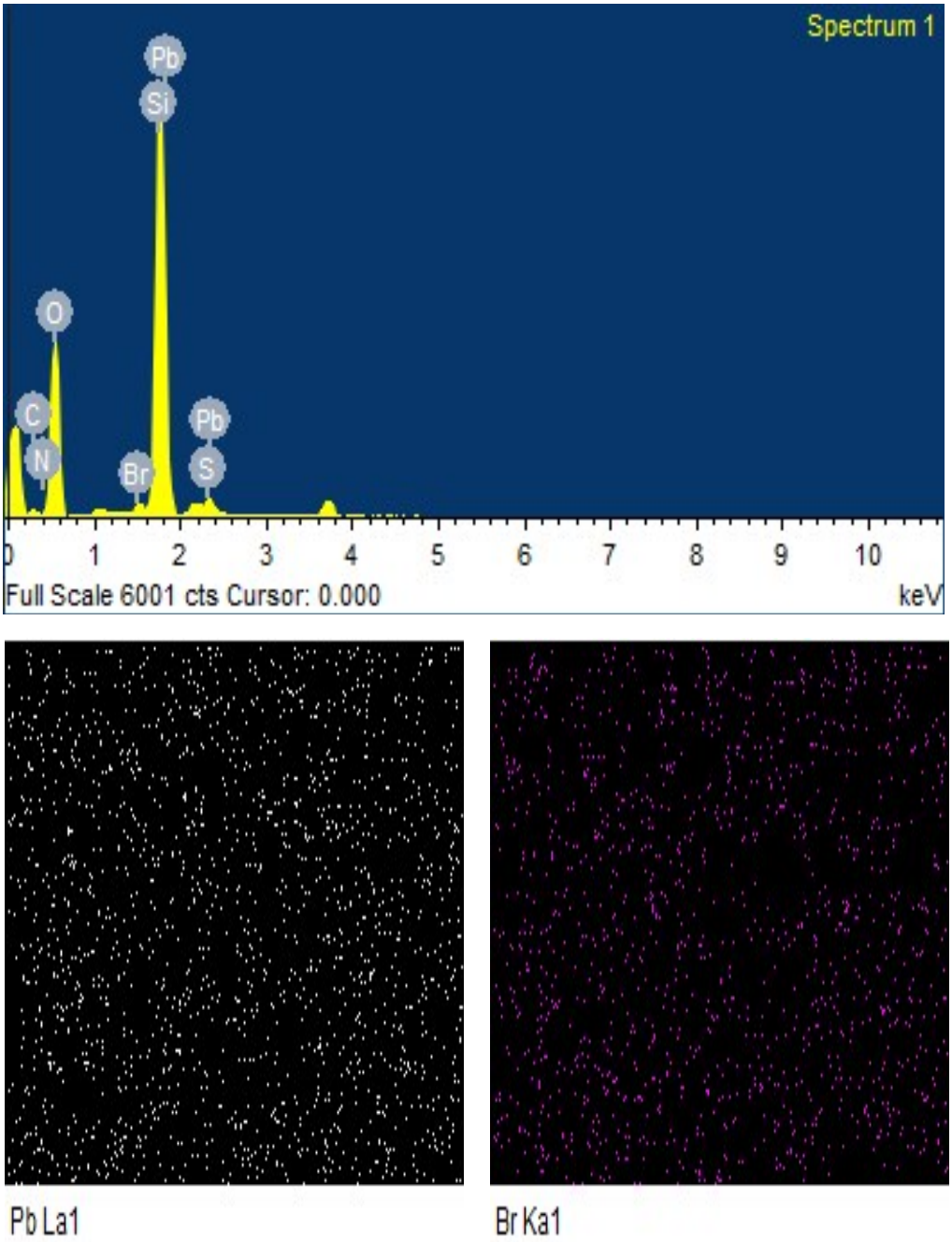

Figure S9 EDX and Mapping of Silica embedded nanocrystal showing presence of Pb and Br ions.

