Supporting Information

Activation of O_2 over three-dimensional manganese oxide nanoprism at ambient condition towards oxidative removal of aqueous organics

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1. Chemicals and reagents

Oxone ($2KHSO_5 \cdot KHSO_4 \cdot K_2SO_4$, 95%), potassium permanganate, manganese (II) sulfate monohydrate, cerium nitrate hexahydrate and bismuth nitrate pentahydrate were bought from Shanghai Titan Scientific Technology Co., Ltd. and used in the degradation reactions directly. Antibiotics in Fig. 10b and bisphenol A were purchased from Shanghai Jiuding Chemical Technology Co., Ltd.. Estriol was purchased from Aladdin Reagent Co., Ltd..

2. Synthesis of catalysts

Undoped OMS-2 was obtained following the reported procedure [73]. Ce- and Bi-doped OMS-2 catalysts with different dopant loading (Ce and Bi = 1, 2, 8 and 20 wt% to Mn) were prepared following the method from our previous work [72].

3. Experimental procedure

Typically, the reactions were performed at room temperature (25 ± 2 °C) under exposure to air or N_2. Specifically, 12.5 mg of catalyst was added into a round-neck flask with 50 mL of model pollutant solution at 50 mg/L concentration. The reaction solution was stirred under ambient conditions for indicated time. 1 mL of sample was obtained for the reaction solution and analyzed by UV-vis under the maximum adsorption wavelength after filtration by a film. The pH of the solution was adjusted *via* the addition of H_2SO_4 and NaOH solution (1.0 M). The degradation rate was calculated as:

$$\text{Degradation rate (\%)} = \frac{C_0 - C_t}{C_0} \times 100\%$$

where C_0 and C_t are the initial and final pollutant concentration determined on UV absorbance value .

TOC was analyzed following the reaction conditions as: 500 mg/L of catalyst and 50 mg/L of model pollutant. The mineralization rate was determined when the reaction was run at 65 min as:

$$\text{Mineralization rate (\%)} = \frac{T_0 - T_t}{T_0} \times 100\%$$

where T_0 and T_t are the initial and final TOC value in the model wastewater

determined on a TOC device.

4. Analytical methods

The crystal phase of as-obtained materials was analyzed by XRD analysis (Rigaku Ultima IV). N_2 adsorption/desorption isotherms of as-obtained materials was performed Micrometrics Tristar II 3020. The structural morphologies, sizes and shapes of as-obtained materials were characterized by scanning electron microscopy (SEM, HITACHI, SU8020) and transmission electron microscopy (TEM, JEOL 2100F, Netherlands). And, element mapping of Ce-Bi-OMS-2-8wt% was conducted on the same transmission electron microscope operated at 200 kV. XPS analysis was carried out in an ultra-high vacuum (UHV) chamber using a Thermo Scientific Escalab 250XI (Thermo Fischer, USA). Hydrogen temperature-programmed reduction (H_2-TPR) and oxygen temperature-programmed desorption (O_2-TPD) experiments were conducted on a chemosorption analyzer (Bjbuilder, PCA1200) to investigate the reducibility and surface oxygen species of the as-obtained materials. Electron paramagnetic resonance (EPR) experiments were conducted on a Bruker spectrometer (EMXnano). UV-vis. analysis was performed by using a UV–Vis spectrophotometer from Shimadzu Company (UV-1900). And, total organic carbon (TOC) removal rate was investigated by the use of a total organic carbon analyzer from Shimadzu Company (TOC-L CPN).

5. Characterization of catalysts

Table S1. The textural properties of OMS-2, Ce-Bi-OMS-2-8wt% and Ce-Bi-OMS-2-xwt%.

Material	Surface area ($m^2\ g^{-1}$)	Pore volume ($cm^3\ g^{-1}$)	Pore size (nm)
OMS-2	79	0.59	33.6
Ce-OMS-2-8wt%	115	0.29	9.1
Ce-Bi-OMS-2-1wt%	94	0.48	21.2
Ce-Bi-OMS-2-2wt%	101	0.51	19.9
Ce-Bi-OMS-2-8wt%	147	0.36	9.2
Ce-Bi-OMS-2-20wt%	205	0.28	4.7
Used Ce-Bi-OMS-2-8wt%	48	0.21	18.0

