

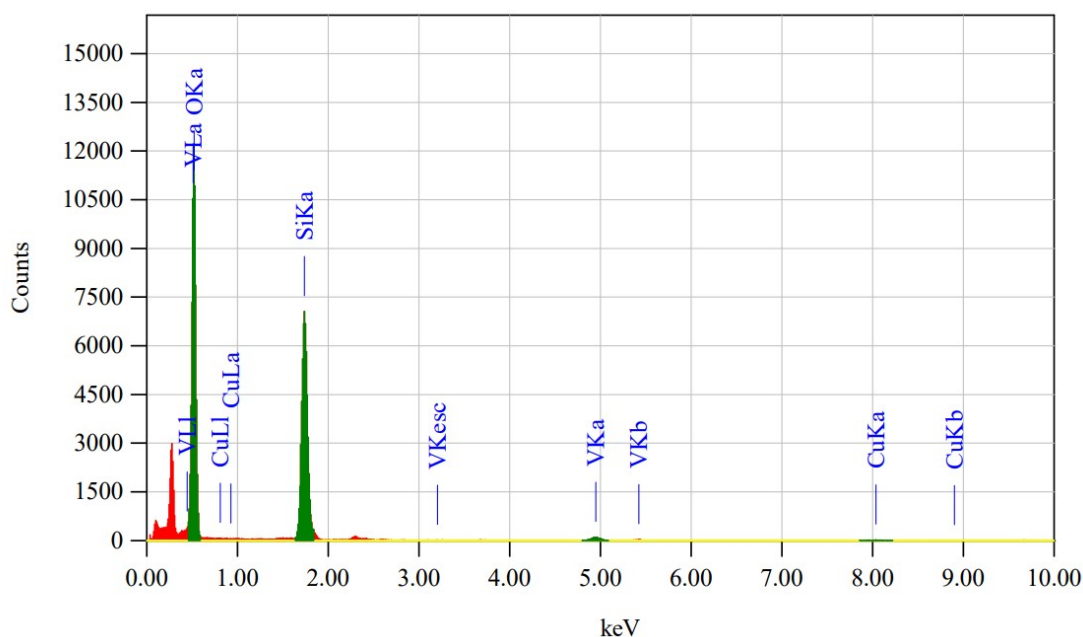
## Supporting Information

### Highly efficient selective oxidation of toluene to benzaldehyde over Cu-V oxides supported on amorphous SiO<sub>2</sub>

Xiaozhong Wang<sup>a,b</sup>, Xiongfei Shi<sup>a</sup>, Shenyuan Gao<sup>a</sup>, Gang Xu<sup>a,\*</sup>, Jianhai Yang<sup>a,b</sup>, Jia Guo<sup>a,b</sup>, Liyan Dai<sup>a,b,\*</sup>

<sup>a</sup> College of Chemical and Biological Engineering, Zhejiang University, Zhejiang Provincial Key Laboratory of Advanced Chemical Engineering Manufacture Technology, Hangzhou 310027, China