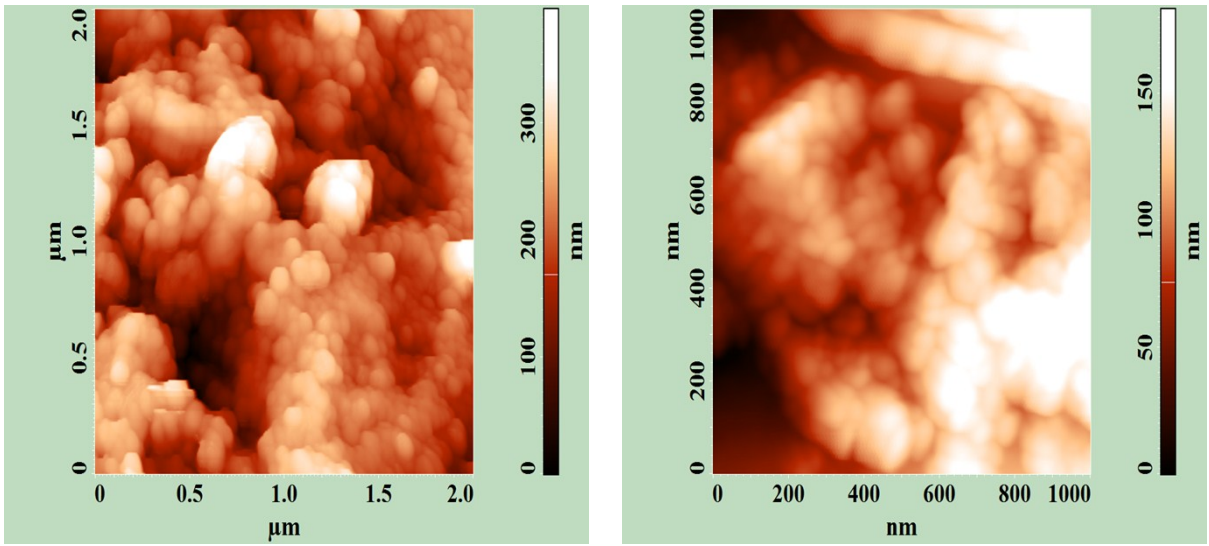

Figure S10 AFM images of Silica Gel G (Left) and Silica Gel G embedded with PQD (Right).

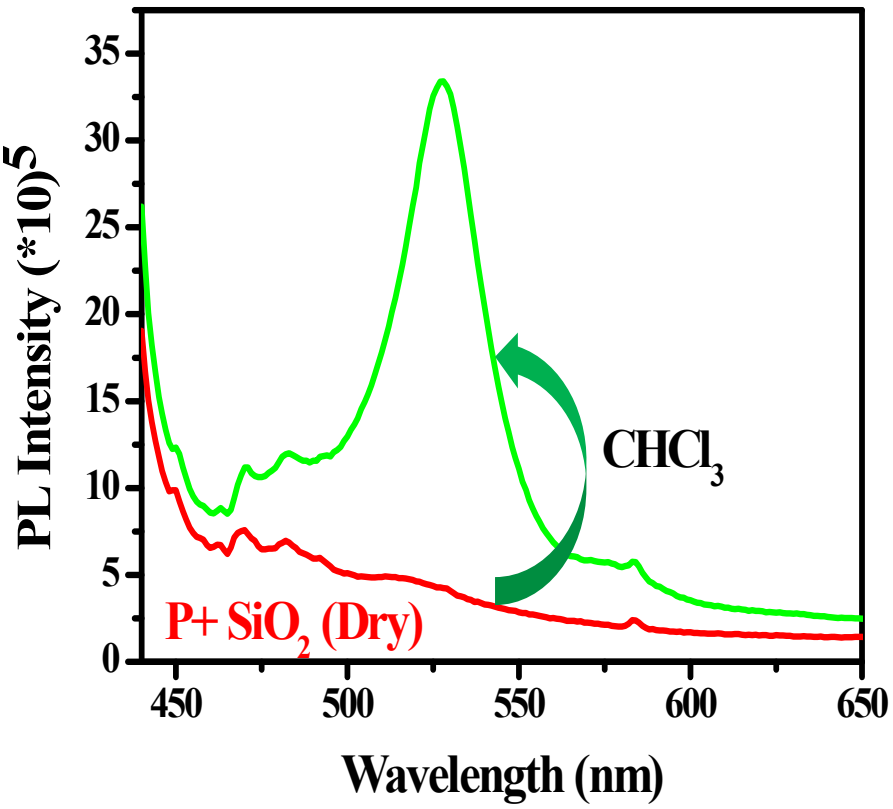

Figure S11 Effect of chloroform on photoluminescence spectra of Silica embedded $MAPbBr_3$ Nanocomposite

