

ESI (Supporting information)

Title

Low-temperature CO₂ methanation over Ni catalysts supported on nanocrystalline CeO₂ in an electric field

Authors:

Ryota Yamano[†], Takuma Higo[†] and Yasushi Sekine^{†*}

Affiliation:

[†] Department of Applied Chemistry, Waseda University, 3-4-1, Okubo, Shinjuku, Tokyo, 169-8555, Japan

Corresponding author*: Yasushi SEKINE, ysekine@waseda.jp

This file includes:

Figs. S1 to S11

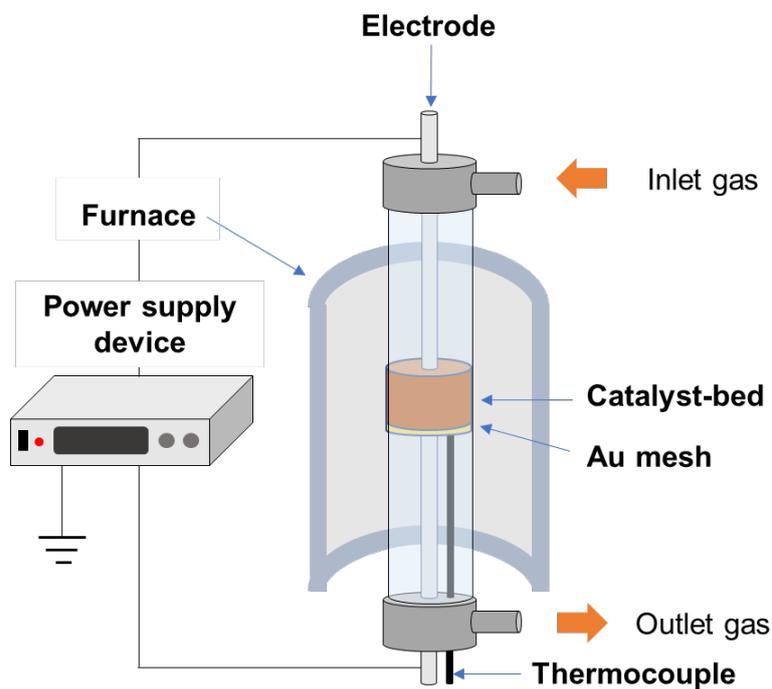


Figure S1 Schematic image of the apparatus for the catalytic activity tests.

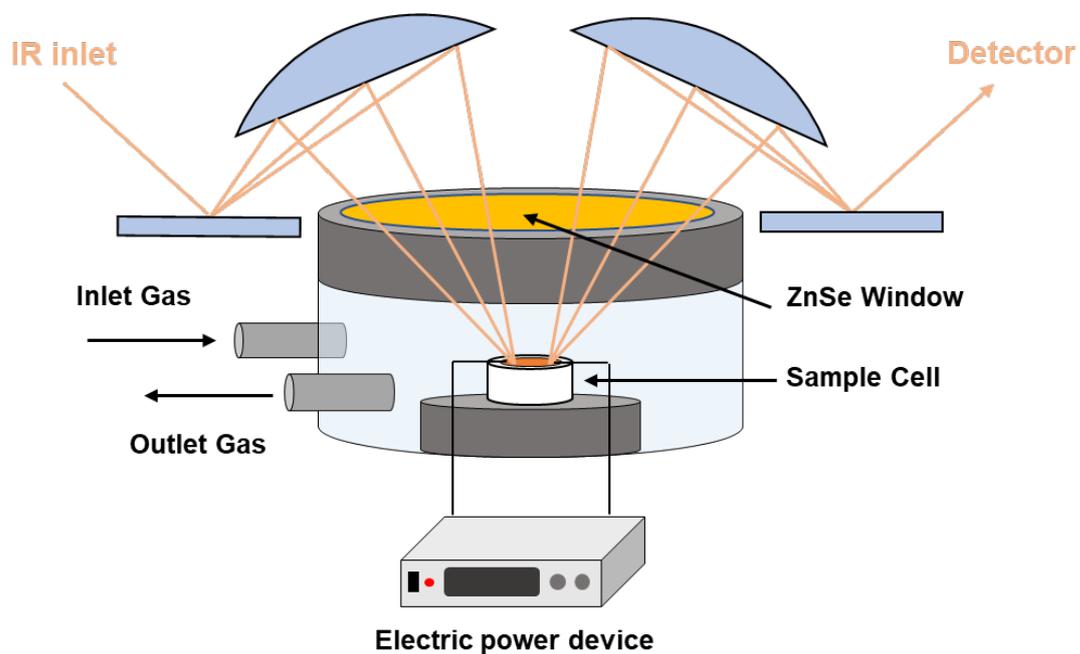


Figure S2 Schematic image of the apparatus for *in-situ* DRIFTS measurements.

