*Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*

# Enhancement in the $Hg^0$ oxidation efficiency and sulfur resistance of $CuCl_2$-modified $MnO_x$-$CeO_x$ nanorod catalysts

Shujie Gao

Cite this as: Shujie GAO, Yongjin HU, Zhichang JIANG, Xiaoxiang WANG, Dong YE, Changxing HU, 2024. Enhancement in the $Hg^0$ oxidation efficiency and sulfur resistance of $CuCl_2$-modified $MnO_x$-$CeO_x$ nanorod catalysts. *Journal of Zhejiang University-SCIENCE A (Applied Physics & Engineering)*, 25(8):680-686. https://doi.org/10.1631/jzus.A2300276

# Physical structures of the catalysts

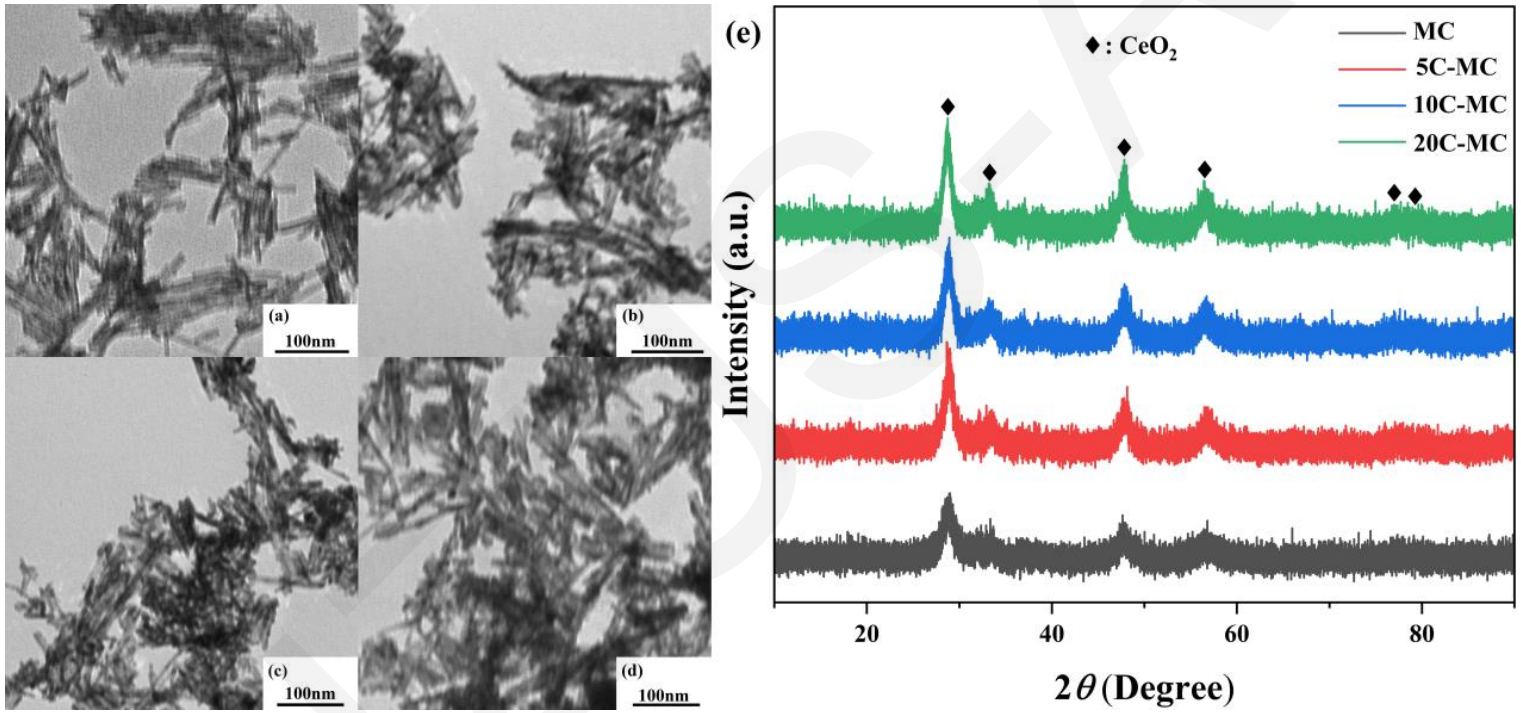



**Fig. 1** TEM images: (a) MC, (b) 5C–MC, (c) 10C–MC, and (d) 20C–MC; (e) XRD patterns of the catalyst series.

# Physical structures of the catalysts

**Table 1** Specific surface area, average pore diameter, and total pore volume of the catalyst series.

| Samples | Specific surface area ($m^2/g$) | Average pore diameter (nm) | Pore volume ($cm^3/g$) |
|---|---|---|---|
| MC | 78 | 17.2 | 0.50 |
| 5C–MC | 53 | 22.6 | 0.44 |
| 10C–MC | 44 | 21.0 | 0.35 |
| 20C–MC | 43 | 20.8 | 0.31 |

