Electronic Supplementary Material (ESI) for RSC Advances.


# Support Information

**Table S1** $H_2$-TPR results for various unreduced catalysts

**Table S2** XPS binding energies for various unreduced catalysts

**Fig. S1** O 1s and Ru 3d XPS spectra for various unreduced catalysts

Table S1 $H_2$-TPR results for various unreduced catalysts [a]

| Catalyst | Reduction temperature (°C) [a] of Ni and Ru species / percentage content (%) of Ni species [b] | | | | |
|---|---|---|---|---|---|
| | HD-$RuO_2$ [c] | L-NiO [d] | S-NiO [e] | W-NiO-$SiO_2$ [f] | S-NiO-$SiO_2$ [g] |
| **20Ni/$SiO_2$** | | | **382.8 / 49.3** | **450.3 / 48.2** | **585.7 / 2.5** |
| **40Ni/$SiO_2$** | | **306.0 / 3.3** | **381.0 / 71.1** | **453.5 / 25.7** | |
| **Ru-40Ni/$SiO_2$** | **177.0** | | **299.0 / 51.3** | **355.5 / 48.7** | |

*a.* Temperature at the maximum of reduction peak;

*b.* Evaluated from the normalized area of reduction peak for Ni species;

*c.* Highly-dsipersed $RuO_2$;

*d.* Large particle-sized NiO;

*e.* Small particled-sized NiO

*f.* NiO particle weakly interacting with $SiO_2$

*g.* NiO particle strongly interacting with $SiO_2$

Table S2 Binding energy (B.E.) of Ni $2p_{3/2}$ for various unreduced catalysts

| Catalyst | Ni species | B.E. (eV) | % Content [a] |
|---|---|---|---|
| 20Ni/$SiO_2$ | NiO | 854.0 | 64.7 |
| | $Ni^{2+}$-$SiO_2$ | 855.8 | 35.3 |
| 40Ni/$SiO_2$ | NiO | 854.0 | 66.2 |
| | $Ni^{2+}$-$SiO_2$ | 855.8 | 33.8 |
| Ru-40Ni/$SiO_2$ | NiO | 854.1 | 65.8 |
| | $Ni^{2+}$-$SiO_2$ | 855.9 | 34.2 |

[a] The percentage content of Ni species evaluated from the normalized area of the fitted component peak

Fig. S1

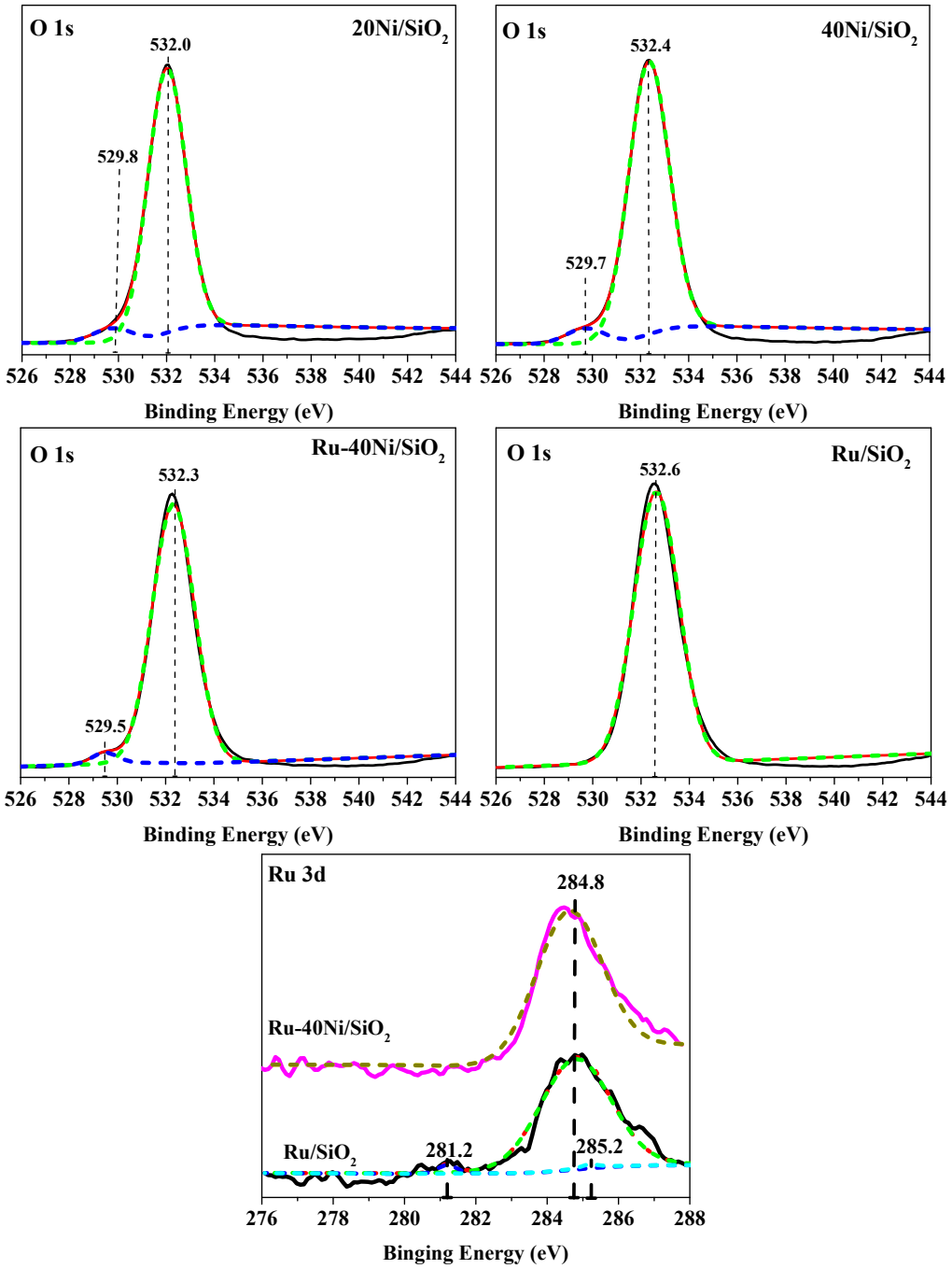


Fig. S1 O 1s and Ru 3d XPS spectra for various unreduced catalysts