Supplemental Information

Mesoporous Amorphous Al_2O_3/Crystalline WO_3 Heterophase Hybrids for Electrocatalysis and Gas Sensing Applications

Yidong Zou[‡a], Shibo Xi[‡b], Tao Bo[c], Xinran Zhou[a], Junhao Ma[a], Xuanyu Yang[a], Caozheng Diao[d] and Yonghui Deng[a,*]

[a] Department of Chemistry, State Key Laboratory of Molecular Engineering of Polymers, Shanghai Key Laboratory of Molecular Catalysis and Innovative Materials, *iChEM*, Fudan University, Shanghai 200433, China

[b] Institute of Chemical and Engineering Sciences, Agency for Science, Technology and Research in Singapore (A*STAR), 1 Pesek Road, Jurong Island, 627833, Singapore

[c] Institute of High Energy Physics, Chinese Academy of Science (CAS), Beijing 100049, China

[d] Singapore Synchrotron Light Source, National University of Singapore, 5 Research Link, Singapore 117603, Singapore

* Corresponding author.

E-mail: yhdeng@fudan.edu.cn (Y. H. Deng)

‡ Y. D. Zou and Dr S. B. Xi contributed equally to this work.

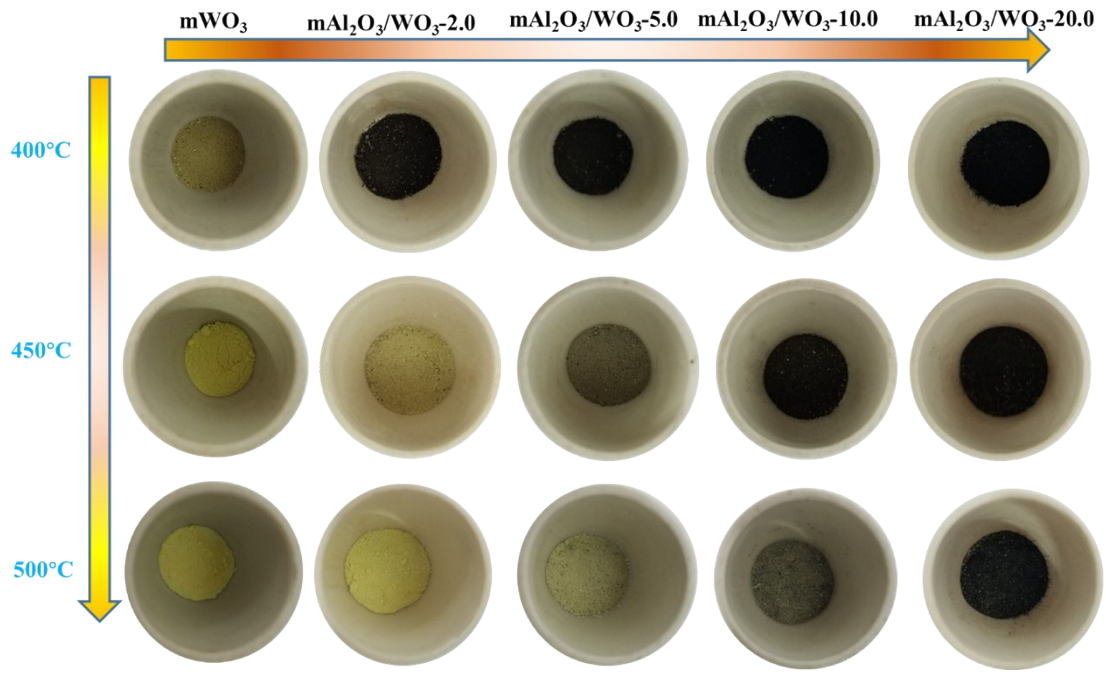

Figure S1. Optical photographs of the mAl_2O_3/WO_3-*X* (*X* =0, 2.0, 5.0, 10.0 and 20.0) after carbonization in N_2 (350 °C/500 °C) and calcination in air at 400 °C for 1 h, 450 °C for 1 h and 500 °C for 0.5 h, respectively.