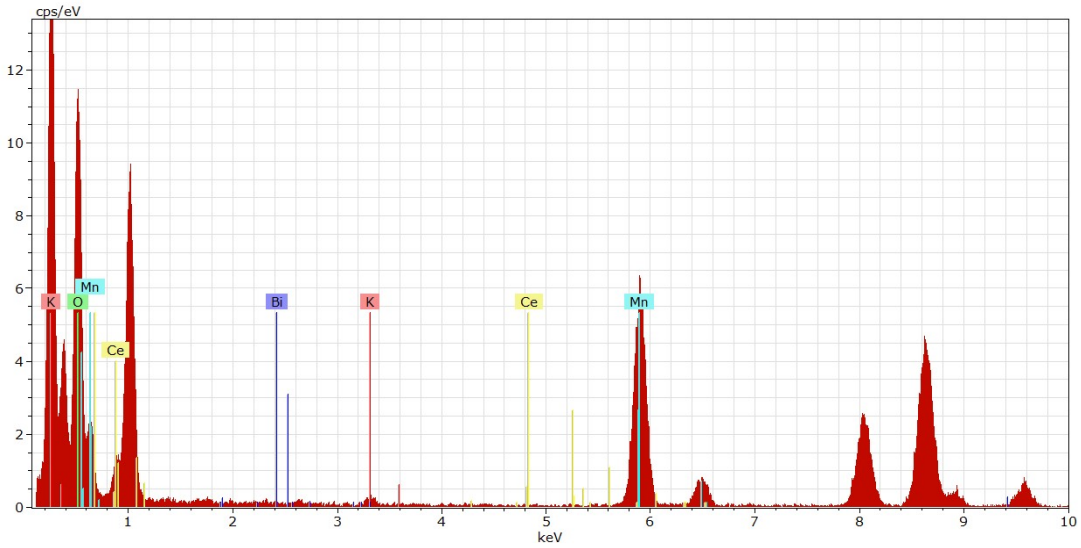

Figure S1. EDX map sum spectrum of Ce-Bi-OMS-2-8wt%.

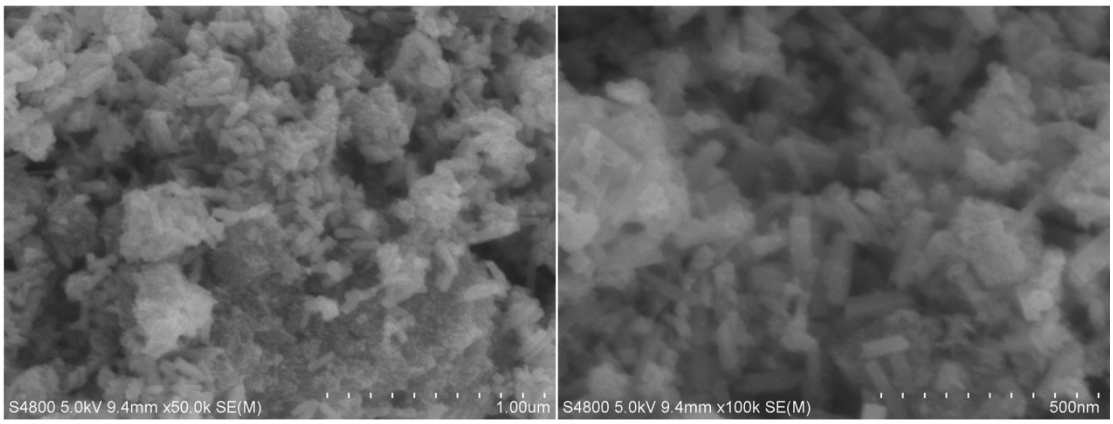

Figure S2. SEM images of ground Ce-Bi-OMS-2-8wt% after ball-milling.

