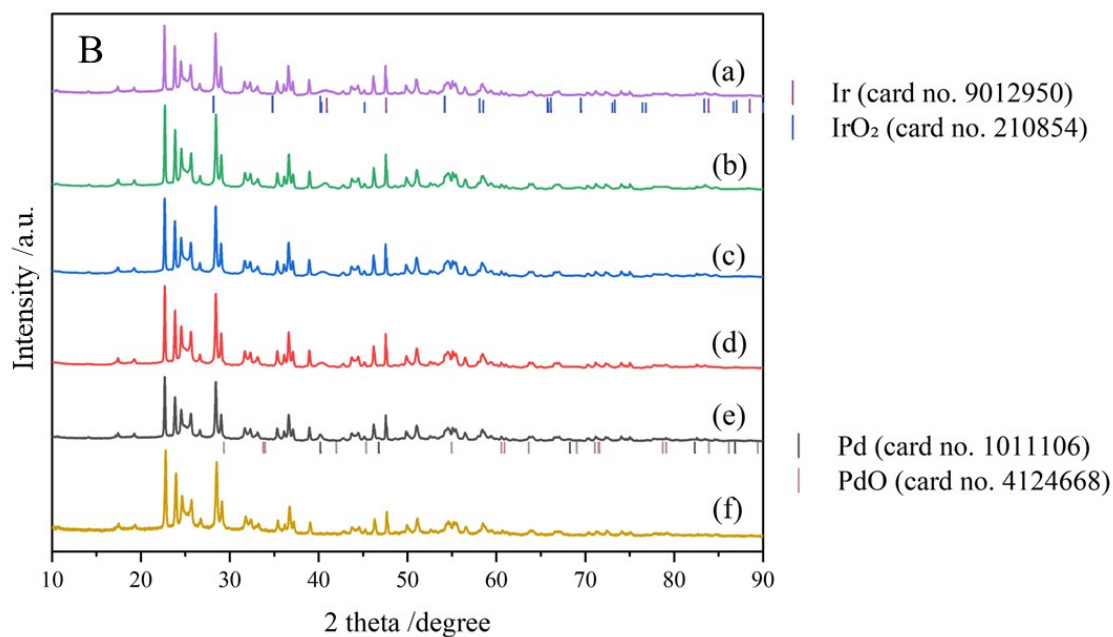
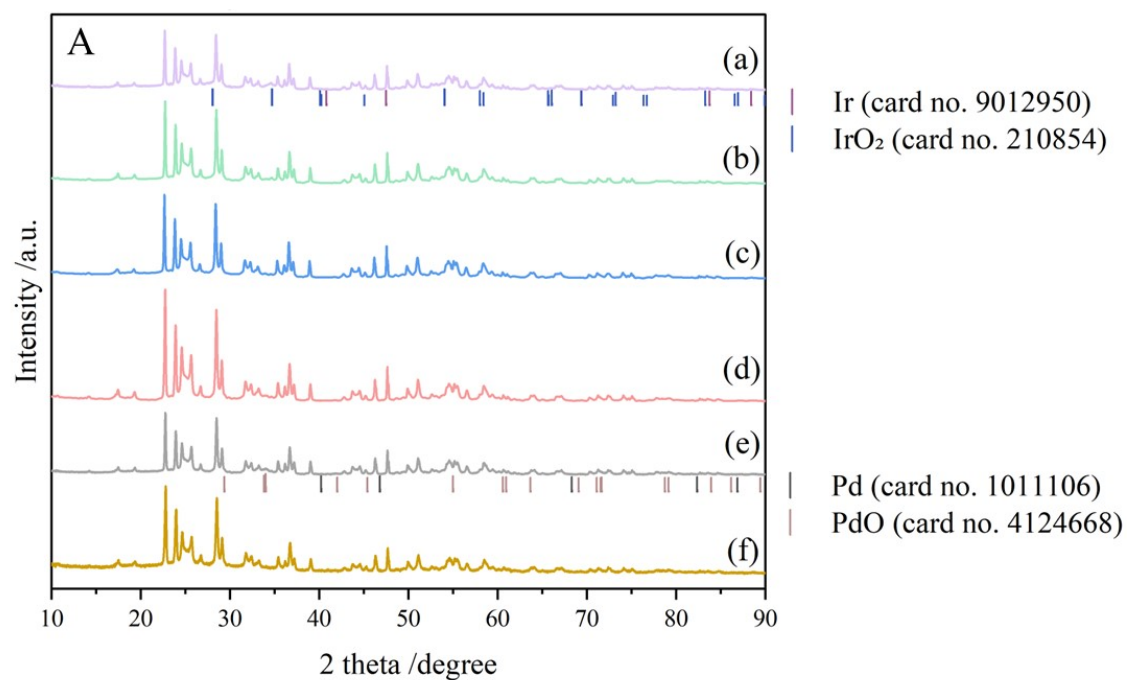
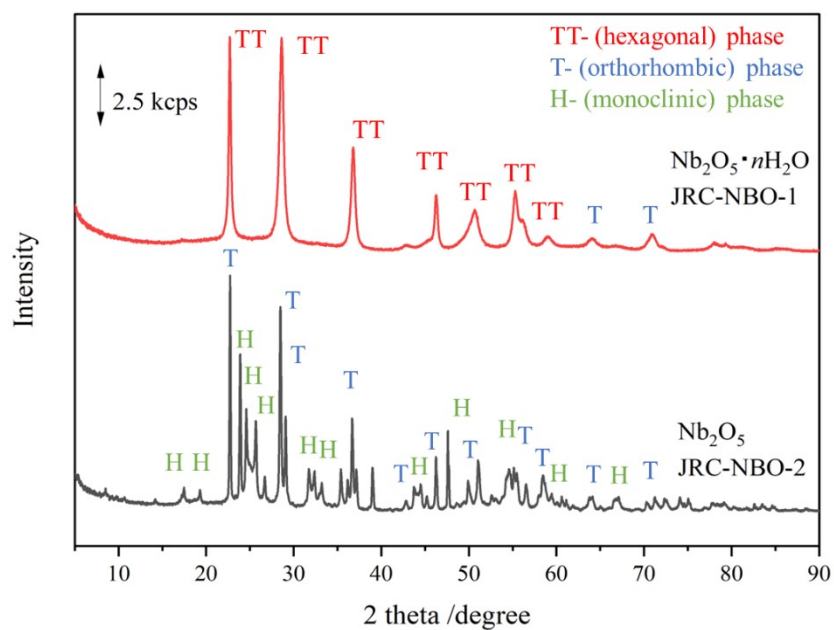


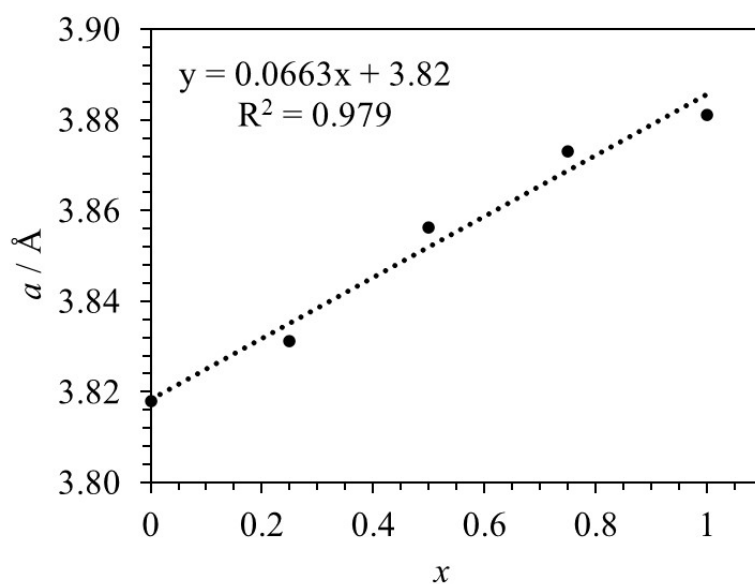
**Figure S1.** Comparison of hydrogenation reaction of dodecanoic acid over Ir<sub>50</sub>Pd<sub>50</sub>/Nb<sub>2</sub>O<sub>5</sub> (Ir = Pd = 0.15 mmol, total 0.30 mmol) vs physical mixture of Ir<sub>50</sub>/Nb<sub>2</sub>O<sub>5</sub> (Ir = 0.15 mmol) and Pd<sub>50</sub>/Nb<sub>2</sub>O<sub>5</sub> (Pd = 0.15 mmol). *Reaction conditions:* dodecanoic acid (0.1 g, ca. 0.5 mmol), catalyst (0.1 g), 1,4-dioxane (10 mL), H<sub>2</sub> (4.0 MPa), 150 °C, 900 rpm.