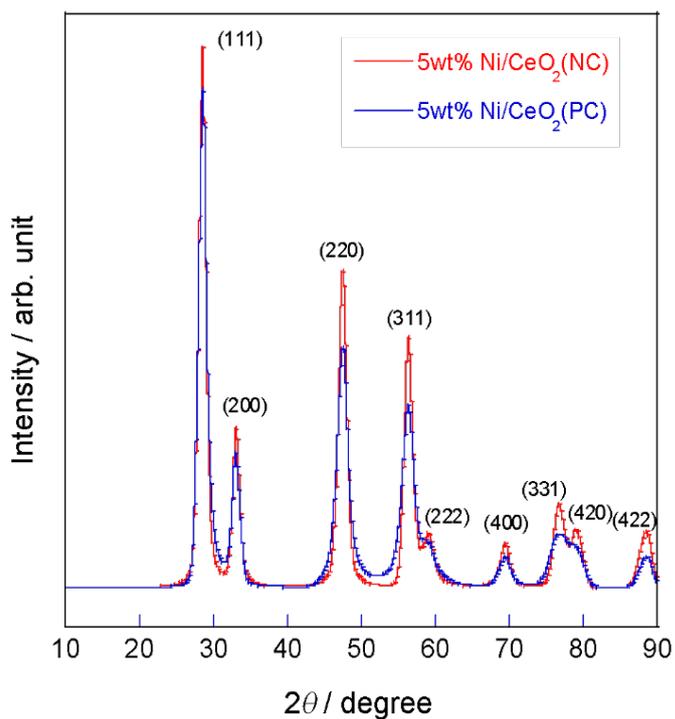


Figure S3 XRD patterns of the 5wt%Ni/CeO₂ (NC or PC) catalysts.

Table. S1 Peak analysis of the XRD patterns of the 5wt% Ni/CeO₂ (NC or PC) catalysts

Miller index	5wt% Ni/CeO ₂ (NC)			5wt% Ni/CeO ₂ (PC)		
	Peak Area	Percentage of total peak area / %	Scherrer diameter (crystallite size) / nm	Peak Area	percentage of total peak area / %	Scherrer diameter (crystallite size) / nm
111	34672	40.3	7.7	32606	41.1	7.2
200	7703	8.9	7.9	7193	9.1	7.6
220	18501	21.5	6.8	16810	21.2	5.4
311	8042	9.3	9.7	10549	13.3	5.0
222	1582	1.8	10.3	1421	1.8	5.3
400	3240	3.8	6.9	2283	2.9	4.4
331	4790	5.6	7.2	3650	4.6	3.8
420	4477	5.2	5.6	2178	2.7	6.1
422	3083	3.6	9.4	2593	3.3	5.6

