Recently, three dimensionally ordered macroporous (3DOM) Au/CeO$_2$ catalysts with superior catalytic properties were created, and the temperature for complete catalytic oxidation of HCHO over such 3DOM Au/CeO$_2$ catalysts can be lowered to ~75°C.[1,2] Due to decreased aggregation and good distribution of the Au catalytic species on the 3DOM CeO$_2$ skeleton, the 3DOM Au/CeO$_2$ catalysts showed enhanced catalytic property for HCHO catalytic oxidation. The implementation of 3DOM structures into oxide-supported Au catalysts may result in novel catalysts with excellent catalytic functionality. On the other hand, it is generally accepted that the catalytic activity of supported noble metallic catalysts is tightly correlated to their compositions, phase structures, surface elemental valence states as well as support types. Thus, the incorporation of other transition metallic oxides into the CeO$_2$ support may improve the catalytic activity of Au/CeO$_2$ catalysts due to a synergistic interaction between different oxide supports, which could greatly activate Au species, accelerate the migration rate of active oxygen on catalyst surface, and eventually enhance the catalytic activity.[3-5]

This work is devoting to creating a series of Au/CeO$_2$-MO$_x$ (M=Co, Mn, Ti, Ni, Cu, Fe, and Mo) catalysts with three-dimensionally ordered macroporous structures and composite metal oxides as supports, and systematically explore the superior catalytic property for HCHO oxidation over such Au/CeO$_2$-MO$_x$ catalysts. By modulating the phase structures, surface elemental compositions, and valence states, the low conversion temperature for HCHO catalytic oxidation with a 100% conversion rate at temperatures as low as ~39°C can be realized in 3DOM Au/CeO$_2$-Co$_3$O$_4$ catalysts.

Fig. 1 typically shows the SEM images of 3DOM CeO$_2$-Co$_3$O$_4$, CeO$_2$-MnO$_2$, CeO$_2$-NiO, and CeO$_2$-Cr$_2$O$_3$ catalyst supports. From Fig. 1, it can be seen that the CeO$_2$-MO$_x$ supports exhibit well-defined 3DOM interconnected structures, with the pore sizes of ~150 nm for 3DOM CeO$_2$-Co$_3$O$_4$, CeO$_2$-Fe$_2$O$_3$ and CeO$_2$-Cr$_2$O$_3$ ~150 nm and ~100 nm for 3DOM CeO$_2$-MnO$_2$ and CeO$_2$-NiO. Well-ordered colloidal templates and interconnected inorganic walls create a “honeycomb” pore structures in three dimensions, and the close packing order of the original colloidal templates is preserved in all 3DOM CeO$_2$-MO$_x$ supports.

3DOM Au/CeO$_2$-MO$_x$ catalysts with different Au loading contents can be synthesized via in situ formation of active catalytic species of Au nanoparticles on 3DOM CeO$_2$-MO$_x$ supports. The obtained 3DOM Au/CeO$_2$-Co$_3$O$_4$, Au/CeO$_2$-MnO$_2$, Au/CeO$_2$-TiO$_2$, Au/CeO$_2$-NiO, Au/CeO$_2$-CuO, Au/CeO$_2$-Fe$_2$O$_3$, Au/CeO$_2$-Cr$_2$O$_3$, and Au/CeO$_2$-MoO$_3$ catalysts show relatively high catalytic activity for HCHO catalytic oxidation. It is found that the lowest temperature for HCHO catalytic oxidation over 3DOM Au/CeO$_2$-MO$_x$ catalysts is largely correlated to the supports of metal oxide composites. The Au/CeO$_2$-MO$_x$ catalysts exhibit superior catalytic activities for HCHO catalytic oxidation, with a 100% conversion rate at temperatures as low as ~39°C for 3DOM Au/CeO$_2$-Co$_3$O$_4$ catalysts. The superior catalytic activity of 3DOM Au/CeO$_2$-MO$_x$ catalysts makes them potentially applicable to indoor HCHO decontamination and industrial catalysis.

References