

## **Supplementary Information**

### **MOF derived-Mn<sub>2</sub>O<sub>3</sub> decorated MoS<sub>2</sub>-graphene composite for visible light assisted degradation of environmentally hazardous penicillin G in water**

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#### **Instrumentation**

Powdered X-ray Diffraction (PXRD) was measured by Bruker APEX-2 diffractometer. Fourier Transform Infra Red spectra (FT-IR) were carried out with a Perkin-Elmer FT-IR spectrophotometer RXI. The X-ray Photoelectron Spectroscopy (XPS) was performed by Specs (German). Thermogravimetric Analysis (TGA) was analysed on Perkin-Elmer instrument, Pyris Diamond TG/DTA with Al<sub>2</sub>O<sub>3</sub> crucible. Transmission Electron Microscopy (TEM) and High Resolution TEM (HRTEM) were performed with JEOL JEM2010 electron microscope operating at 200 kV. Energy Dispersive X-ray (EDX) measurement was carried out with FEI TECNAI-G2-20S-TWIN (USA). BET surface area and N<sub>2</sub> sorption isotherms (77K) were carried out by Quantachrome Autosorb-1 instrument. Photoluminescence spectra were recorded by F-7000 FL Spectrophotometer. The photodegradation of PG were measured by UV- 1601, Shimadzu spectrophotometer and high performance liquid chromatography (HPLC, Thermo Fisher Scientific Dionex UltiMate 3000). Photo-electrochemical analyses,

such as photocurrent (LSV) and EIS were measured by a potentiostat (Versa STAT 3, Princeton Research, USA) consisted of a standard three-electrode system. Ag/AgCl (3 M KCl) was used as the reference electrode and Pt gauge was used as the counter electrode, and fluorine doped-tin oxide (FTO) glasses coated with the MSG, pure Mn<sub>2</sub>O<sub>3</sub> and MMG-3 composites were used as the working electrodes. The working electrode was prepared by doctor-blade method<sup>1</sup>. In each case, 0.2 M aqueous sodium sulphate solution has been used as the supporting electrolyte. The photocurrent response was measured at a scan rate of 50 mV s<sup>-1</sup> over the potential range -1.0 to 1.0 V. The electrochemical response was recorded under light irradiation ( $\lambda > 420$  nm, 300 W Xe lamp with a UV-cutoff filter).