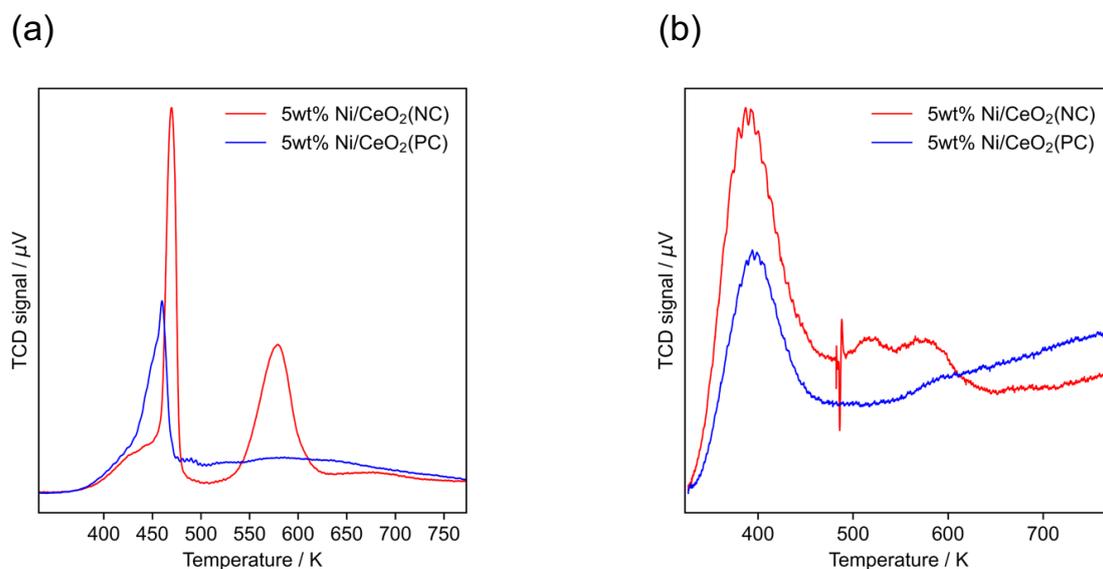


Figure S4 (a) H₂-TPR and (b) CO₂-TPD profiles of the 5wt% Ni/CeO₂(NC or PC) catalysts.

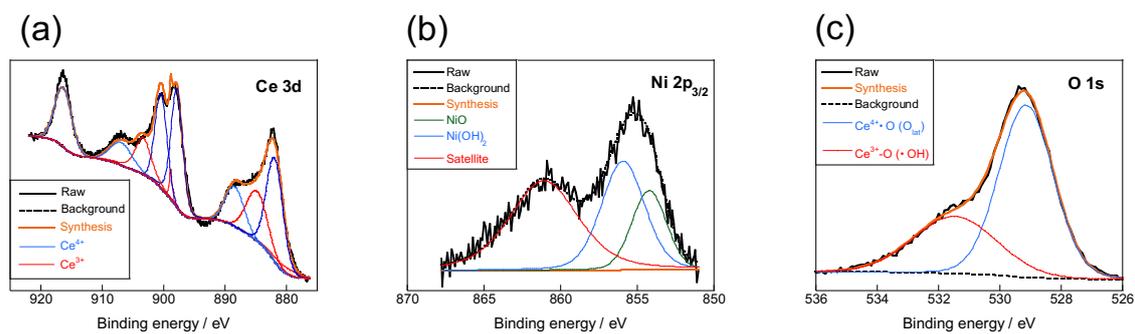


Figure S5 XPS spectra of (a) Ce 3d, (b) Ni 2p_{3/2} and (c) O 1s for the as-made 5wt%Ni/CeO₂ (NC) catalyst.

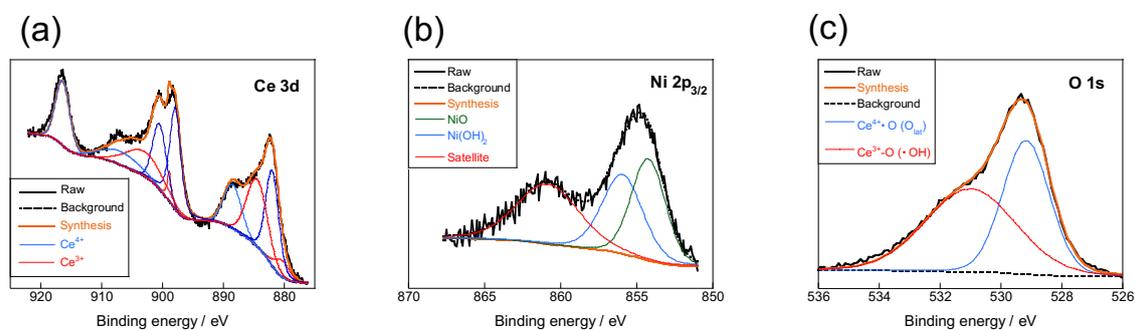


Figure S6 XPS spectra of (a) Ce 3d, (b) Ni 2p_{3/2} and (c) O 1s for the as-made 5wt%Ni/CeO₂ (PC) catalyst.