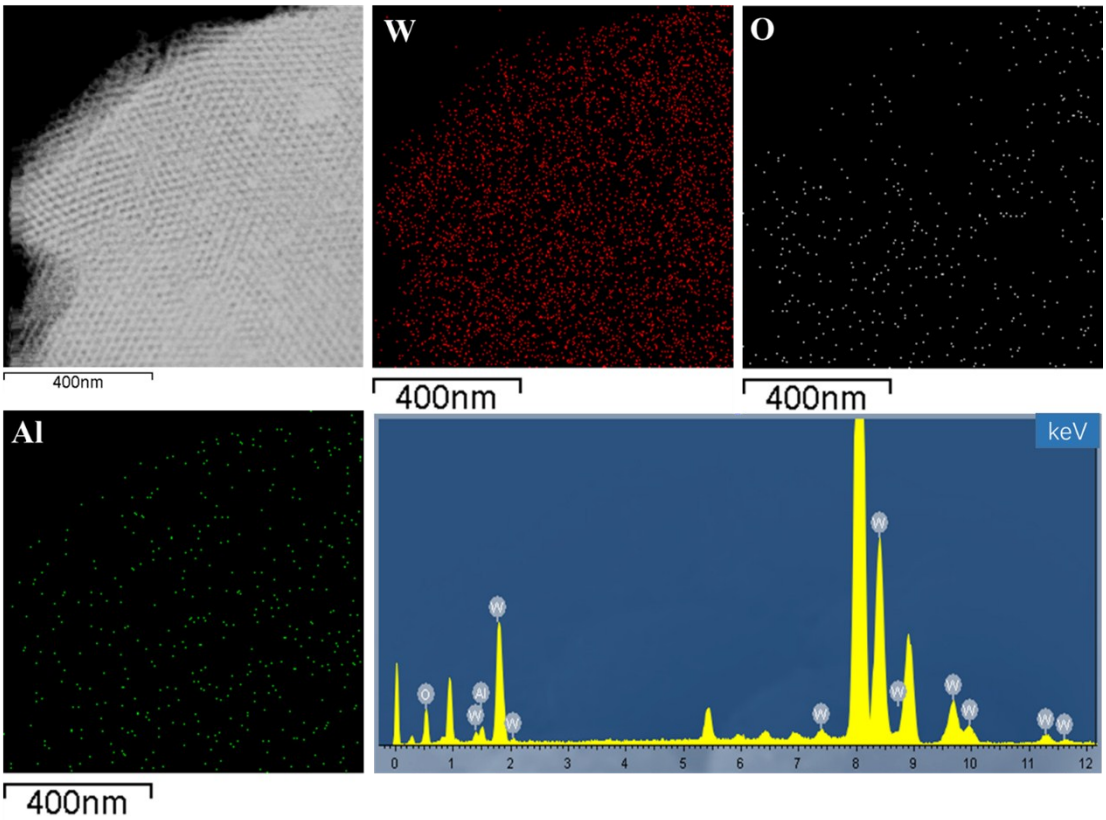

Figure S2. HAADF-STEM image of mAl_2O_3/WO_3-5.0 after carbonization in N_2 (350 °C/500 °C) and calcination in air at 450 °C. The corresponding EDX and elemental mapping images of mAl_2O_3/WO_3-5.0 with W, Al and O elements.