1. J. Power Sources, 195 (2010) 7078-7082.

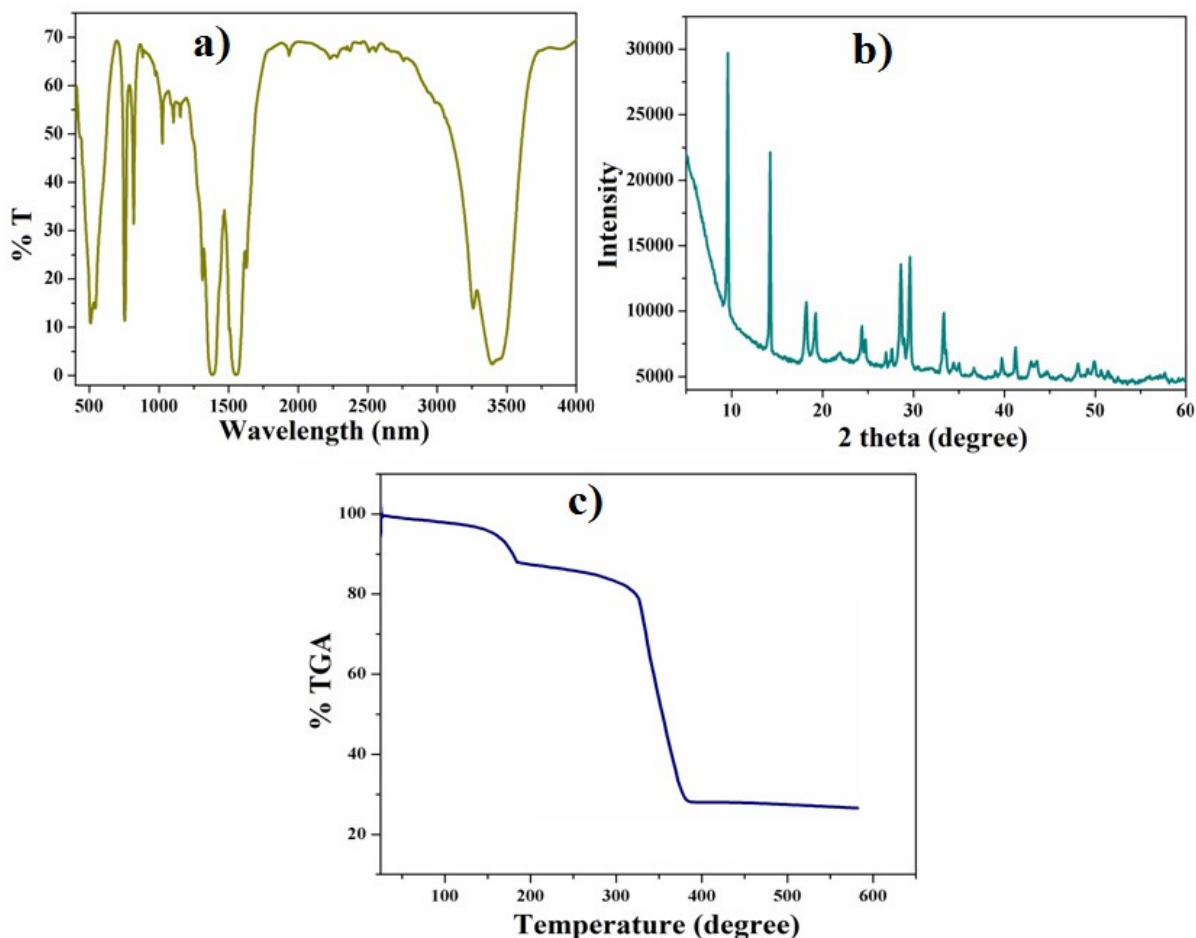


Fig. S1 a) FT-IR spectrum, b) PXRD pattern and c) TGA of the synthesized Mn-MOF.

The CO stretching frequency shifted from  $1686\text{ cm}^{-1}$  for the un-coordinated ligand 1,4- $\text{H}_2\text{BDC}$  to  $1564\text{ cm}^{-1}$  after the coordination with  $\text{Mn}^{2+}$  ions.<sup>1</sup> A strong and broad peak at around  $3384\text{ cm}^{-1}$  is due to  $\text{H}_2\text{O}$  molecules with hydrogen bonds, which participates in the coordination of  $\text{Mn}^{+2}$  in the Mn-MOF structures. The peak at  $1386\text{ cm}^{-1}$  in the MOF is for carboxylate stretching frequencies of the ligand,  $\text{BDC}^{2-}$ .

The PXRD of the MOF reveals sharp intense peaks indicating its crystalline nature.

TGA shows a minor weight loss at around  $150\text{--}175\text{ }^\circ\text{C}$  due to loss of water molecules from the MOFs, and a major weight loss ( $\sim 70\%$ ) at around  $350\text{ }^\circ\text{C}$  due to presence of terephthalate ligands in the Mn-MOF. Hence, the MOF was heated at  $400\text{ }^\circ\text{C}$  for their transformation to corresponding  $\text{Mn}_2\text{O}_3$ .