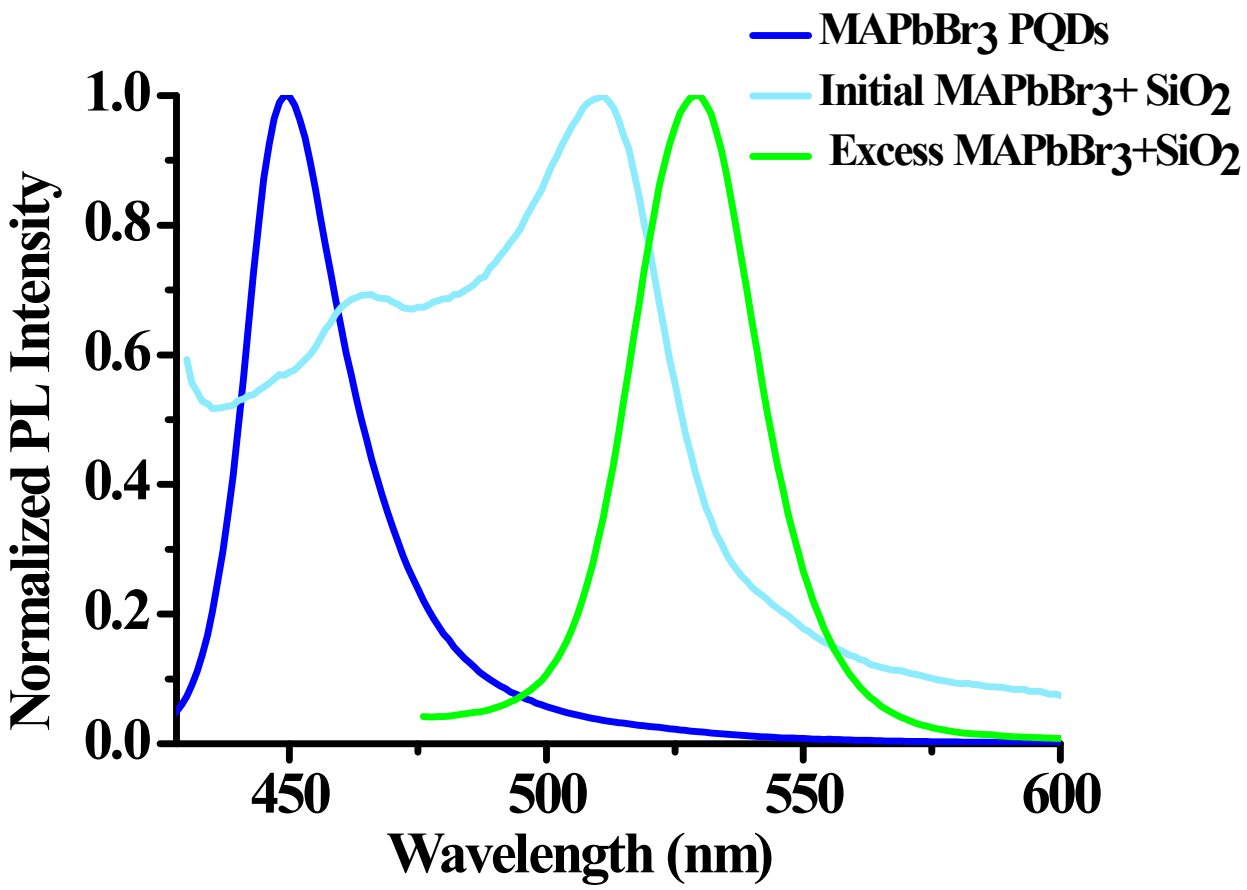

Figure S12. Bathochromic shift observed during careful addition of $CH_3NH_3PbBr_3$ PQD solution on silica gel.