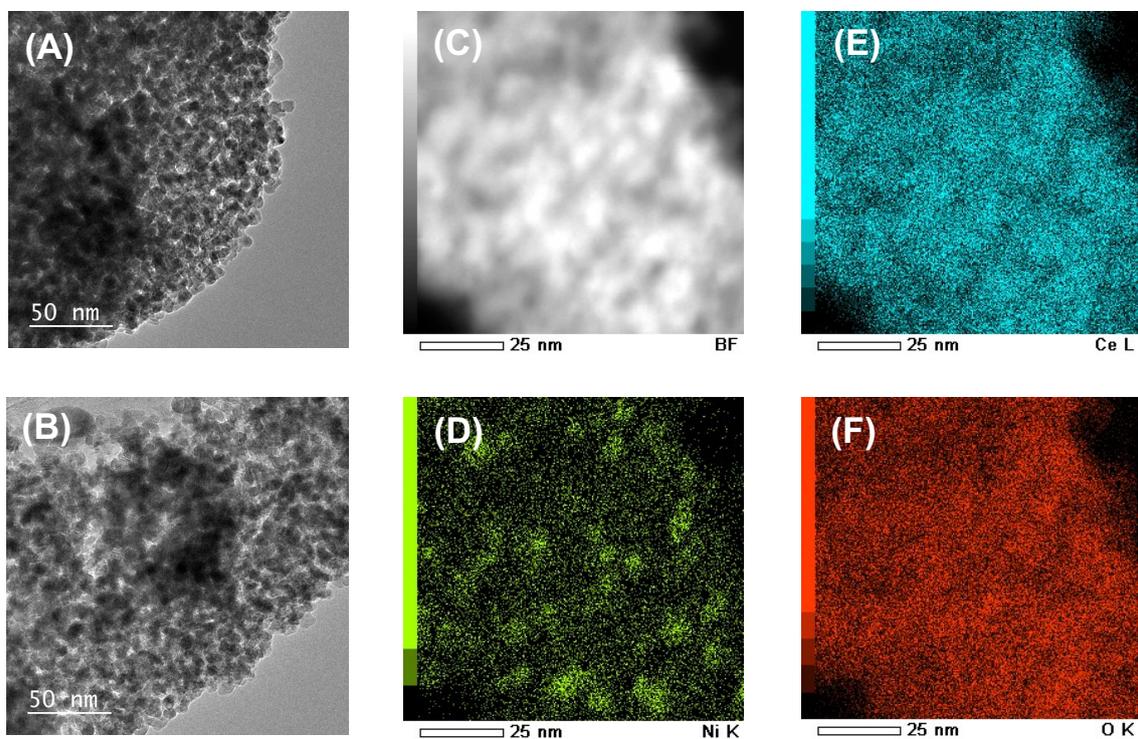


Figure S7 (A, B) TEM, (C) HAADF-STEM images, and (D–F) corresponding EDX elemental maps of the Ni/CeO₂ (NC) catalyst after the reaction in an electric field.