1. M. Rakibuddin, R. Ananthkrishnan, RSC Adv. 5 (2015) 68117-68127.

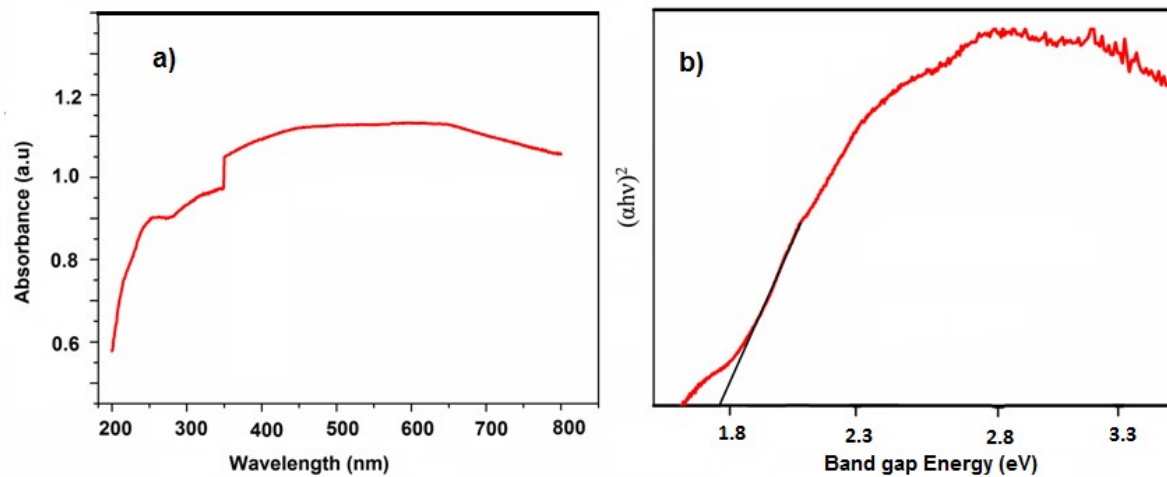


Fig. S2 a) Diffuse reflectance spectrum and b) Tauc plot for determination of band gap of the pure MSG.

The band gap of the pure MSG sample is calculated to be 1.75 eV.

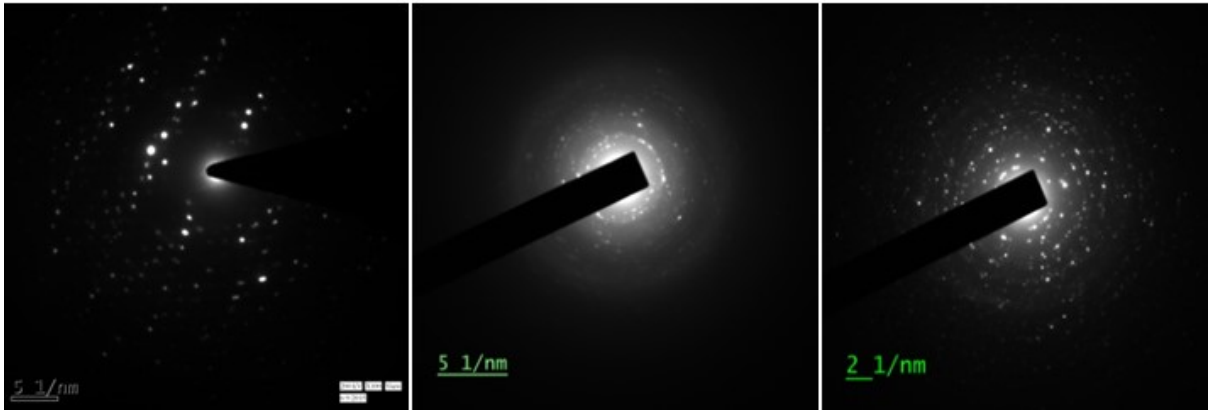


Fig. S3 SAED pattern of the  $\text{Mn}_2\text{O}_3$ , MSG and MMG hybrid.

