Supplementary Information

Ag-ZrO_2-graphene oxide nanocomposite as a metal-leaching-resistant catalyst for the aqueous-phase hydrogenation of levulinic acid into gamma-valerolactone

Xufeng Bai[1], Ting Rin[1,2], Jingbo Mao[1], Shenmin Li[1*], Jingmei Yin[1], and Jinxia Zhou[1*]

[1] College of Environmental and Chemical Engineering, Dalian University, Dalian, 116622, China.

[2] No. 3 Middle School of Liaocheng, North District, Liaocheng 252000, China

* Corresponding Email: zhoujxmail@163.com (J. Z.); lishenmin@dlu.edu.cn (S. L.)

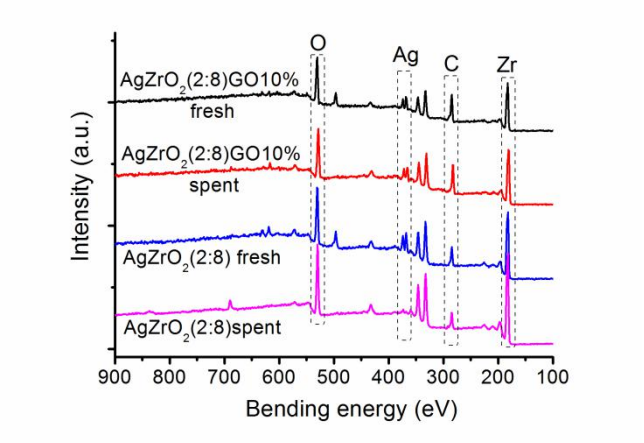

Fig. S1 The whole XPS survey profiles of the fresh and spent $AgZrO_2$(2:8)GO10% and $AgZrO_2$(2:8) catalysts.

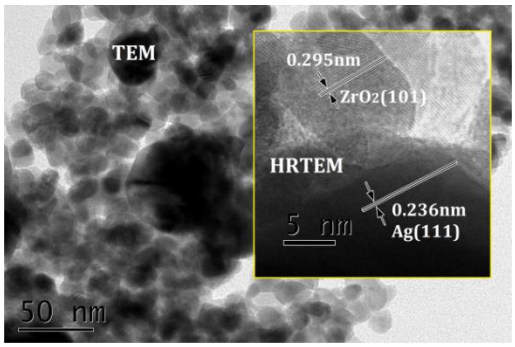

Fig. S2 TEM and HRTEM images of the spent $AgZrO_2$(2:8) catalyst.

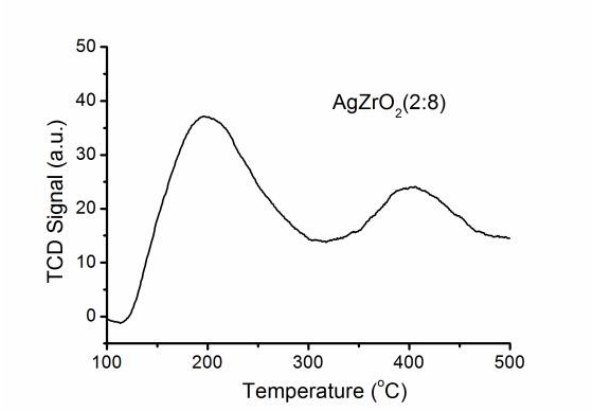

Fig. S3 NH_3-TPD analysis of $AgZrO_2$(2:8).

The catalysts containing graphene oxide (GO) cannot undergo NH_3-TPD analysis because of the thermal reaction between GO and NH_3. Reference [S1] and [S2] introduced chemical methods to obtain N-dopedgraphene through thermal annealing of GO in an NH_3atmosphere. GO sheets annealed at various reaction temperatures reveals that N-doping occurs at a temperature as low as 300 °C, while the doping levels of N variate between 300 and 1100 °C. Oxygen groups in GO were found responsible for reactions with NH_3 and C-N bond formation. The functional groups such as carbonyl, carboxyl, lactone and quinone at the edges and in the plane of graphene oxide were favorable for the binding of nitrogen.

We tested the acidity of $AgZrO_2$(2:8) by NH_3-TPD analysis. As shown in Fig. S3. The large desorption peak at around 200 °C and the small desorption peak at around 400 °C in the sample curve indicate that it has sufficient weak acid sites and a few moderately strong acid sites. It means that the *t*-ZrO_2 component possesses acidity and can perform acidic catalysis. $AgZrO_2$(2:8)GO10% and $AgZrO_2$(2:8) contain the same *t*-ZrO_2component according to the XRD and XPS analysis. Therefore, the *t*-ZrO_2 component of$AgZrO_2$(2:8)GO10% can also perform acidic catalysis.

Reference

[S1] X. Li, H. Wang, J. T. Robinson, H. Sanchez, G. Diankov, H. Dai, J. Am. Chem. Soc. 131(2009)15939-15944.

[S2] S. Yang, L. Zhi, K. Tang, X. Feng, J. Maier, K. Müllen, Adv. Funct. Mater. 17(2012)3634-3640.