<sup>b</sup> Institute of Zhejiang University - Quzhou, Quzhou 324000, China

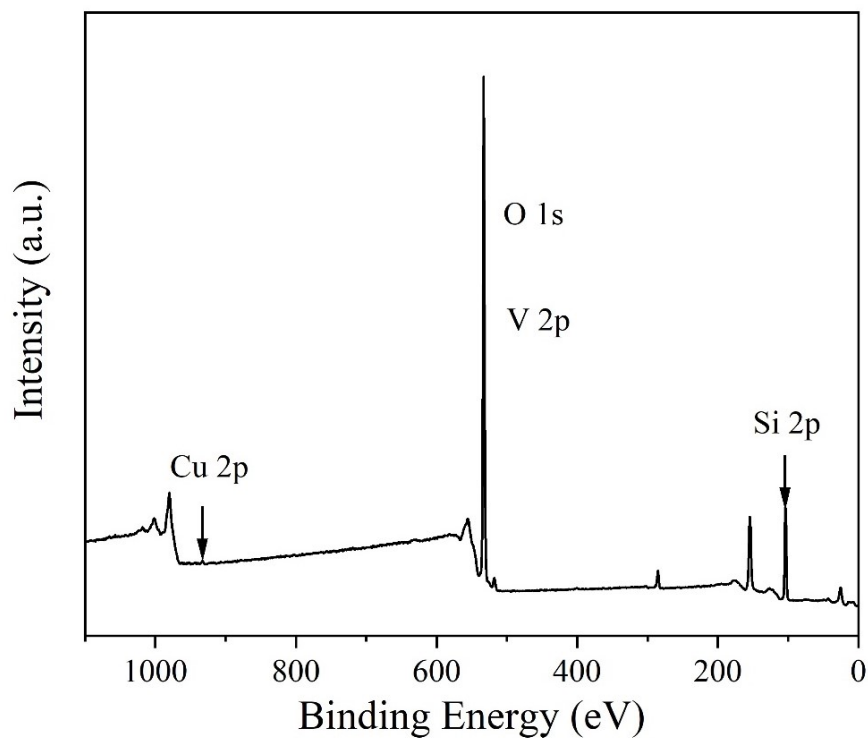


**Fig. S1** The corresponding energy dispersive X-ray spectrum (EDS) of 1Cu-4V/SiO<sub>2</sub>

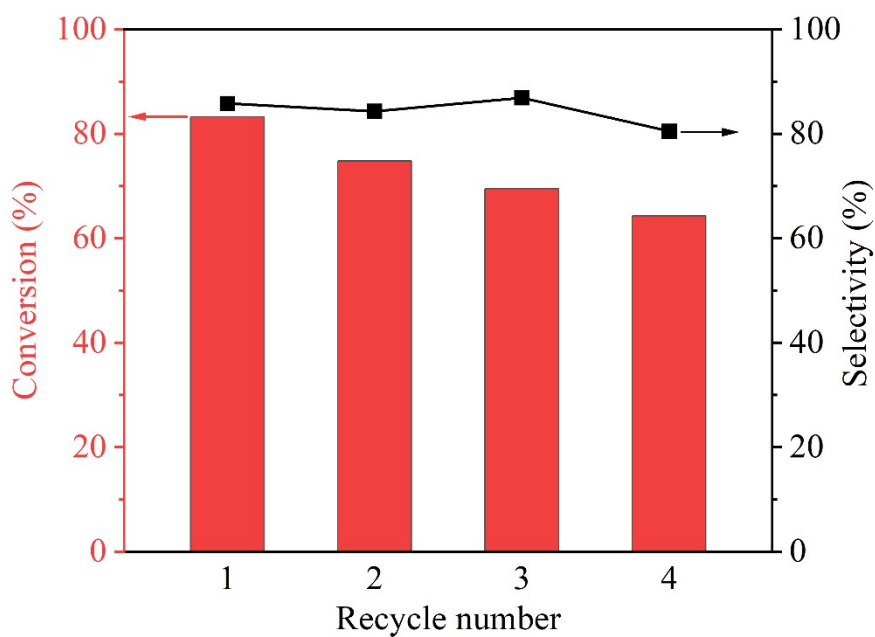
**Table S1** The loadings of Cu and V in the catalysts

Catalyst	Cu loadings (wt%)	V loadings (wt%)
4Cu-1V/SiO <sub>2</sub>	9.85	0.31
2Cu-1V/SiO <sub>2</sub>	6.34	0.92
1Cu-1V/SiO <sub>2</sub>	4.01	1.89
1Cu-2V/SiO <sub>2</sub>	2.79	2.98
1Cu-4V/SiO <sub>2</sub>	2.56	5.57