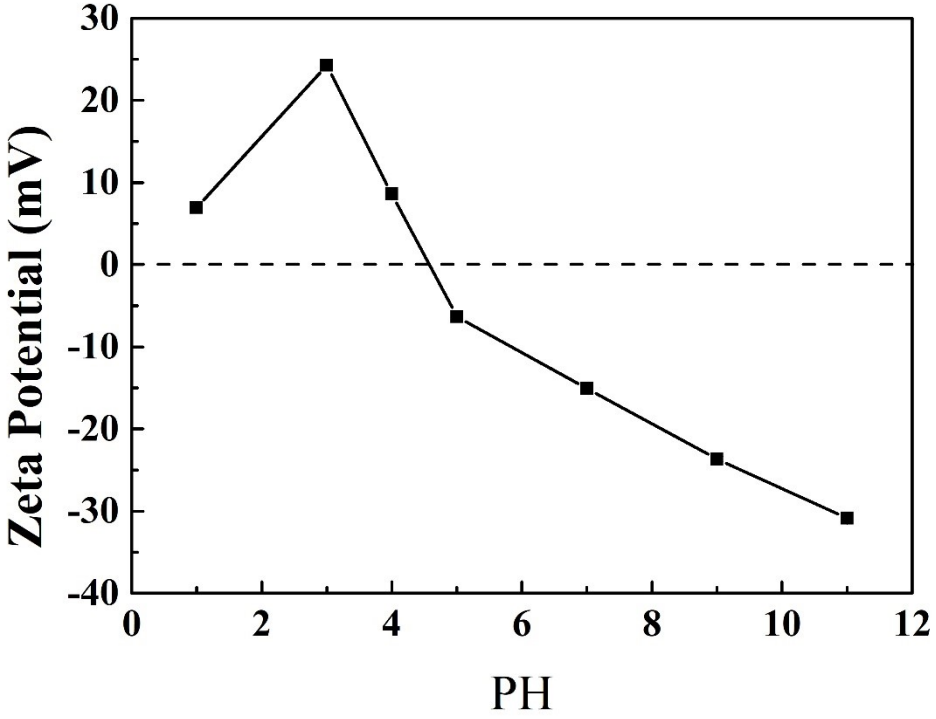

Figure S3. The zero point of charge (zpc) of Ce-Bi-OMS-2-8wt%.

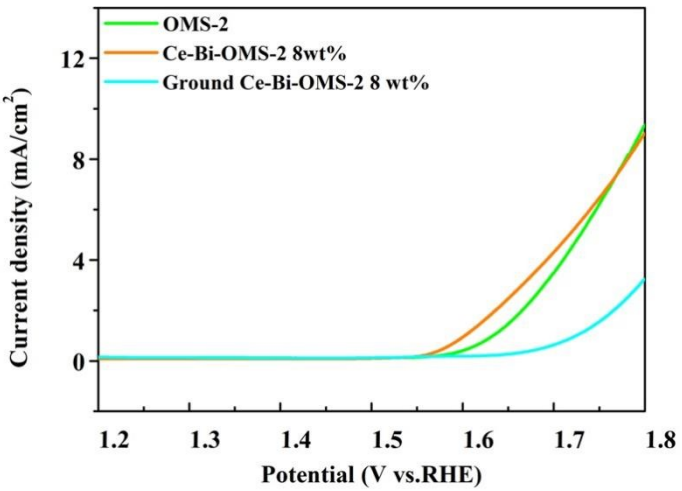

Figure S4. linear-sweep voltammograms curves of OMS-2, Ce-Bi-OMS-2-8wt% and ground Ce-Bi-OMS-2-8wt%.