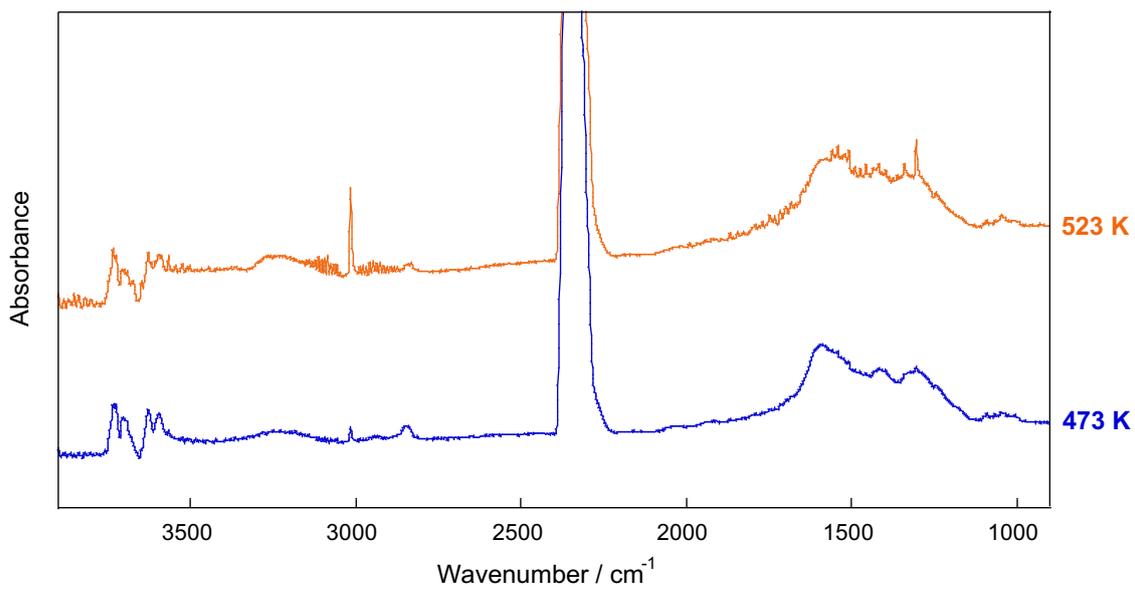


Figure S8 *In-situ* DRIFTS spectra under the reaction atmosphere over the 5wt% Ni/CeO₂(PC) catalyst without the electric field at 473 K-573 K (CO₂: H₂: Ar = 1:4:5; 40 mL min⁻¹ total flow rate).

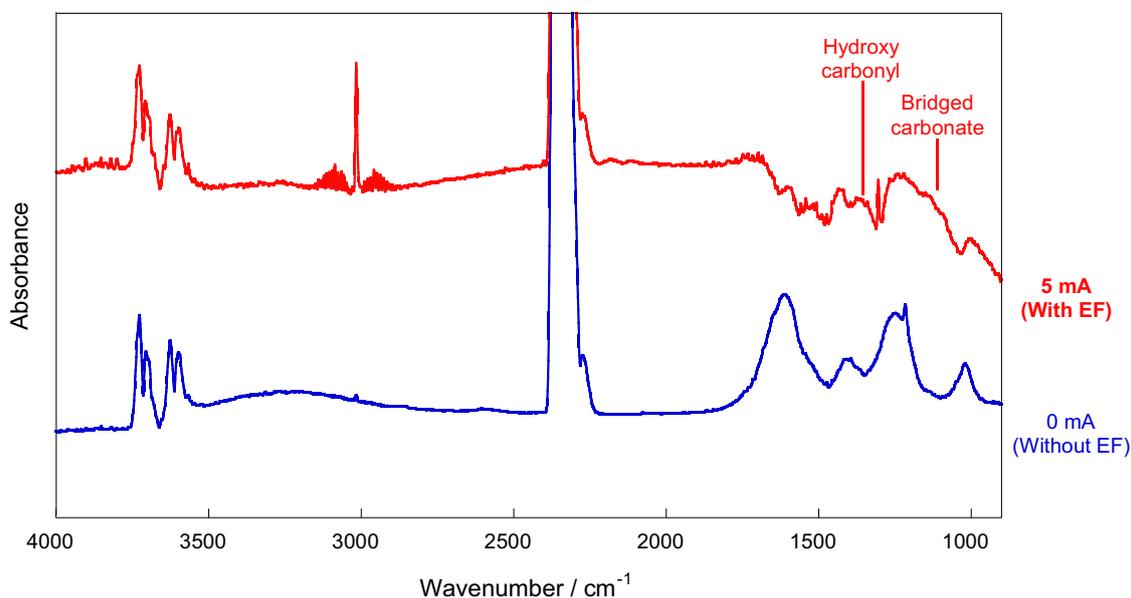


Figure S9 *In-situ* DRIFT spectra under the reaction atmosphere over the 5wt% Ni/CeO₂ (PC) catalyst recorded before/during applying the electric field (EF) at 423 K, CO₂: H₂: Ar = 1: 4: 5; 40 mL min⁻¹ total flow rate; 0 or 5.0 mA imposed current.