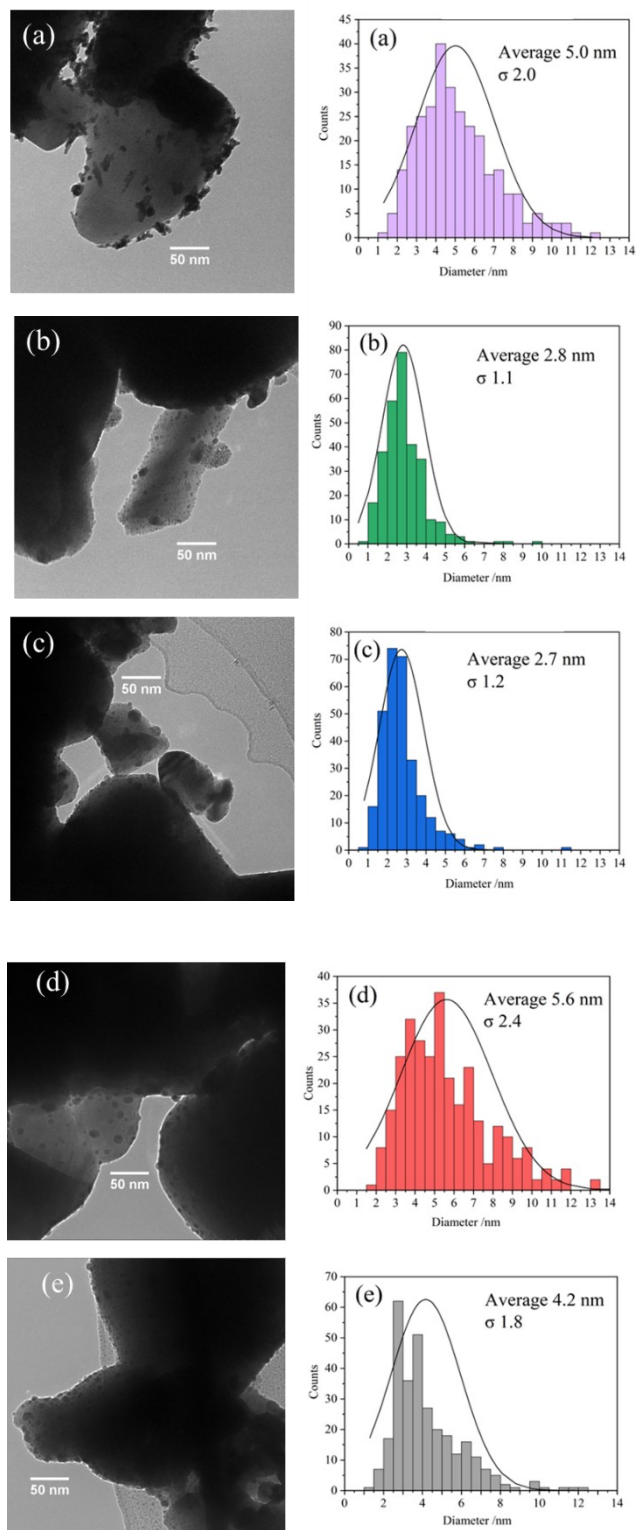
**Figure S2.** XRD patterns of (A) calcined and (B) reduced Ir<sub>x</sub>Pd<sub>y</sub>/Nb<sub>2</sub>O<sub>5</sub> at the full range of 2θ = 10–90 degrees: (a) Ir<sub>100</sub>/Nb<sub>2</sub>O<sub>5</sub>, (b) Ir<sub>75</sub>Pd<sub>25</sub>/Nb<sub>2</sub>O<sub>5</sub>, (c) Ir<sub>50</sub>Pd<sub>50</sub>/Nb<sub>2</sub>O<sub>5</sub>, (d) Ir<sub>25</sub>Pd<sub>75</sub>/Nb<sub>2</sub>O<sub>5</sub>, (e) Pd<sub>100</sub>/Nb<sub>2</sub>O<sub>5</sub>, and (f) Nb<sub>2</sub>O<sub>5</sub>.