6. Recycling experiments and detection of intermediates

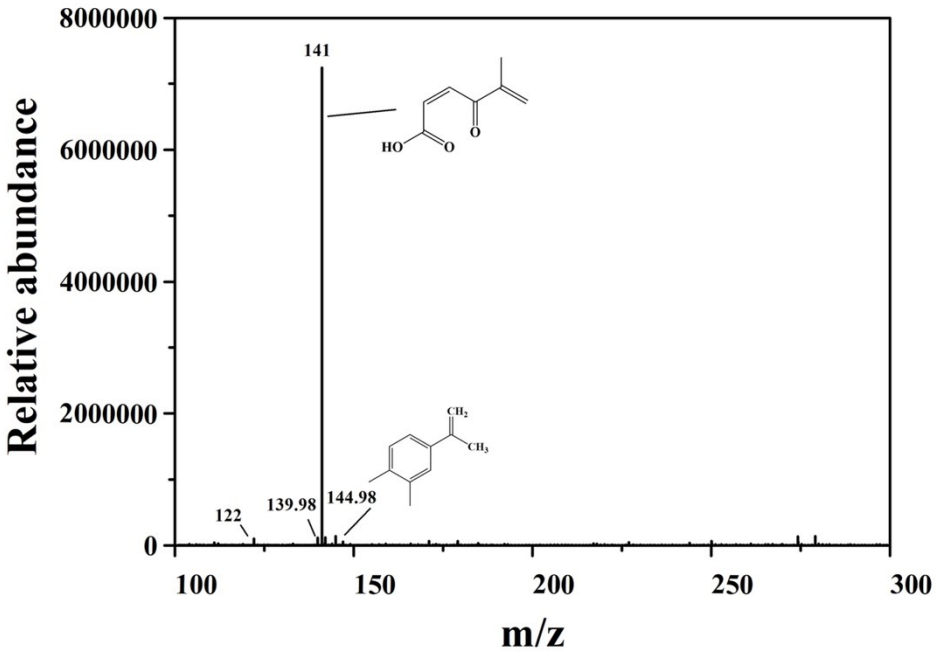

Figure S5. The HR-MS of the product after BPA degradation

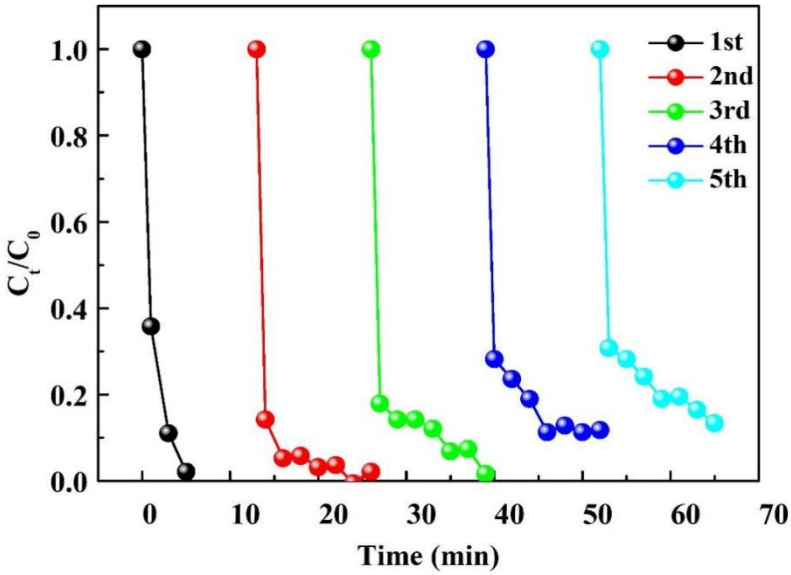

Figure S6. Cycling runs in the degradation of BPA, reaction condition: 20 mg/L of BPA, 0.5 g/L of Ce-Bi-OMS-2-8wt%, 50 mL of water, pH=1 at 30 °C.

7. Characterization of used catalyst

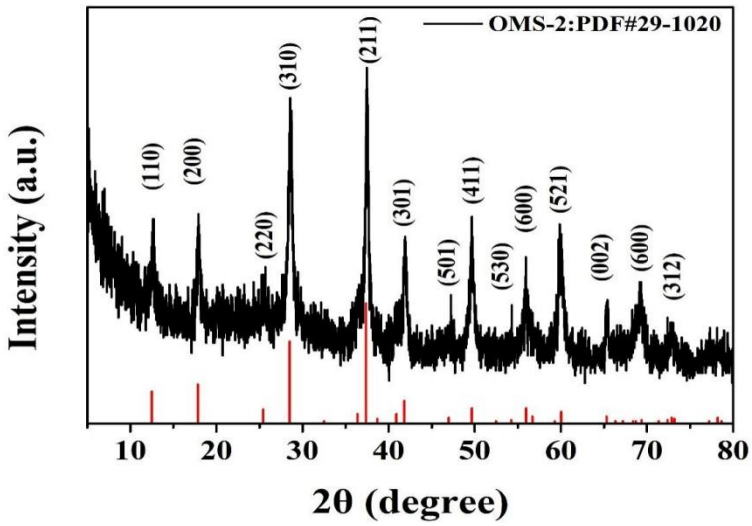

Figure S7. XRD of 5th reused Ce-Bi-OMS-2-8wt%.