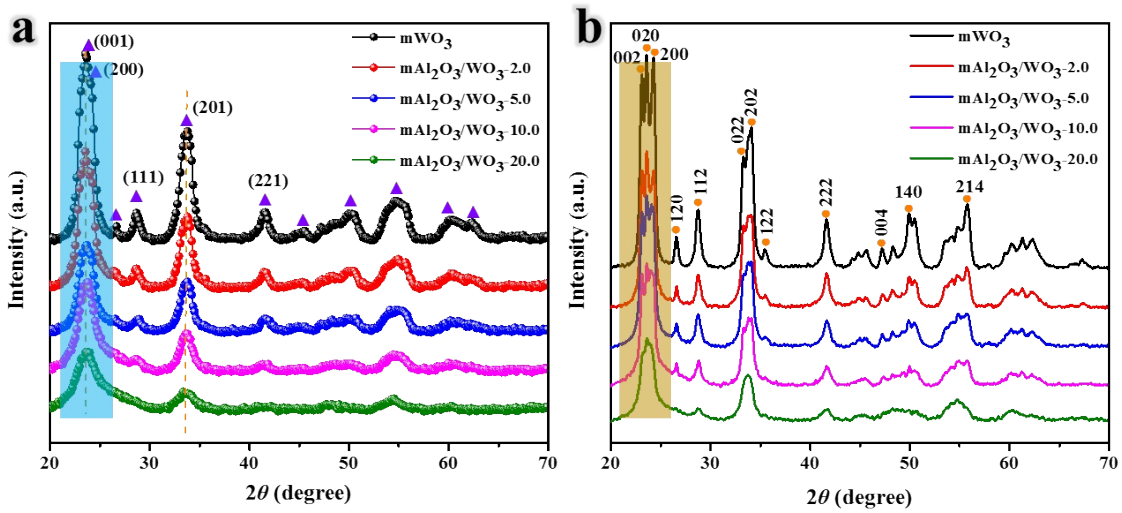

Figure S3. (a) XRD patterns of the various Al_2O_3 content for mAl_2O_3/WO_3-*X* composites after calcination in air at 400 °C (*X* =0, 2.0, 5.0, 10.0 and 20.0). (b) XRD patterns of the various Al_2O_3 content for mAl_2O_3/WO_3-*X* composites after calcination in air at 500 °C (*X* =0, 2.0, 5.0, 10.0 and 20.0).

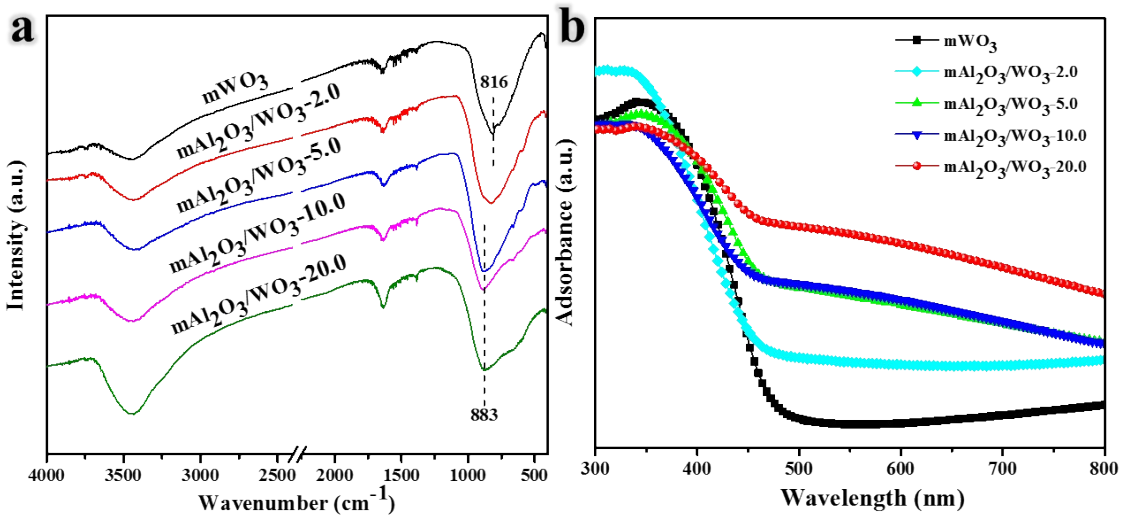

Figure S4. (a) FT-IR spectra and (b) UV-DRS of the various Al_2O_3 content for mAl_2O_3/WO_3-*X* composites after calcination in air at 450 °C.

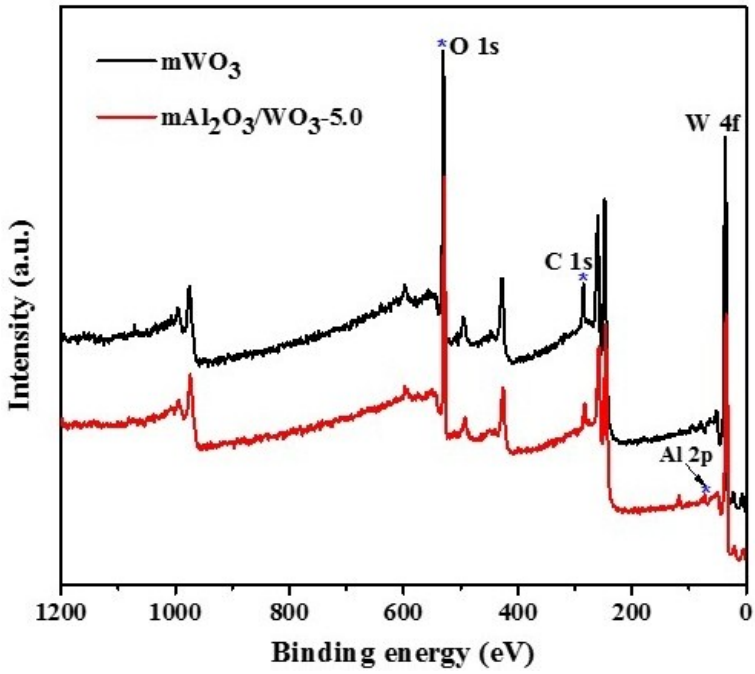

Figure S5. Wide scan XPS spectra of pure mWO_3 and mAl_2O_3/WO_3-5.0 composites after carbonization in N_2 at 350 °C and calcination at 450 °C in air.

