Supplementary Materials

Preparation of egg-shell-type Ru/Al₂O₃ catalysts for hydrogen production using steam-methane reforming on PEMFC

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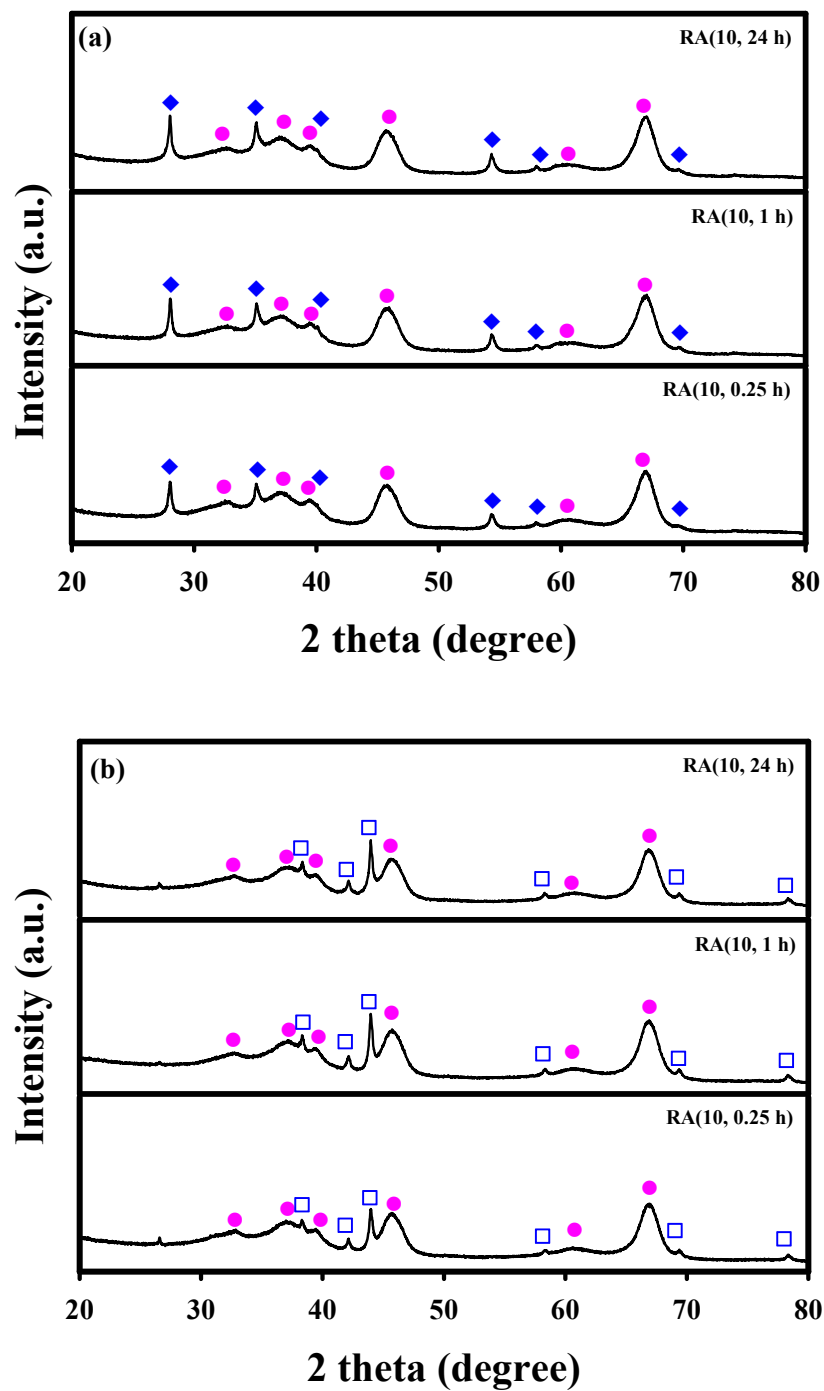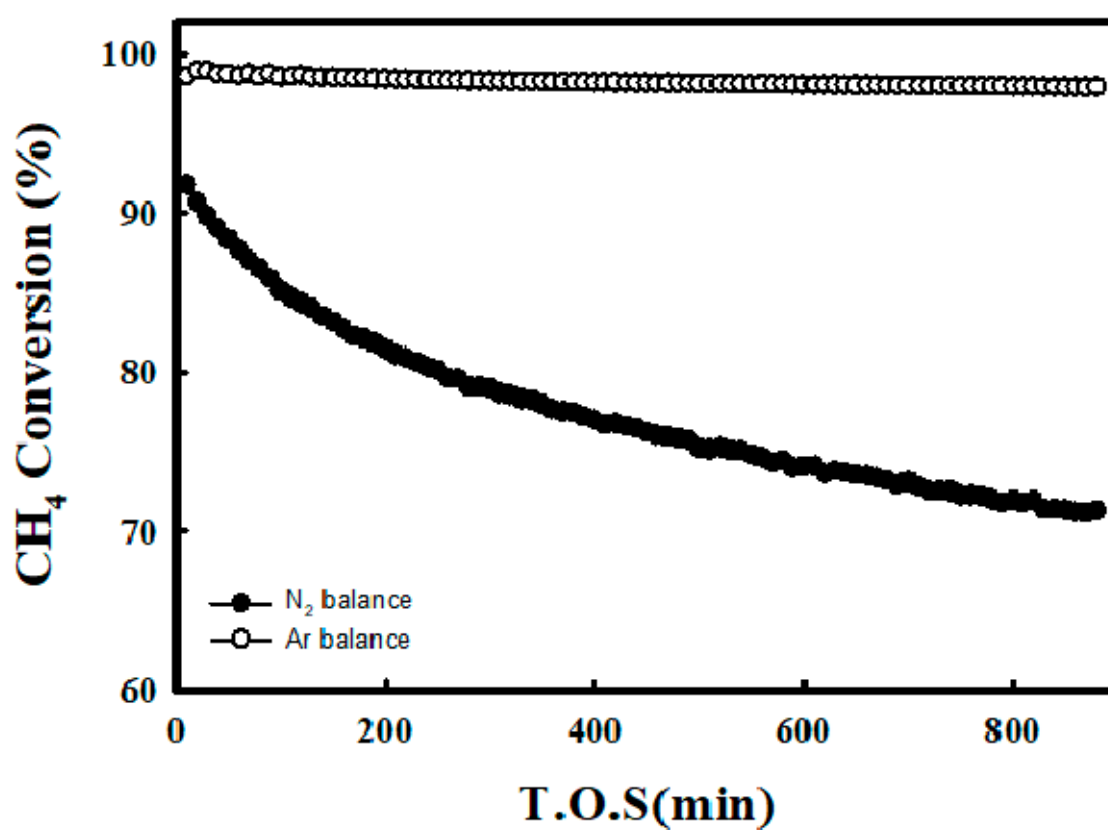
Figure S1. XRD patterns of the Ru/Al$_2$O$_3$ catalysts with different contact time in its fresh (**a**) and reduced (**b**) states.