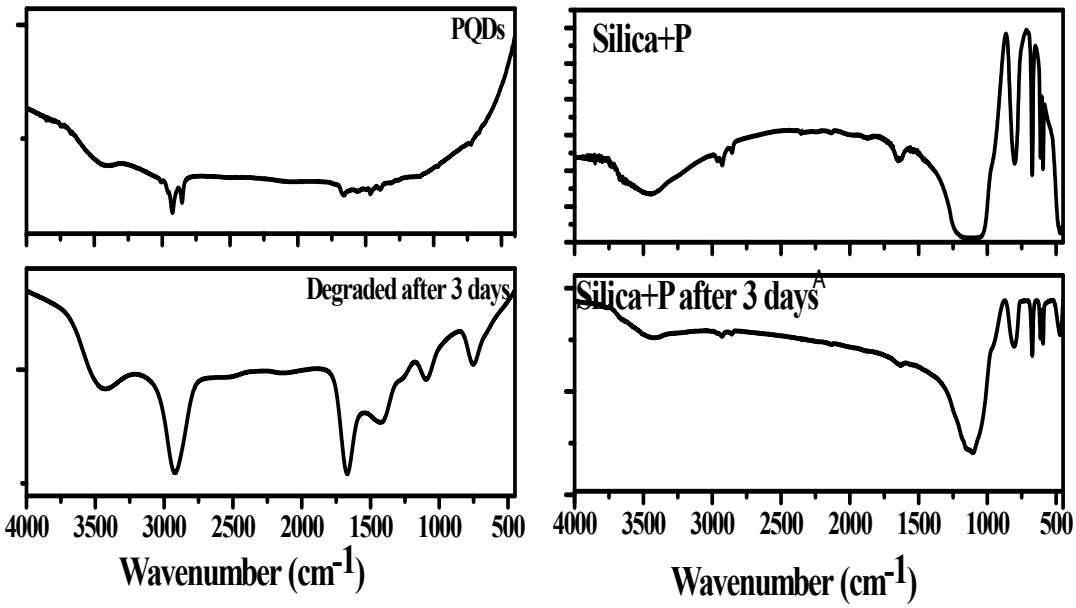

Figure S13 FT-IR spectrum of $CH_3NH_3PbBr_3$ Perovskite quantum dots labelled as PQDs and Silica embedded nanocrytsals on first and third day

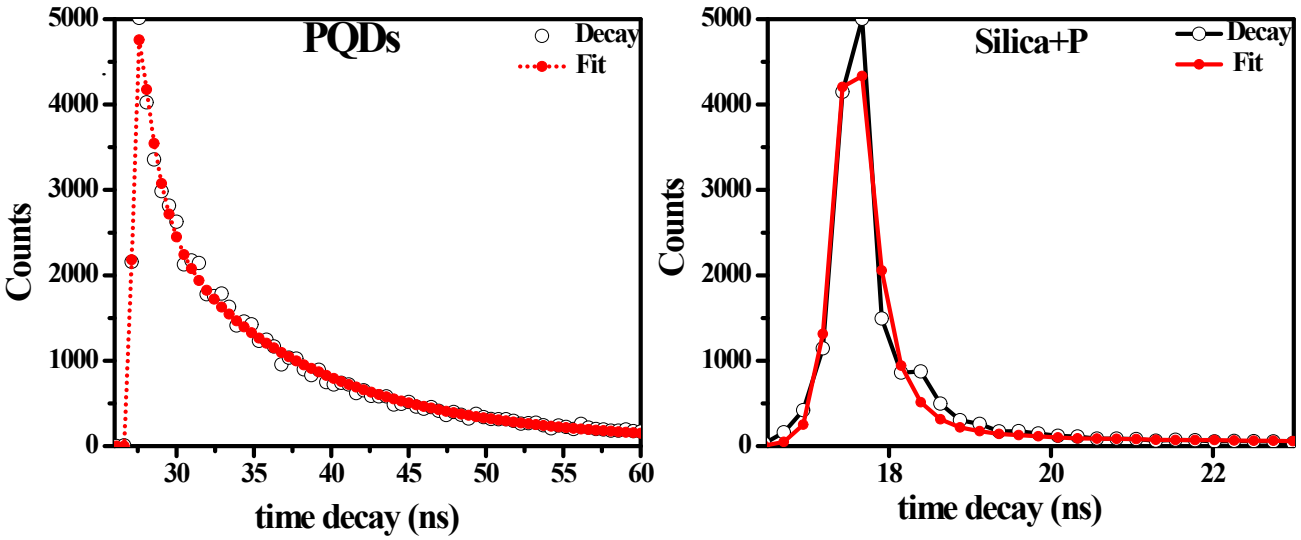

Figure S14 shows the TCSPC (life study) data of $MAPbBr_3$ (a) and $MAPbBr_3$ +Silica.

The data have taken in solution form on excitation value 405nm for perovskite quantum dot. And thin film of silica impregenated nanocrystal on excitation value 440nm [3].

References

1. R. Zhu, H. Liu, L. Shen, D. Sun, X. Li, *J. phy. and chem. solids* **2017***, 103,* 164-169.

2. M. B. Teunis, A. Jana, P. Dutta, M. A. Johnson, M. Mandal, B. B. Muhoberac, R. Sardar, *Chem. Mater.* **2016**, *28*, 5043-5054.

3. Y. Zhao, X. Xu, X. You, *Sci. Rep.* **2016,** *6*, 35931