JZUS-A

# Atom environment of the catalysts

**Table 2** XPS data of the catalyst series.

| Samples | $Mn^{4+}$ (%) | $Ce^{3+}$ (%) | $Cu^{+}$ (%) |
|---|---|---|---|
| MC | 24.4 | 14.5 | / |
| 5C–MC | 22.1 | 16.0 | 16.9 |
| 10C–MC | 20.9 | 17.4 | 14.1 |
| 20C–MC | 18.2 | 17.9 | 7.2 |

JZUSA

# Performance of the catalysts

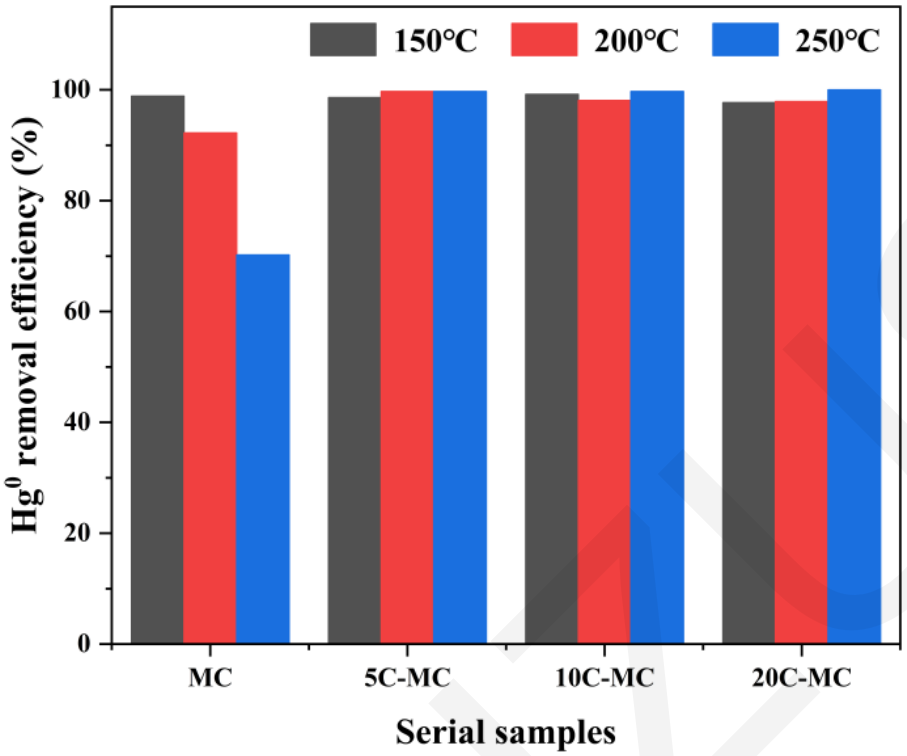



**Fig. 3** $Hg^0$ removal efficiency of the catalyst series.

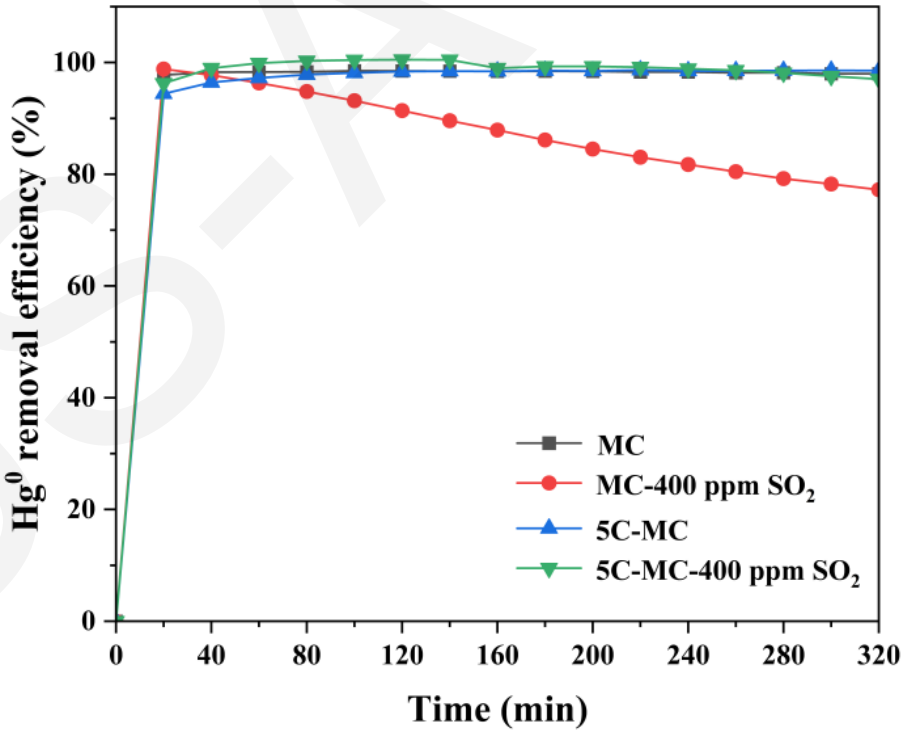
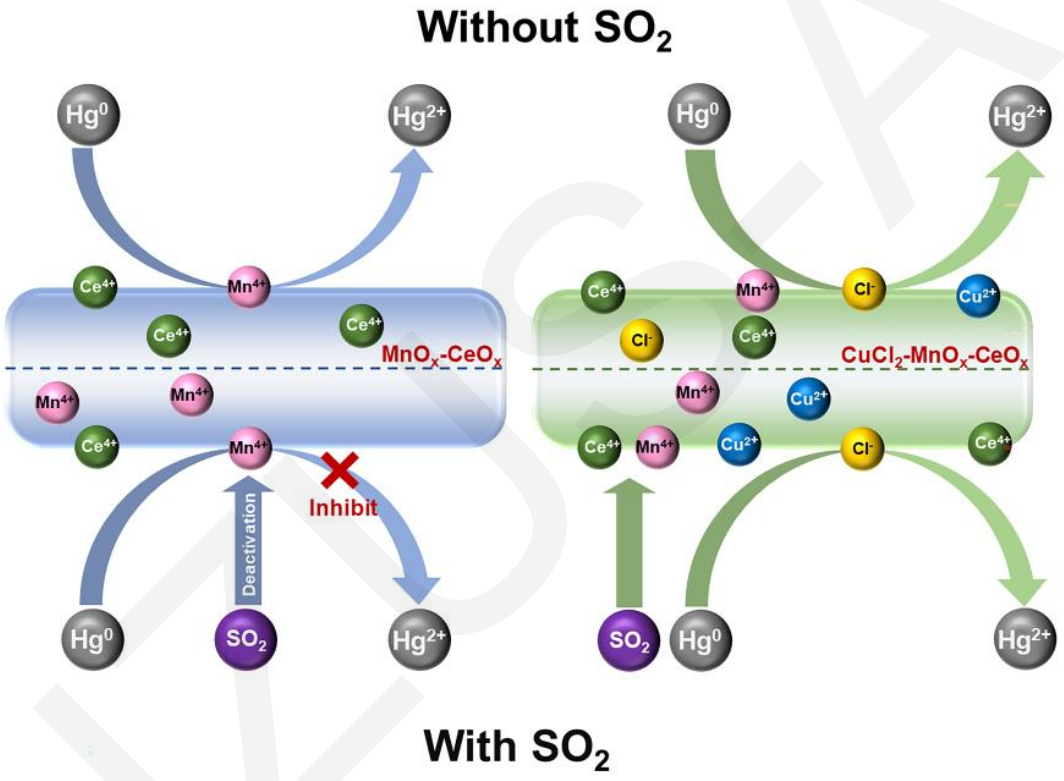



**Fig. 4** $SO_2$-tolerance of MC and 5C–MC catalysts.

# Mechanisms




**Scheme 1** Mechanisms of the enhanced $Hg^0$ oxidation capability and $SO_2$-tolerance of $CuCl_2$-doped $MnO_x$–$CeO_x$ catalysts.

# Conclusions

- The addition of $CuCl_2$ enhances the catalyst's $Hg^0$ oxidation capability, with $Hg^0$ oxidation efficiency at >97% throughout the investigated temperature range for $CuCl_2$-doped samples. In the presence of 400 ppm $SO_2$, the $Hg^0$ oxidation efficiency of $MnO_x$–$CeO_x$ steadily decreased from ~100% to ~78% after 320 min, whereas the $CuCl_2$-doped catalysts maintained ~100% $Hg^0$ oxidation efficiency during the $SO_2$ deactivation cycle.
- For the $MnO_x$–$CeO_x$ catalyst, $Mn^{4+}$ served as the active species for $Hg^0$ oxidization. However, with the addition of $CuCl_2$, the introduced $Cl^-$ with high reactivity was mainly responsible for accelerating the oxidation of $Hg^0$, resulting in enhanced $Hg^0$ oxidation capability of the $CuCl_2$-doped catalysts.