

Supplementary Information

Ruthenium and ruthenium oxide nanofiber supports for enhanced activity of platinum electrocatalysts in the methanol oxidation reaction

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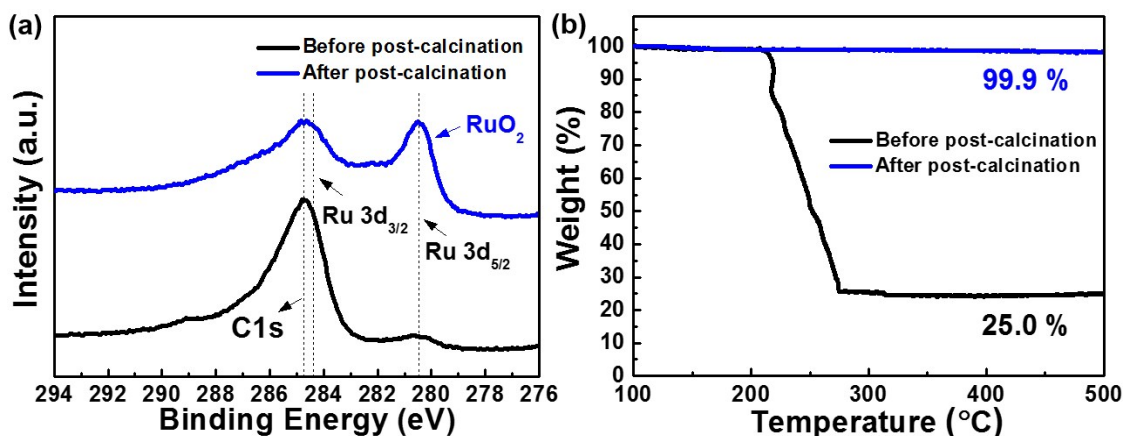


Fig. S1 (a) XPS spectra (b) TGA curves of Ru-RuO₂ 400 supports before and after post-calcination.

To address the removal of CNF matrix after post-calcination, we carried out X-ray photoelectron spectroscopy (XPS, ESCALAB 250) with an Al K α X-ray source. However, the evidence of a removal of CNF matrix is difficult to verify using XPS spectra due to the neighboring Ru 3d spectra with C1s, as shown in Fig. S1a. Thus, we carried out thermogravimetric analysis (TGA-50, Shimadzu) examinations in the temperature range from 100 to 500 °C at a heating rate of 10 °C min⁻¹ under air environment. As shown in Fig. S1b, Ru-RuO₂ 400 supports before post-calcination exhibited a weight loss of 25.0%, implying the existence of carbon materials. However, it is important to note that Ru-RuO₂ 400 supports after post-calcination exhibited a weight loss of 0.01%, which means that carbon materials are completely removed. Thus, the CNF matrix is removed by post-calcination by the oxidation reaction between carbon and oxygen.

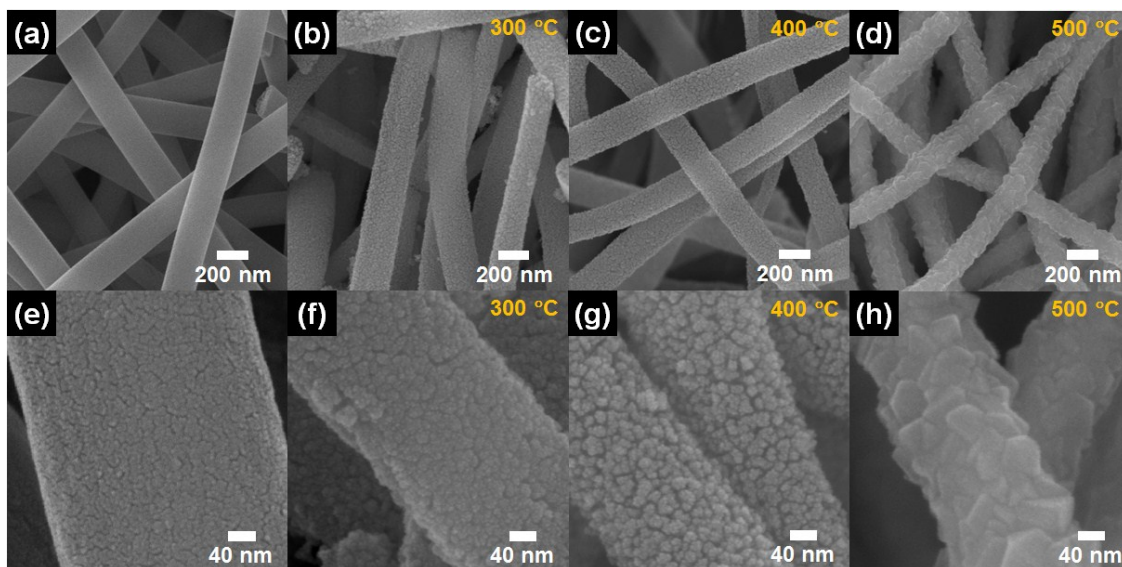


Fig. S2 (a–d) Low-resolution and (e–h) high-resolution SEM images. (a and e) Ru-CNF, (b and f) Ru-RuO₂ 300, (c and g) Ru-RuO₂ 400, and (d and h) Ru-RuO₂ 500.

