Supplementary Material **Open Access**

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Supplement: Hydrotalcite Anchored Ruthenium Catalyst for CO_2 Hydrogenation Reaction

Table 1: Physiochemical analyses of the synthesized materials.

S.No.	Sample	Mg %	Al %	Si %	Ru %	S_{BET} (m^2/g)	Pore volume (cm^3/g)	Pore size (nm)	Particle size of Ru nanometal
	Hydrotaclite	27.2	12.0	-	-	113	0.38	7.3	-
	Hydrotalcite-clacined	39.7	11.3	-	-	122	0.46	8	-
	ABIL-HT-A	39.0	11.2	-	-	111	0.41	7.4	-
	ABIL-HT-B	37.8	11.0	-	-	79	0.3	6.9	-
	ABIL-HT-C	37.8	10.9	-	-	101	0.36	6.3	-
	ABIL-HT-D	38.6	10.0	-	-	84	0.34	6.6	-
	HRUC-A	38.8	11.0	8.98	3.2	109	0.39	7.3	8
	HRUC-B	37.1	10.6	8.69	2.1	78	0.28	6.7	10
	HRUC-C	37.3	10.9	8.71	2.3	96	0.35	6.2	9.3
	HRUC-D	38.0	10.9	8.72	2.9	83	0.32	6.4	8.7

Table 2: XPS analyses of the developed materials.

Samples	Ru $3d_{3/2}$ [eV]	Ru $3d_{5/2}$ [eV]	Cl_2 2p [eV]	P 2p [eV]	N 1s [eV]
$RuCl_3$	284.7	280.2	199.2	-	-
$RuCl_3$/Calcined hydrotalcite	284.5	280.1	199.1	-	-
Ru-PNPr[1]	284.8	280.8	198.6	131.9	399.8
ABIL-HT-A	-	-		131.8	398.1
ABIL-HT-B	-	-	-	-	-
ABIL-HT-C	-	-	-	131.1	-
ABIL-HT-D	-	-	-	131.1	-
HRUC-A	284.8	280.8	197.1	131.8	400.1-
HRUC-B	284.8	284.8	198.6	131.7	-
HRUC-C	284.7	284.5	199.3	131.6	-
HRUC-D	284.7	284.5	199.3		400.2-
HRUC-A (*after catalyst recycling*)	284.7	284.4	198.5	131.6	-

a. Measurement error of ±0.2 eV; XPS data of Si 2p at 103.3 eV. b. XPS data referenced to C1s at 284.5 eV.

Table 3: CO_2 Hydrogenation reaction.

Entry	Catalyst (0.1 g+ 5 mL water + 2 mL EtN_3)	P (H_2) (P_{total}) (MPa)	T°C	t (h)	TON (mol_{FA}/mol_{Ru})	TON (mol_{FA}/mol_{Ru} x h^{-1})
	None	20 (40)	80	5	-	-
	$RuCl_3.3H_2O$	20 (40)	80	5	14.54	2.4
	$RuCl_3$/Calcined hydrotlcite	20 (40)	80	5	39.41	2.7
	HRUC-A	20 (40)	80	5	1277.22	7.9
	HRUC-B	20 (40)	80	5	603.24	255.4
	HRUC-C	20 (40)	80	5	767.51	120.6
	HRUC-D	20 (40))	80	5	893.18	153.5
	HRUC-A	30 (60)	80	5	1269.59	178.6
	HRUC-A	15 (30)	80	5	611.33	253.9
	HRUC-A	20 (40)	120	5	1273.24	122.3
	HRUC-A	20 (40)	60	5	1014.71	254.6
	HRUC-A	20 (40)	80	2	919.19	507.4
	HRUC-A (0.05 g)	20 (40)	80	2	563.18	459.6
	HRUC-A (0.15 g)	20 (40)	80	2	1280.08	281.6
	HRUC-A	20 (40)	80	7	1274.39	182.9
	Moiety-A	20 (40)	80	5	57.78	254.9
	$RuCl_2$ $(PPh_3)_3$	20 (40)	80	5	177.28	11.6

a. FA= formic acid

Table 4: Ionic liquid-mediated HRUC-A-catalyzed CO_2 hydrogenation reactions.

Entry[a]	T (°C)	Water (mL)	P (H_2) (P_{total}) (MPa)	Time (h)	HCOOH/IL	TON (mol_{FA}/mol_{Ru})	TON (mol_{FA}/mol_{Ru} x h^{-1})
	80	0	20 (40)	5	0.14	782.58	156.5
	80	1	20 (40)	5	0.29	846.5	169.3
	80	2	20 (40)	5	0.81	1013.28	202.7
	80	3	20 (40)	5	0.97	1218.95	243.8
	80	4	20 (40)	5	1.21	1321.05	264.2
	80	5	20 (40)	5	1.81	1572.99	314.6
	80	6	20 (40)	5	1.84	1575.9	315.2
	100	5	20 (40)	5	1.85	1582.99	316.6
	80	5	20 (40)	2	0.29	792.38	396.2
	80	5	20 (40)	6	1.95	1581.28	263.5
	80	5	20 (40)	8	1.95	1582.34	197.8
	80	5	20 (40)	10	2.1	1580.3	158.0
	60	5	20 (40)	5	0.38	1232.54	246.5
	80	5	30 (60)	5	1.81	1588.31	317.7
	80	5	10(20)	5	0.42	722.37	144.5
b	80	5	20 (40)	5	0.17	318.99	63.8
c	80	5	20 (40)	5	1.98	1573.74	314.7
d	80	5	20 (40)	5	0.84	1039.47	207.9

a. [DAMI][$CF_3CF_2CF_2CF_2SO_3$] ionic liquid (0.150 g)+ HRUC -A (0.1 g); b. [bmim][NTf_2] (0. 150 mL) +HRUC-A (0.1 g); c. [DAMI][$CF_3CF_2CF_2CF_2SO_3$] ionic liquid (0.250 g)+ HRUC -A (0.1 g); d. [DAMI][$CF_3CF_2CF_2CF_2SO_3$] ionic liquid (0.50 g)+ HRUC -A (0.1 g).