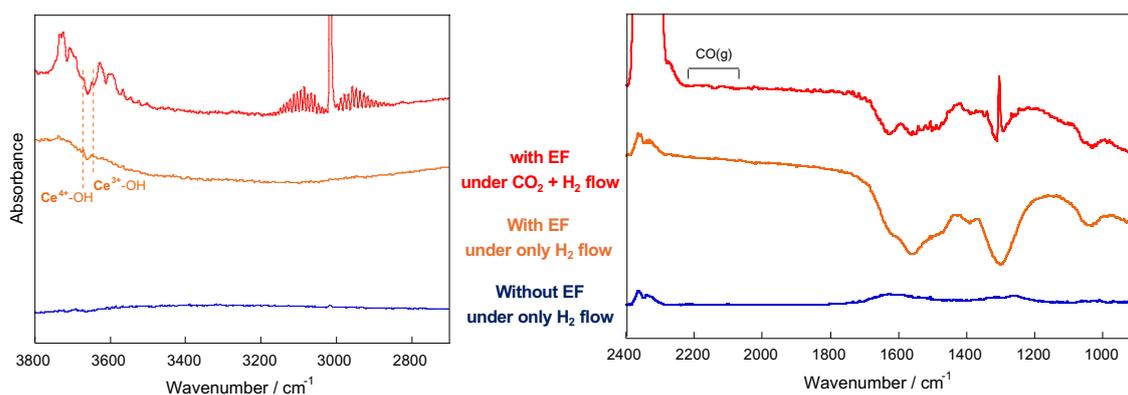


Figure S10 *In-situ* DRIFT spectra under only H₂ flow over the 5wt%Ni/CeO₂ (PC) catalyst recorded before/during applying the electric field (EF) at 423 K, H₂: Ar = 1: 1; 40 mL min⁻¹ total flow rate, 0 or 5.0 mA imposed current.

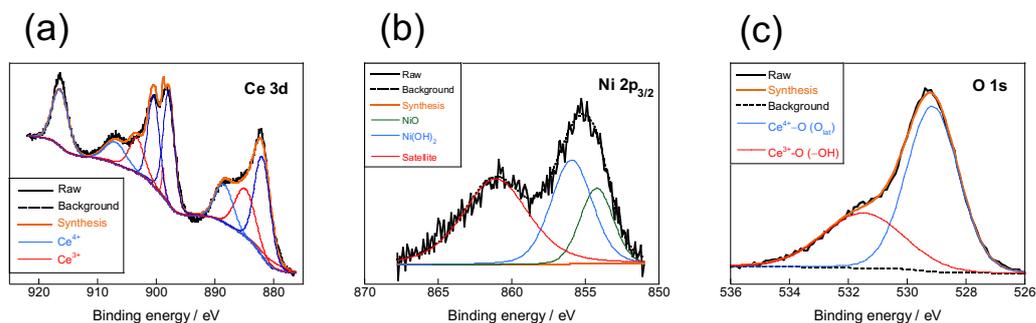


Figure S11 XPS spectra of (a) Ce 3d, (b) Ni 2p_{3/2} and (c) O 1s for the 5wt% Ni/CeO₂ (NC) catalyst before applying the EF (only Ar pre-treatment).

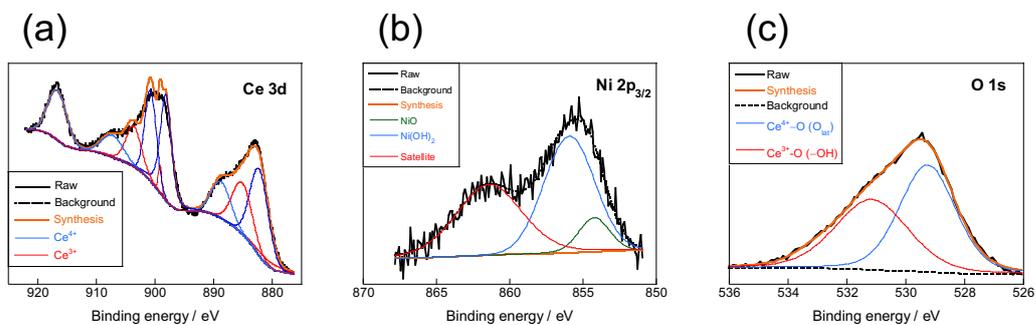


Figure S12 XPS spectra of (a) Ce 3d, (b) Ni 2p_{3/2} and (c) O 1s for the 5wt% Ni/CeO₂ (NC) catalyst after applying the EF in the reducing atmosphere.