Obtained by ICP-OES test



**Fig. S2** XPS survey of 1Cu-4V/SiO<sub>2</sub>

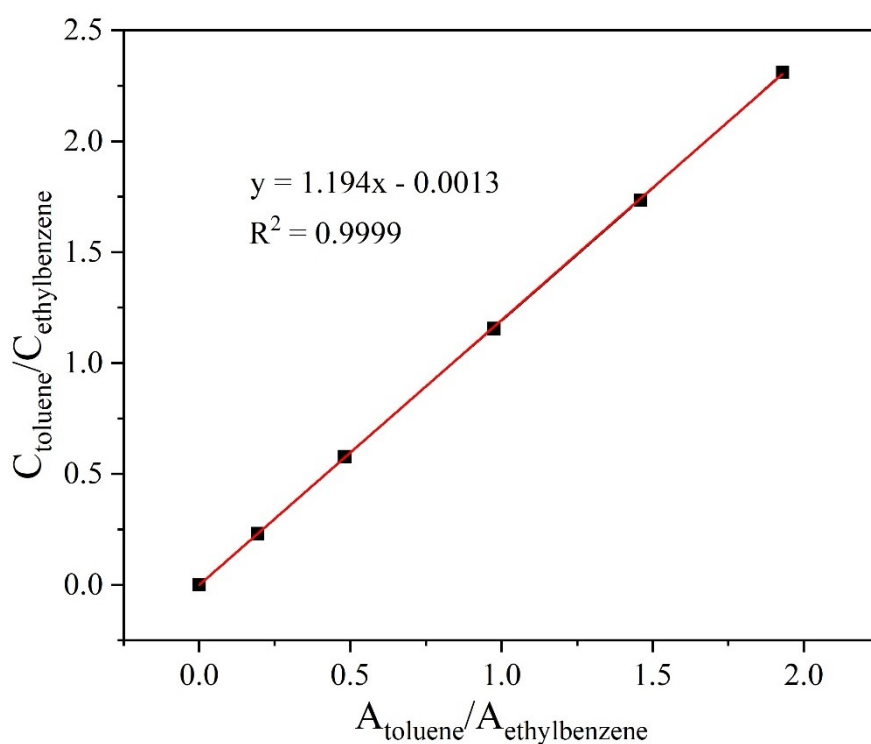


**Fig. S3** Recycle experiment of 1Cu-4V/SiO<sub>2</sub>. Reaction conditions: toluene (2.5 mmol), PDS (5.0 mmol), H<sub>2</sub>O/CH<sub>3</sub>CN (5ml, volume ratio: 1:1), catalyst (46 mg), 60 °C, 6 h.

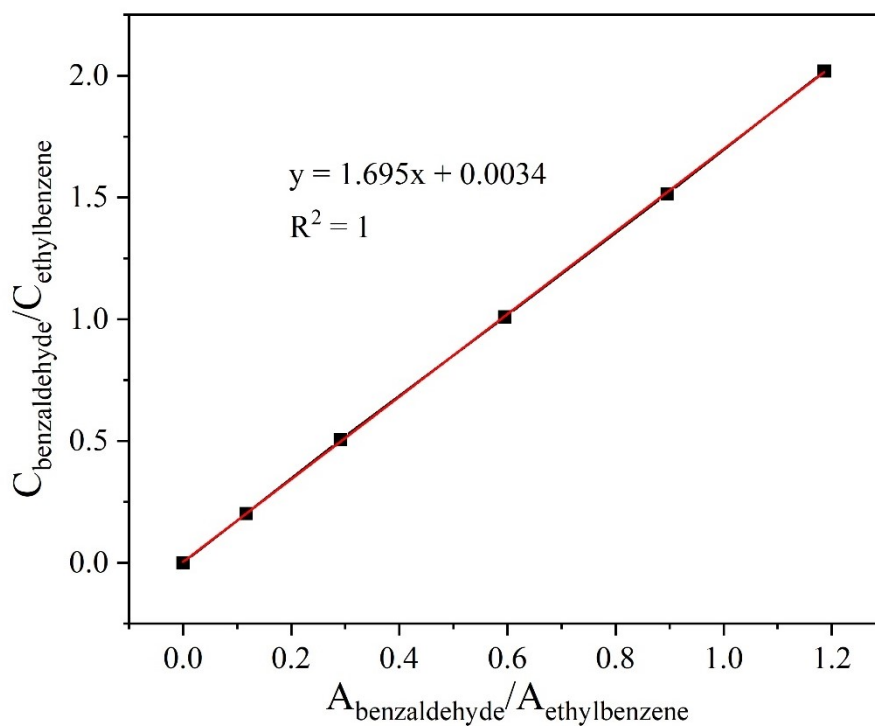
**Experimental details for GC analysis**

The reaction products are analyzed using the internal standard method with gas chromatography (Fuli 9790II, FID detector). Firstly, using ethylbenzene as the internal standard to prepare standard solutions of toluene and benzaldehyde in several concentrations, but the concentration of ethylbenzene remained unchanged. Then, the standard curves of toluene and benzaldehyde were obtained using the peak area ratio as the abscissa and the concentration ratio as the ordinate.

