## **Electronic Supplementary Information (ESI)**

Nonstoichiometric tungsten oxide resides in 3D nitrogen doped carbon matrix, a

composite photocatalyst for oxygen vacancy induced VOCs degradation and  $\ensuremath{\text{H}}_2$ 

## production

Luyue Wang,<sup>a</sup> Xinxin Xu,\*<sup>a</sup> Shijie Wu<sup>a</sup> and Feng Cao\*<sup>b</sup>

<sup>a</sup> Department of Chemistry, College of Science, Northeastern University, Shenyang,

110819, P.R. China.

<sup>b</sup> Key Laboratory for Anisotropy and Texture of Materials (Ministry of Education),

Northeastern University, Shenyang, 110819, P.R. China.



Fig. S1 High resolution C 1s of WO<sub>3-x</sub>/NC, (a) WO<sub>3-x</sub>/NC(A); (b) WO<sub>3-x</sub>/NC(B) and (c)

WO<sub>3-x</sub>/NC(C).



Fig. S2 High resolution N 1s of  $WO_{3-x}/NC$ , (a)  $WO_{3-x}/NC(A)$ ; (b)  $WO_{3-x}/NC(B)$  and (c)

WO<sub>3-x</sub>/NC(C).



Fig. S3 (a) Photocatalytic degradation efficiency of formaldehyde by  $WO_3$ ; (b) Time course of  $CO_2$  produced by  $WO_3$ .



**Fig. S4** FTIR of **WO<sub>3-x</sub>/NC** composite photocatalyst before and after adsorption of formaldehyde, (a) **WO<sub>3-x</sub>/NC(A)**; (b) **WO<sub>3-x</sub>/NC(B)** and (c) **WO<sub>3-x</sub>/NC(C)**.



Fig. S5 (c) Repeated time courses of benzene degradation.



Fig. S6 (a) Photocatalytic degradation efficiency of formaldehyde by  $WO_{3-x}/NC(D)$ ; (b) Time course of  $CO_2$  produced by  $WO_{3-x}/NC(D)$ ; (c) EPR of  $WO_{3-x}/NC(C)$  and  $WO_{3-x}/NC(D)$ .



Fig. S7 Time courses of photocatalytic  $H_2$  production for  $WO_{3-x}/NC(C)$  in dark.