Supporting Information

A novel one-step hydrothermal preparation of Ru/Sn\textsubscript{x}Ti\textsubscript{1-x}O\textsubscript{2} Diesel Oxidation Catalysts and Its Low Temperature Performance

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Fig. S1 Effect of different hydrothermal temperature on Ru/Sn\textsubscript{0.67}Ti\textsubscript{0.33}O\textsubscript{2} catalytic CO

Fig. S1 shows the catalytic activities of CO oxidation on the Ru/Sn\textsubscript{0.67}Ti\textsubscript{0.33}O\textsubscript{2} catalysts under the different hydrothermal temperature (140 °C, 180 °C and 220 °C) while the hydrothermal time is 24 h and calcination temperature is 400 °C. It can be seen that catalytic performances of Ru/Sn\textsubscript{0.67}Ti\textsubscript{0.33}O\textsubscript{2} catalysts increased firstly and then tended to be stabilized with the increase of reaction temperature. The T\textsubscript{50} of Ru/Sn\textsubscript{0.67}Ti\textsubscript{0.33}O\textsubscript{2} catalyst to oxidize CO is 180 °C when the hydrothermal temperature at 180 °C, which is lower reaction temperature than other hydrothermal temperature and the conversion of CO reaches 90% at 240 °C. It is attributed to the increase of hydrothermal temperature is beneficial to the growth of solid solution grains, but the excessive hydrothermal temperature will lead to overgrowth of grains and reduce the catalytic oxidation performance. Therefore, the optimal hydrothermal temperature is determined to be 180 °C.
Fig. S2 Effect of different hydrothermal time on Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ catalytic CO oxidation

Fig. S2 shows the catalytic activities of CO oxidation on the Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ catalyst under the different hydrothermal time (12 h, 24 h and 48 h) while the hydrothermal temperature is 180 °C and calcination temperature is 400 °C. It shows that catalytic performances of Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ catalysts increased first and then tended to be stabilized with the increase of reaction temperature. The T$_{50}$ of Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ to CO is 180 °C when the hydrothermal time at 24 h, which is lower reaction temperature than other hydrothermal time and the conversion of CO reached 90% at 240 °C. This phenomenon suggests that the increase of hydrothermal time could promote the growth of grains, but too long hydrothermal time will lead to the aging of grains and the reduction of catalytic oxidation efficiency.

Fig. S3 Effect of different calcination temperature on Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ catalytic CO oxidation

Fig. S3 shows the catalytic activities of CO oxidation on the Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ catalyst under the different calcination temperature (200 °C, 400 °C and 600 °C) while the hydrothermal temperature is 180 °C and hydrothermal time is 24 h. It can be seen that catalytic performances of Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ catalysts increased first and then tended to be flat with the increase of reaction temperature. Before reaction
temperature at 200 °C, the activity of Ru/Sn0.67Ti0.33O2 decrease in the order of Ru/Sn0.67Ti0.33O2-C200 > Ru/Sn0.67Ti0.33O2-C400 > Ru/Sn0.67Ti0.33O2-C600. While after reaction temperature 200 °C, the activity of Ru/Sn0.67Ti0.33O2 decrease in the order of Ru/Sn0.67Ti0.33O2-C400 > Ru/Sn0.67Ti0.33O2-C200 > Ru/Sn0.67Ti0.33O2-C600 as shown in Fig.S3. This is because the actual value of O/Ru is higher than the theoretical value at 250-700 °C, Ru is easier to oxidize to RuOx. When the calcination temperature is 400 °C, the conversion of CO reached 90% at 240 °C. Therefore, the optimal calcination temperature is determined to be 400 °C.

According to the above analysis, the preparation conditions of Ru/Sn0.67Ti0.33O2 catalysts including hydrothermal temperature, hydrothermal time and calcination temperature were optimized with CO oxidation. The catalytic activity of Ru/Sn0.67Ti0.33O2 for CO is excellent under the conditions of the hydrothermal temperature at 180 °C, the hydrothermal time at 24 h and calcination temperature at 400 °C, the T50 of Ru/Sn0.67Ti0.33O2 is 180 °C. When the reaction temperature is 240 °C, the conversion of Ru/Sn0.67Ti0.33O2 to CO reaches 90%.

Table S1 Catalytic activity comparison of different catalysts for CO oxidation

| Catalyst               | Preparation method               | T50 (°C) | Space velocity (h⁻¹) | Ref  |
|------------------------|---------------------------------|----------|-----------------------|------|
| Ru/C12Al7:O2⁻         | solid-state reaction            | 180      | 25200                 | [6]  |
| Pt/Al₂O₃               | impregnation                    | 230      | 17000                 | [30] |
| Pt/ZnO                 | impregnation                    | 245      | 30000                 | [30] |
| Pt/TiO₂                | Co-precipitation impregnation   | 204      | 60000                 | [4]  |
| 8%CuO/SnO₂             | Sol-gel dispersion-precipitation| 270      | 20040                 | [15] |
| TiO₂₂-SnO₂             | Sol-gel dispersion-precipitation| 240      | 20000                 | [31] |
| 5CuTiS3                | Co-precipitation impregnation   | 185      | 30000                 | [5]  |
| Ce₀.₅Zr₀.₅O₂           | hydrothermal                    | 250      | 43200                 | [22] |
| Ce₀.₃Zr₀.₂O₂           | hydrothermal                    | 300      | 43200                 | [22] |
| Ce₀.₇Zr₀.₃O₂           | hydrothermal                    | 280      | 43200                 | [22] |
| Ce-Ti                  | Co-precipitation                | 348      | 30000                 | [27] |
| Ru/Sn0.67Ti0.33O2      | hydrothermal impregnation       | 180      | 60000                 | This work |

Table S2 Catalytic activity comparison of different catalysts for C₃H₈ oxidation

| Catalyst               | Preparation method | T50 (°C) | Space velocity(h⁻¹) | Ref  |
|------------------------|--------------------|----------|----------------------|------|
| 0.5%Ru/ZnAl₂O₄        | co-precipitation   | 480      | 32000                | [28] |
| 1% Ru/ZnAl₂O₄         | co-precipitation   | 500      | 32000                | [28] |
| 1.5% Ru/ZnAl₂O₄       | co-precipitation   | 540      | 32000                | [28] |
| 0.3Pd-0.7Pt/γ-Al₂O₃   | impregnation       | 360      | 50000                | [29] |
| Catalyst                  | Preparation method | $T_{50}$ (°C) | Space velocity (h$^{-1}$) | Ref |
|--------------------------|--------------------|---------------|---------------------------|-----|
| 0.7Pd-0.3Pt/γ-Al$_2$O$_3$| impregnation       | 325           | 50000                     | [29]|
| Pt/CeO$_2$               | co-precipitation   | 620           | 50000                     | [32]|
| Pt/CeO$_2$               | hydrothermal       | 675           | 50000                     | [32]|
| Pt/Co$_3$O$_4$           | co-precipitation   | 447           | 6000                      | [33]|
| Pd/Al$_2$O$_3$           | impregnation       | 411           | 30000                     | [34]|
| PtPd/Al$_2$O$_3$         | impregnation       | 428           | 30000                     | [34]|
| PtPd/CeAl$_2$O$_3$       | impregnation       | 436           | 30000                     | [34]|
| Ru/Sn$_{0.67}$Ti$_{0.33}$O$_2$ | hydrothermal     | 320           | 60000                     | This work |