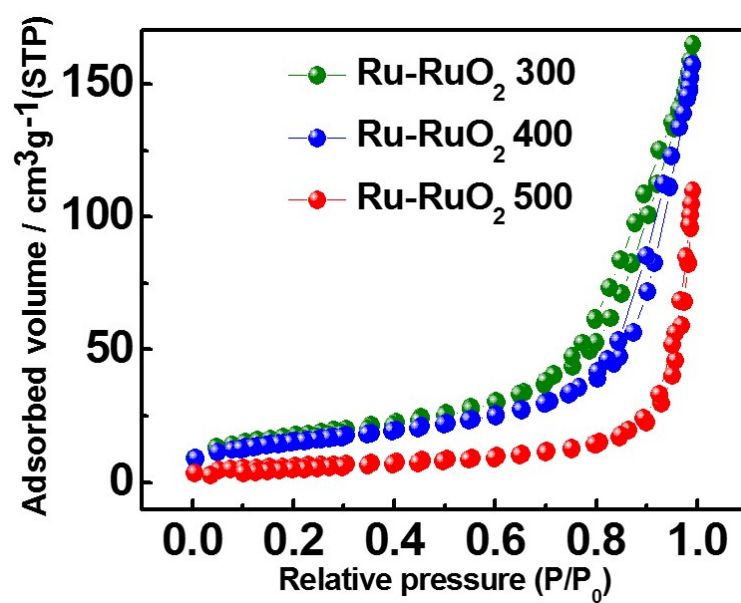


Fig. S3 N₂ adsorption/desorption isotherms of Ru-RuO₂ 300, Ru-RuO₂ 400, and Ru-RuO₂ 500.

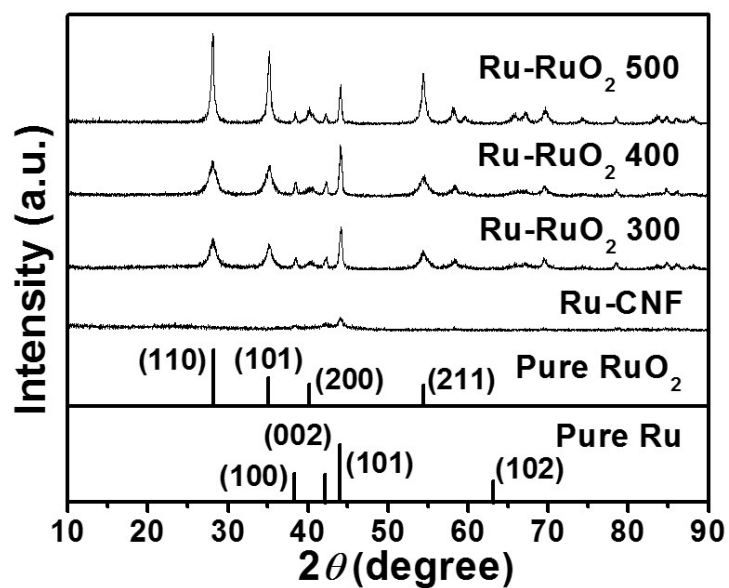


Fig. S4 XRD patterns of Ru-CNF, Ru-RuO₂ 300, Ru-RuO₂ 400, and Ru-RuO₂ 500 without Pt electrocatalysts before a reduction method.