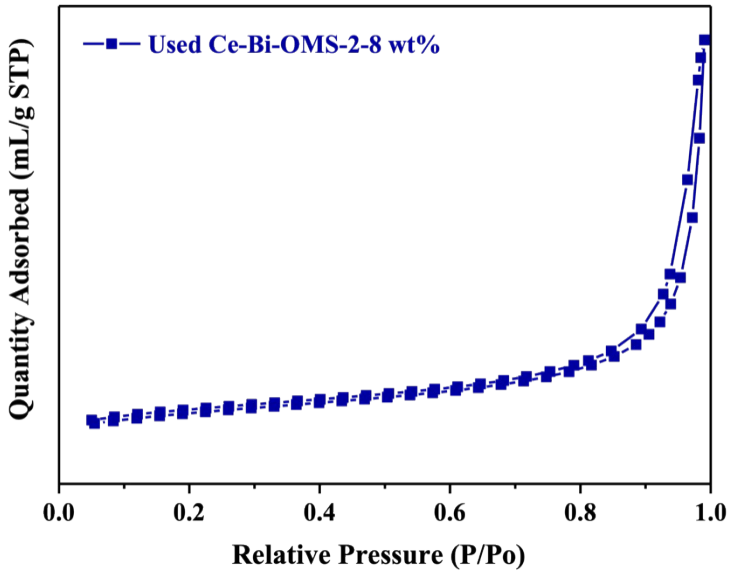

Figure S8. N2 adsorption/desorption isotherm of used Ce-Bi-OMS-2-8wt%.

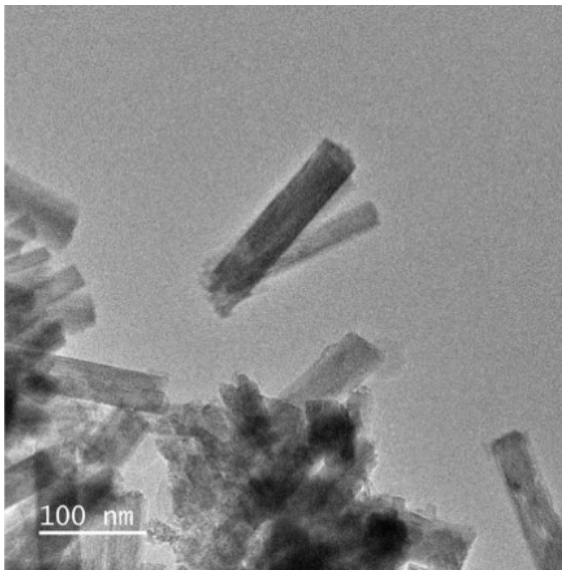

Figure S9. TEM of 5th reused Ce-Bi-OMS-2-8wt%.

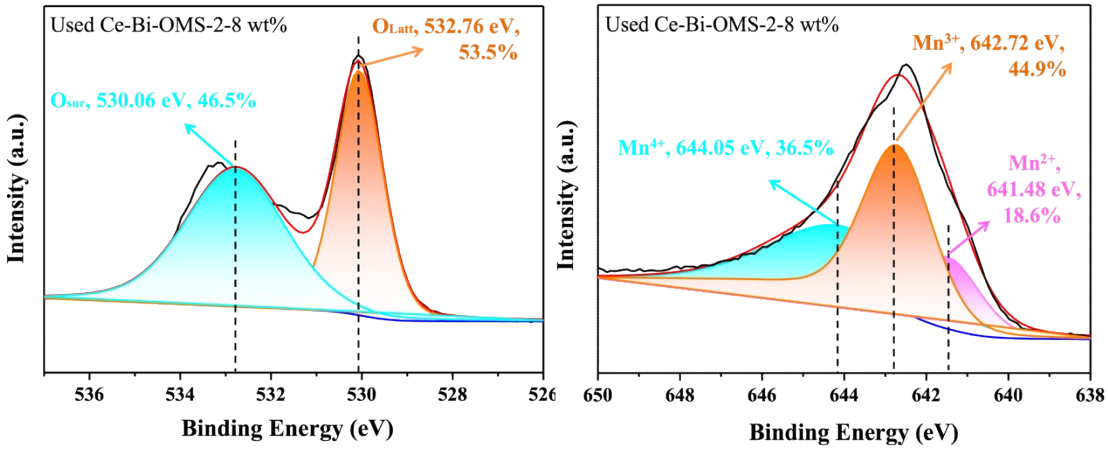

Figure S10. The O1s and Mn 2p3/2 XPS patterns of used Ce-Bi-OMS-2-8wt%.