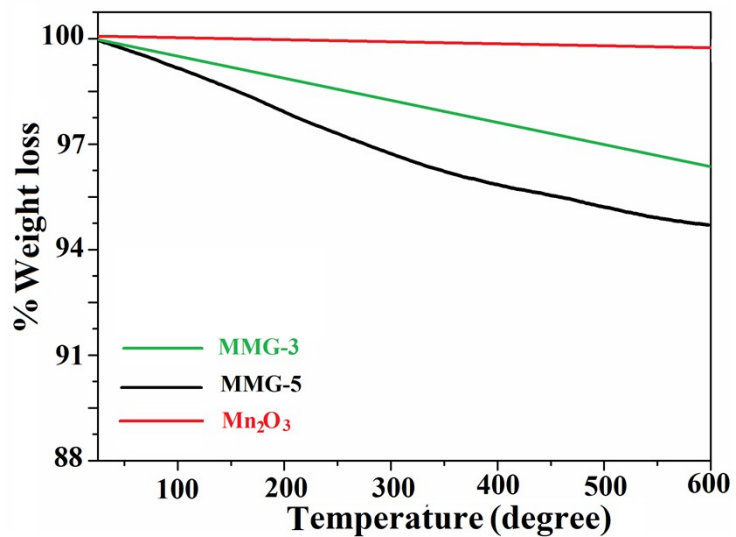
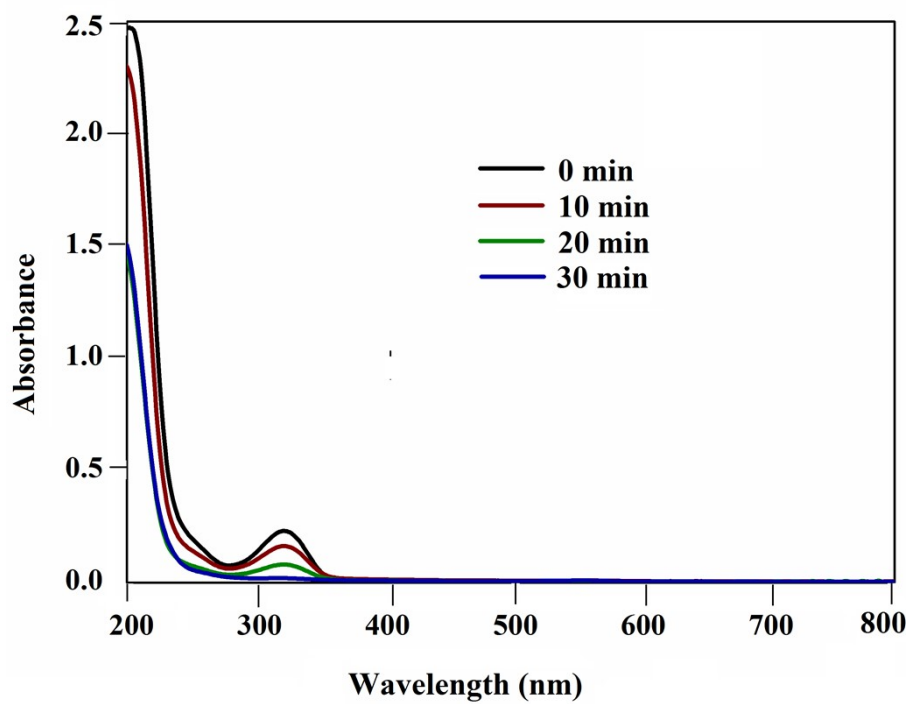
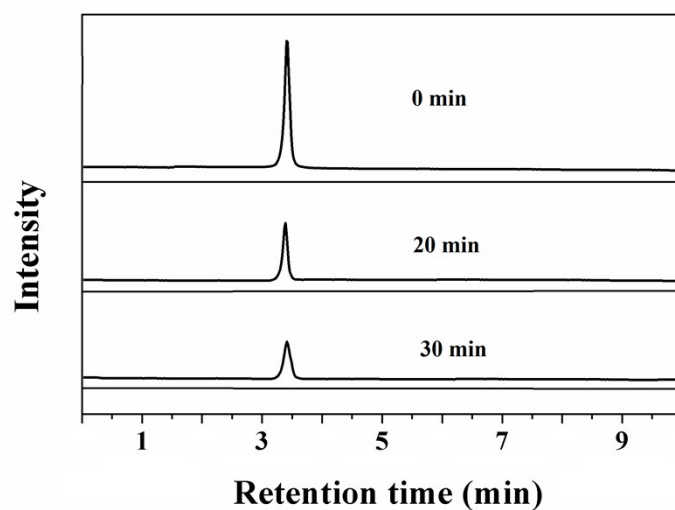


