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RESEARCH ARTICLE

Effects of preparation methods on the activity of CuO/CeO_2 catalysts for CO oxidation

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Electronic Supplementary Material

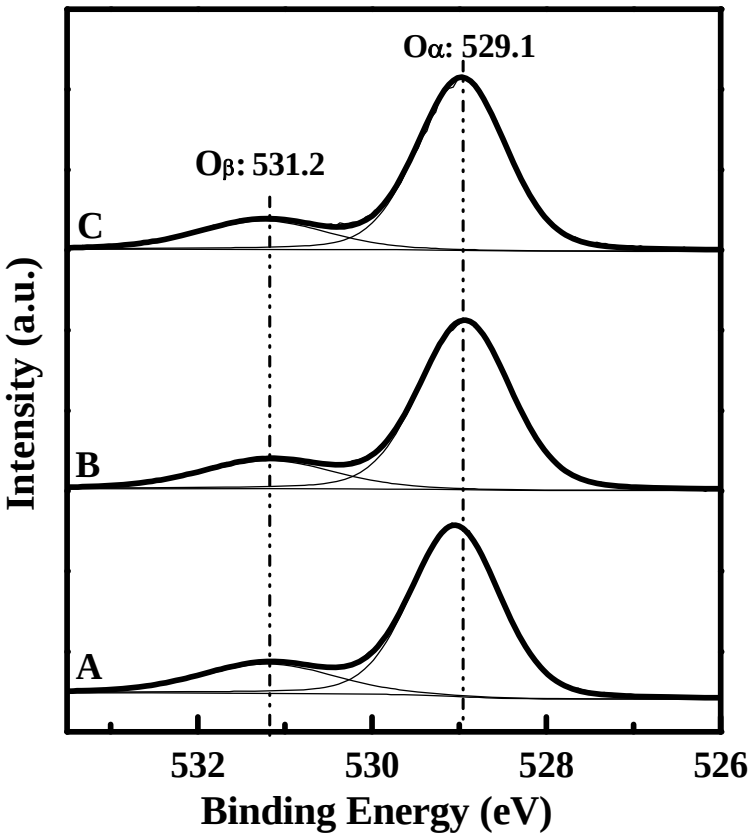

Fig. S1 O 1s spectra of different $5Cu/CeO_2$ catalysts: (A) $5Cu/CeO_2$(IM); (B)$5Cu/CeO_2$(CP); (C) $5Cu/CeO_2$(MIX)

The main peak O_α with binding energy (BE) of 529.1 eV is attributed to the lattice oxygen associated with the oxide, and an apparent shoulder peak O_β with BE of 531.2 eV represents absorbed oxygen or oxygen in hydroxyl-like groups [1]. Compared with 5Cu/CeO_2(CP) and 5Cu/CeO_2(MIX), the BE of O_α in 5Cu/CeO_2(IM) shifted to the higher energy, indicating an electronic structure alteration due to synergetic interaction between CeO_2 and CuO in 5Cu/CeO_2(IM). Additionally, O_β concentration was calculated according to Figure S1. 5Cu/CeO_2(IM) contains higher surface atomic ratio (20.43%) of O_β species than 5Cu/CeO_2(CP) (19.44%) and 5Cu/CeO_2(MIX) (19.20%). It is noted that the "O_β" is the significant active oxygen species and could be responsible for the high catalytic activity of 5Cu/CeO_2(IM) for the CO oxidation.

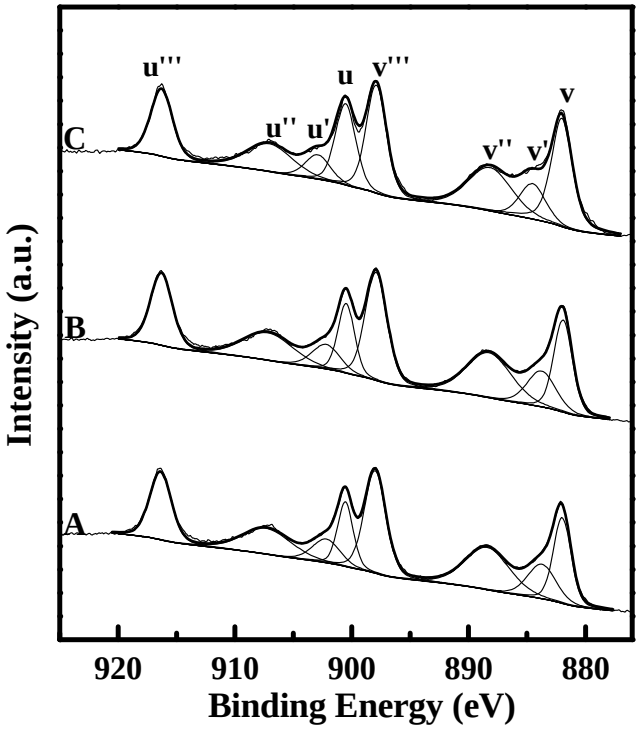

Fig. S2 Ce 3d spectra of different 5Cu/CeO_2 catalysts: (A) 5Cu/CeO_2(IM); (B)5Cu/CeO_2(CP); (C) 5Cu/CeO_2(MIX)

The complex spectra of Ce 3d regions were shown in figure S2. Two sets of spin-orbital multiplets, corresponding to the $3d_{3/2}$ and $3d_{5/2}$ contributions were labeled as u and v, respectively. The core level of Ce 3d signal of ceria is composed of six contributions including v, u(Ce $3d^9$ $4f^2$ O $2p^4$), v", u"(Ce $3d^9$ $4f^1$ O $2p^5$) and v"', u"'(final state of Ce $3d^9$ $4f^0$ O $2p^6$) assigned to Ce^{4+} 3d final states, and two contribution v', u'(Ce $3d^9$ $4f^1$ O $2p^6$) assigned to Ce^{3+} [2], revealing that both Ce^{3+} and Ce^{4+} species are present in all catalysts. A favorable method, which considers the relative area of the u' and v' peaks to the area of Ce 3d region, was applied to estimate Ce^{3+} content [3]:

$$Ce^{3+}(\%) = \frac{100 \times [s(u') + s(v')]}{\Sigma[s(u) + s(v)]}\% \quad (1)$$

The percentages of reduced cerium ions (Ce^{3+}) for 5Cu/CeO_2(IM), 5Cu/CeO_2(CP) and 5Cu/CeO_2(MIX) are 20.43%, 19.44% and 19.30%, respectively.

References

1. Li J, Zhu P, Zuo S, Huang Q, Zhou R. Influence of Mn doping on the performance of CuO-CeO_2 catalysts for selective oxidation of CO in hydrogen-rich streams. Applied Catalysis A: General, 2010, 381(1–2): 261-266.
2. Cecilia J A, Arango-Díaz A, Franco F, Jiménez-Jiménez J, Storaro L, Moretti E, Rodríguez-Castellón E. CuO-CeO_2 supported on montmorillonite-derived porous clay heterostructures (PCH) for preferential CO oxidation in H_2-rich stream. Catalysis Today, 2015, 253: 126-136.
3. Silvestre-Albero J, Rodríguez-Reinoso F, Sepúlveda-Escribano A. Improved Metal-Support Interaction in Pt/CeO_2/SiO_2 Catalysts after Zinc Addition. Journal of Catalysis, 2002, 210(1): 127-136.