Table S1. BET surface area, pore-volume, average pore size, RuO2, Ru crystallite size and Ru content of Ru/Al2O3 catalysts in its fresh and reduced states.

Catalyst		BET Surface Area (m²/g)	Pore Volume (cm³/g)	Average Pore Size (nm)	Crystallite Size (nm)		Ru Content (wt%)
					RuO₂	Ru	
RA (0, 1 h)	F	161	0.48	8.2	39.5		2.42(±0.82%)
	R	163	0.46	8.1		43.5	
RA (10, 0.25 h)	F	167	0.51	8.6	25.9		1.82(±1.15%)
	R	164	0.49	8.7		25.7	
RA (10, 1 h)	F	171	0.49	8.2	27.7		1.59(±0.95%)
	R	174	0.49	8.1		27.9	
RA (10, 24 h)	F	165	0.50	8.7	28.2		1.41(±1.42%)
	R	165	0.50	8.9		27.5	
RA (20, 1 h)	F	175	0.49	8.2	23.9		2.24(±1.04%)
	R	172	0.48	8.3		23.7	

Figure S2. Methane conversion of the RA (0, 1 h) catalysts in SMR reaction under different balance gas.
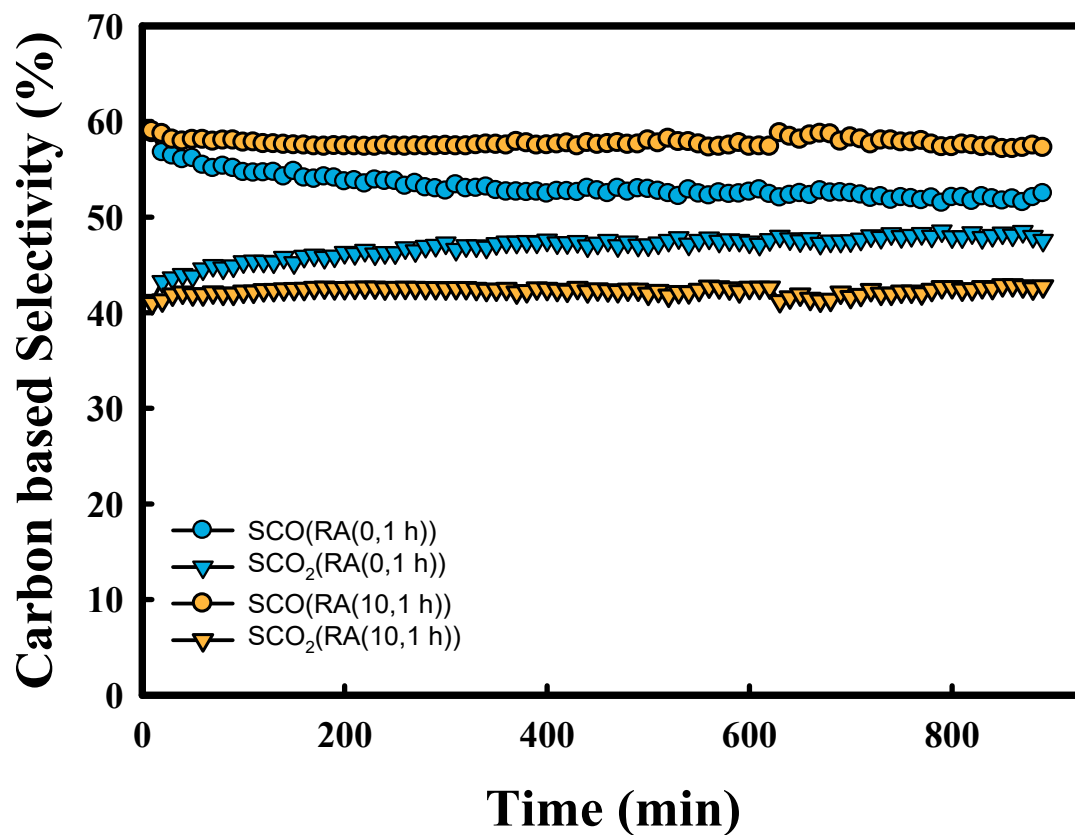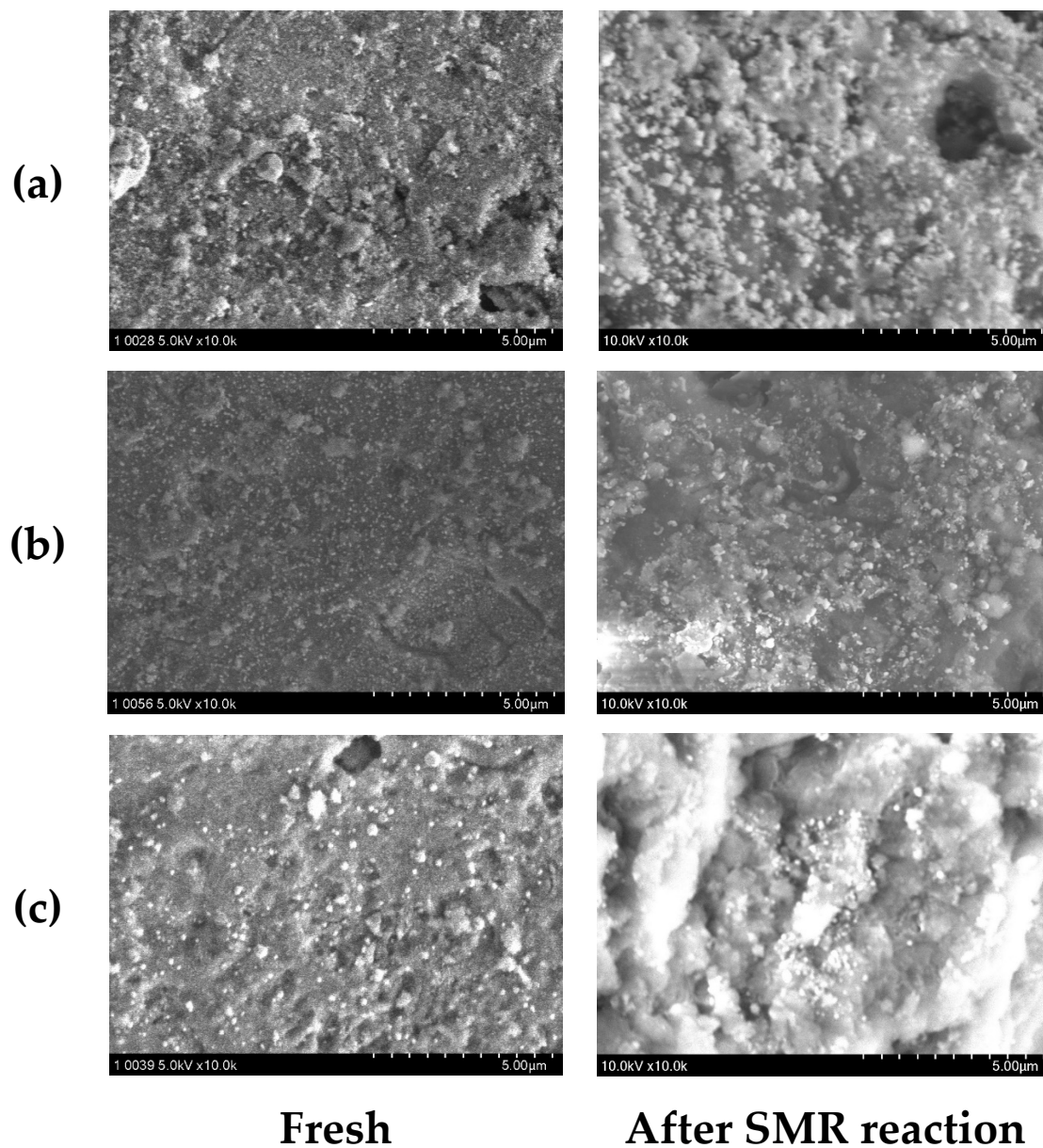
Figure S3. Carbon based selectivity of the RA (0, 1 h) and RA (10, 1 h) catalysts in SMR reaction long-term stability test with 700 °C and S/C ratio 3, WHSV 12,000 ml/g/h.

$$carbon\ based\ S_{CO} = \frac{F_{CO}^{out}}{F_{CO}^{out} + F_{CO_2}^{out}} \times 100$$

$$carbon\ based\ S_{CO_2} = \frac{F_{CO_2}^{out}}{F_{CO}^{out} + F_{CO_2}^{out}} \times 100$$

Table S2. H2/CO ratio of the Ru/Al2O3 catalysts SMR reaction long-term stability test with 700 °C and S/C ratio 3, WHSV 12,000 ml/g/h.

Catalyst	H_2/CO ratio
RA (0, 1 h)	6.57
RA (10, 0.25 h)	5..79
RA (10, 1 h)	5.30
RA (10, 24 h)	5.81
RA (20, 1 h)	5.79

Fresh **After SMR reaction**

Figure S4. SEM images of Ru/γ-Al2O3 catalysts: (**a**) RA (0, 1 h), (**b**) RA (10, 1 h), (**c**) RA (20, 1 h).