Fig. S4 TGA of the MMG-3, MMG-5 hybrid and Mn<sub>2</sub>O<sub>3</sub>

The weight loss in the TGA profile indicates the presence of 3% and 5% MSG in the MMG-3 and MMG-5 hybrid, respectively.



**Fig. S5** UV-Visible absorption spectra (200 to 800 nm) for the degradation of PG under visible light in presence of MMG-3.



**Fig. S6** HPLC Chromatogram for the degradation of PG at different time intervals under visible light in presence of MMG-3 composite.

HPLC chromatogram indicates degradation of PG with time under visible light in presence of the catalyst. The HPLC were consisted of a UV/Vis Diode Array Detector and a reversed-phase Acclaim Polar Advantage-II column (3  $\mu\text{m}$ , 120  $\text{\AA}$ , 3  $\times$ 150 mm). The chromatographic conditions were: 80: 20 for mobile phase (V) acetonitrile: water, 0.3 mL  $\text{min}^{-1}$  for the flow rate of mobile phase, 20  $\mu\text{L}$  for the injection volume, 30  $^{\circ}\text{C}$  for column temperature and the detection wavelengths for PG was 325 nm.

From the HPLC analysis, a sharp chromatogram peak of PG is observed at the retention time of 3.5 min, which is gradually decreased with time indicating gradual degradation of the PG as supported by the UV-Vis spectra. No other products are found in the chromatogram which suggests direct mineralization of PG into  $\text{CO}_2$  and water by the MMG-3 composite.



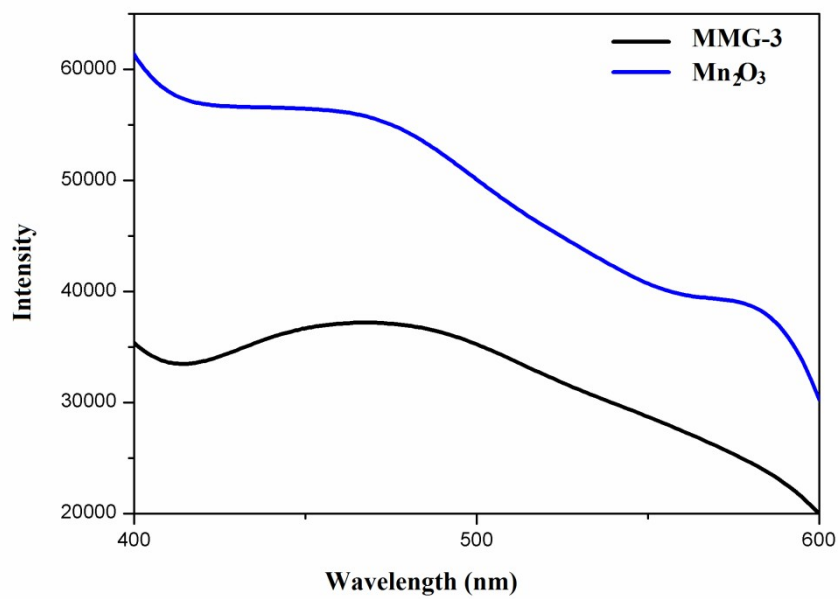


Fig.S7 PL spectra of the MMG-3 hybrid and Mn<sub>2</sub>O<sub>3</sub>.