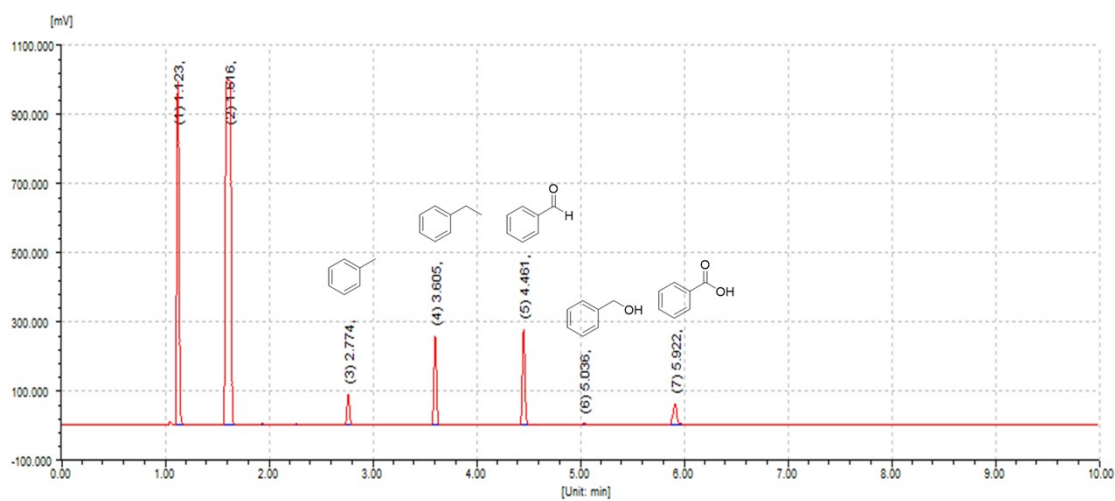
The GC detecting conditions are as follows: using nitrogen as a carrier gas, the injection temperature is 280 °C and the detector temperature is 280 °C. The test procedures are maintaining one minute at 50 °C of the column temperature, and then heating up to 250 °C at a heating rate of 25 °C/min and subsequently maintain for one minute.



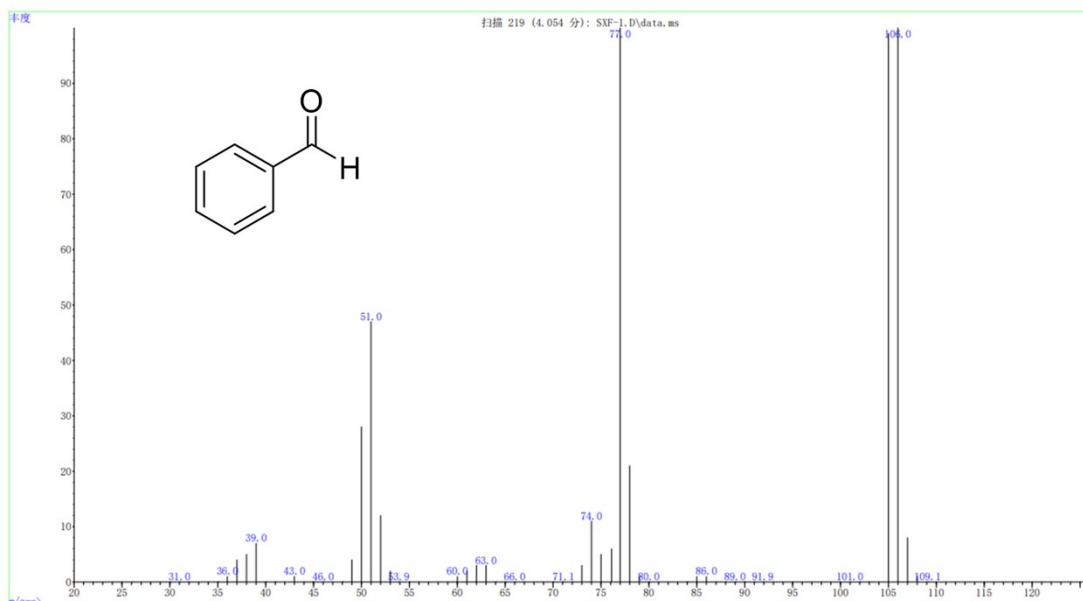
**Fig. S4** The standard curve of toluene