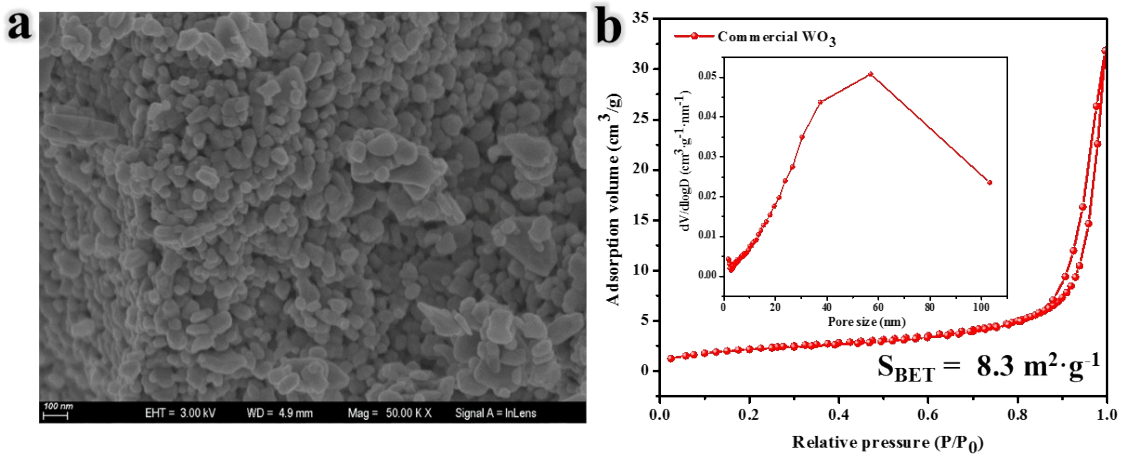

Figure S6. (a) FESEM images of standard commercial WO_3 nano-powders and (b) N_2 adsorption-desorption isotherms recorded at 77 K. The inset in panel (b) is the corresponding pore size distribution curve (the measured pores are from the voids among the closely packed WO_3 particles).

Table S1. Textural properties of the ordered mesoporous mAl_2O_3/WO_3-*X* (*X* = 0, 2.0, 5.0, 10.0 and 20.0) samples calcination in air at 450 °C

Samples	Pore size D (nm) [a]	S_{BET} [b] ($m^2 \cdot g^{-1}$)	V_t [c] ($cm^3 \cdot g^{-1}$)
mWO_3	15.3	42.5	0.150
mAl_2O_3/WO_3-2.0	20.9	52.5	0.179
mAl_2O_3/WO_3-5.0	19.2	58.8	0.178
mAl_2O_3/WO_3-10.0	20.8	67.3	0.188
mAl_2O_3/WO_3-20.0	20.6	72.6	0.202

[a] *D*: pore diameter derived from the adsorption branches at the maxima of BJH pore size distribution curves; [b] S_{BET}: BET specific surface area; [c] V_t: total pore volume was calculated from *t*-plot method.

Table S2. Relative contents of different groups of mWO_3 and mAl_2O_3/WO_3-5.0 calculated from XPS analysis

Samples	O 1s			W 4f			
	lattice oxygen O^{2-}	dissociative O^-	adsorbed molecular oxygen	W^{5+} $4f_{5/2}$	W^{5+} $4f_{7/2}$	W^{6+} $4f_{5/2}$	W^{6+} $4f_{7/2}$
mWO_3	530.10 eV	530.90 eV	532.45 eV	37.40 eV	35.22 eV	35.73 eV	37.88 eV
	76.44%	13.96%	9.60%	31.47%	33.88%	21.70%	12.95%
mAl_2O_3/WO_3-5.0	530.14 eV	531.05 eV	532.40 eV	37.48 eV	35.14 eV	35.81 eV	38.03 eV
	46.99%	44.05%	8.96%	24.60%	16.00%	28.36%	31.04%