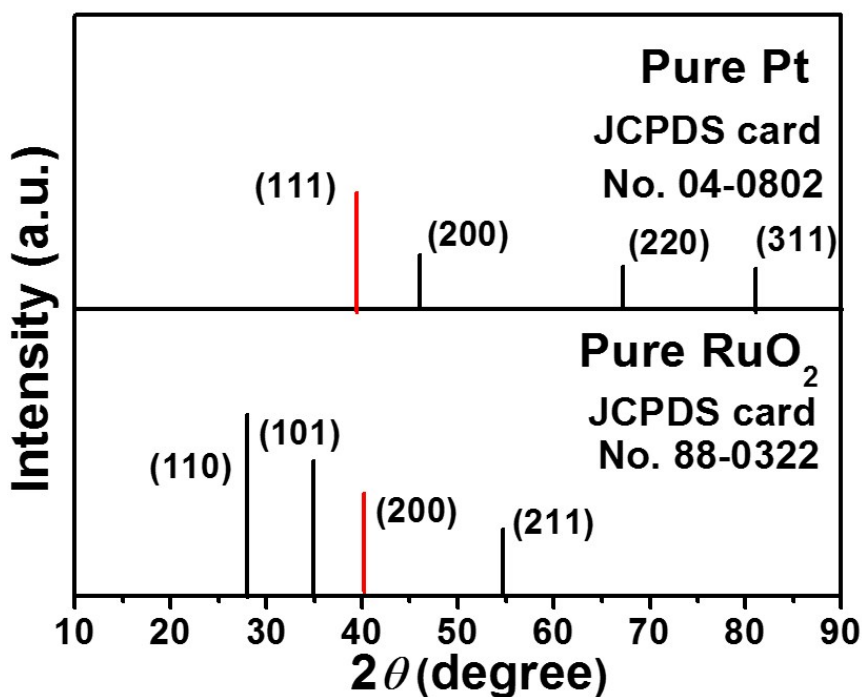


Fig. S5 JCPDS card No. of (a) pure Pt and (b) pure RuO₂.

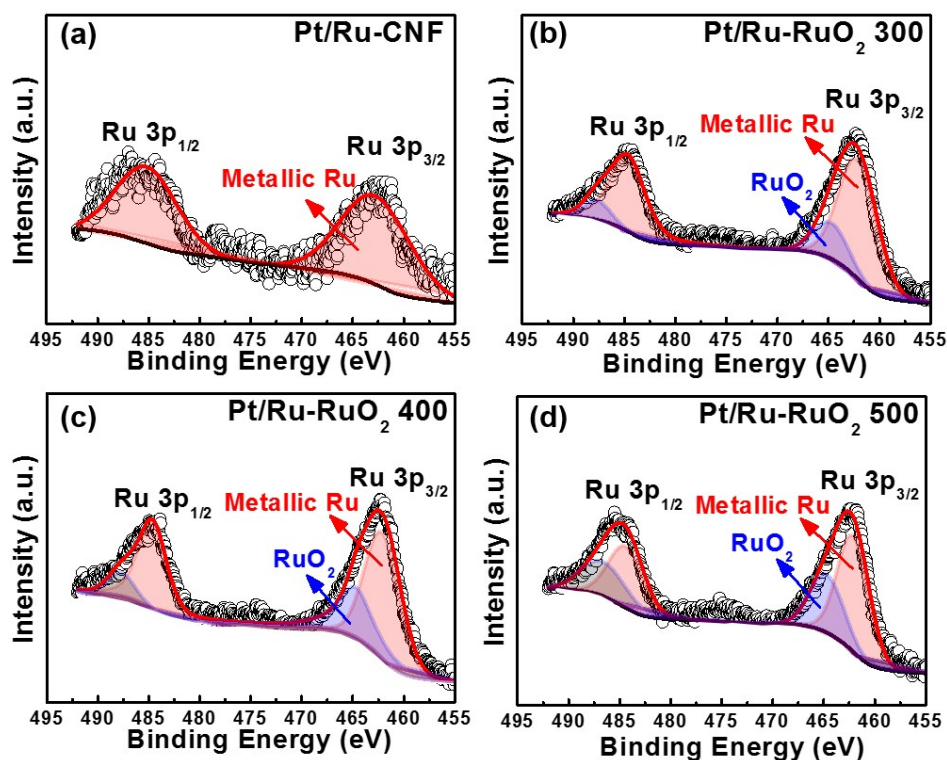


Fig. S6 XPS spectra of Ru 3p core levels from Ru 3p_{3/2} and Ru 3p_{1/2} photoelectrons of (a) Pt/Ru-CNF, (b) Pt/Ru-RuO₂ 300, (c) Pt/Ru-RuO₂ 400, and (d) Pt/Ru-RuO₂ 500.

Table S1. List of a specific surface area, total pore volume, and average pore diameter of Ru-RuO₂ 300, Ru-RuO₂ 400, and Ru-RuO₂ 500 without Pt electrocatalysts before a reduction method.

Samples	$S_{\text{BET}} [\text{m}^2 \text{g}^{-1}]$	Total pore volume ($p/p_0=0.990$) [$\text{cm}^3 \text{g}^{-1}$]	Average pore diameter[nm]
Ru-RuO ₂ 300	62.0	0.25	16.2
Ru-RuO ₂ 400	54.7	0.24	17.5
Ru-RuO ₂ 500	21.3	0.16	30.3