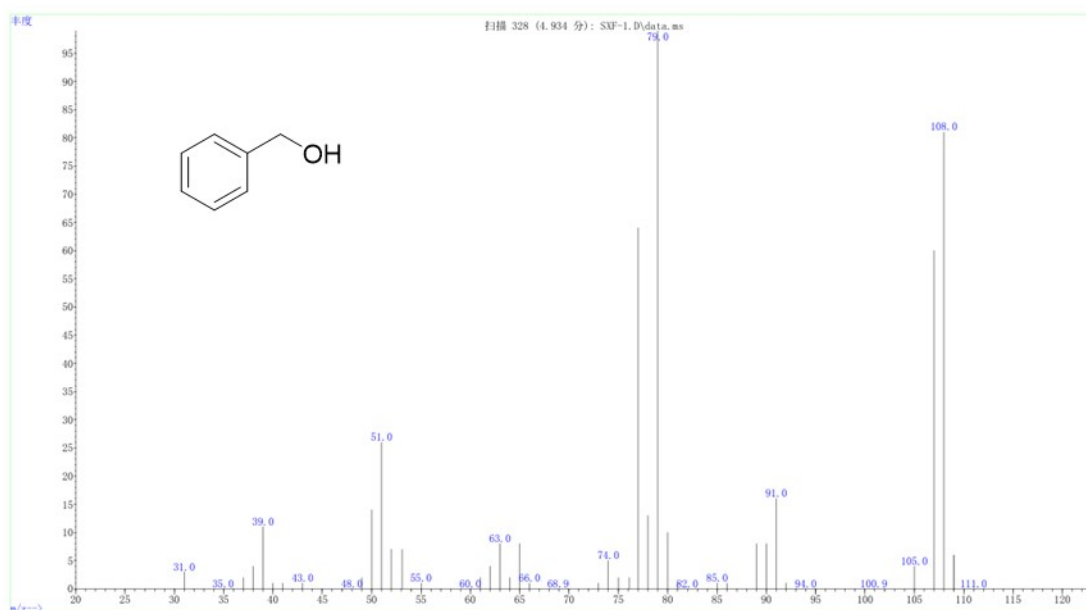
**Fig. S5** the standard curve of ethylbenzene



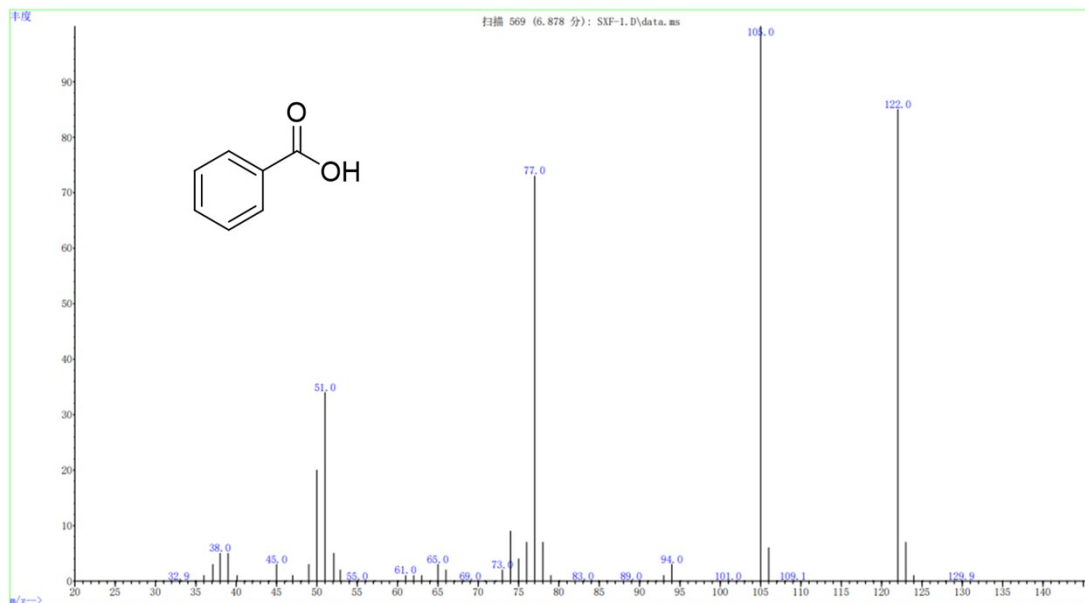
**Fig. S6** The GC result for the oxidation of toluene (T = 2.774 min, toluene; T = 3.605 min, ethylbenzene; T = 4.461 min, benzaldehyde; T = 5.036 min, benzyl alcohol; T = 5.922 min, benzoic acid). The conversion of toluene and yield of benzaldehyde were determined with an internal standard method, the internal standard was ethylbenzene.



**Fig. S7** GC-MS of benzaldehyde



**Fig. S8** GC-MS of benzyl alcohol



**Fig. S9** GC-MS of benzoic acid