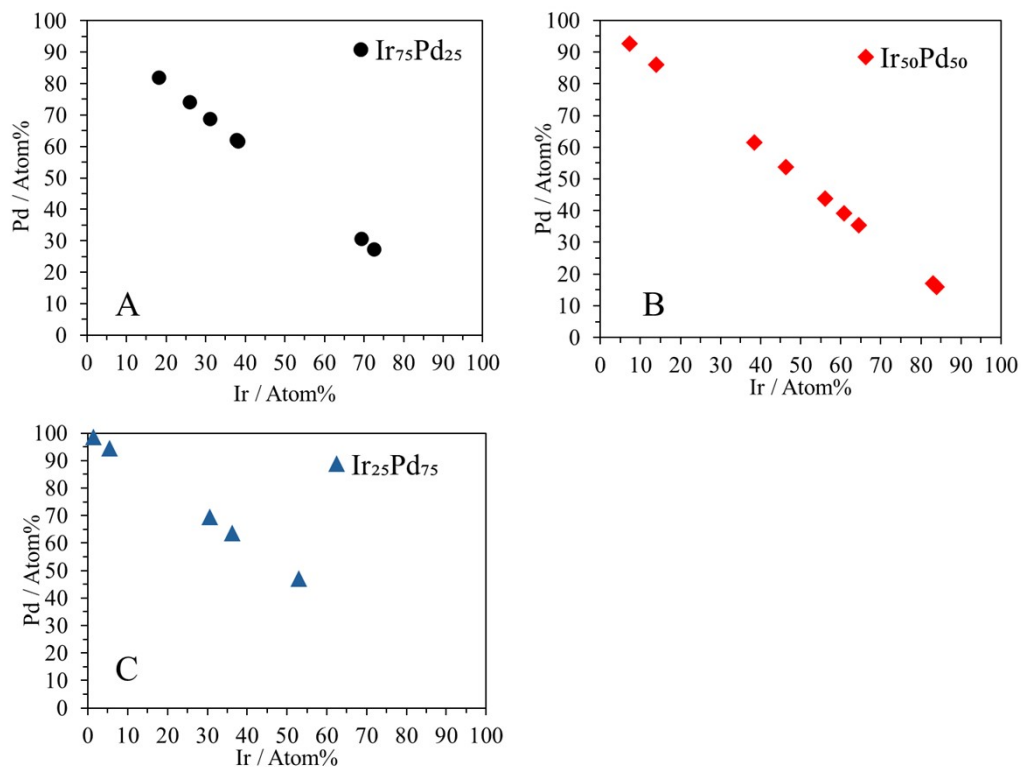
**Figure S3.** XRD patterns of Nb<sub>2</sub>O<sub>5</sub>·*n*H<sub>2</sub>O (JRC-NBO-1) and Nb<sub>2</sub>O<sub>5</sub> (JRC-NBO-2), which were calcined for 5 h at 500 °C and then reduced for 2 h at 500 °C.



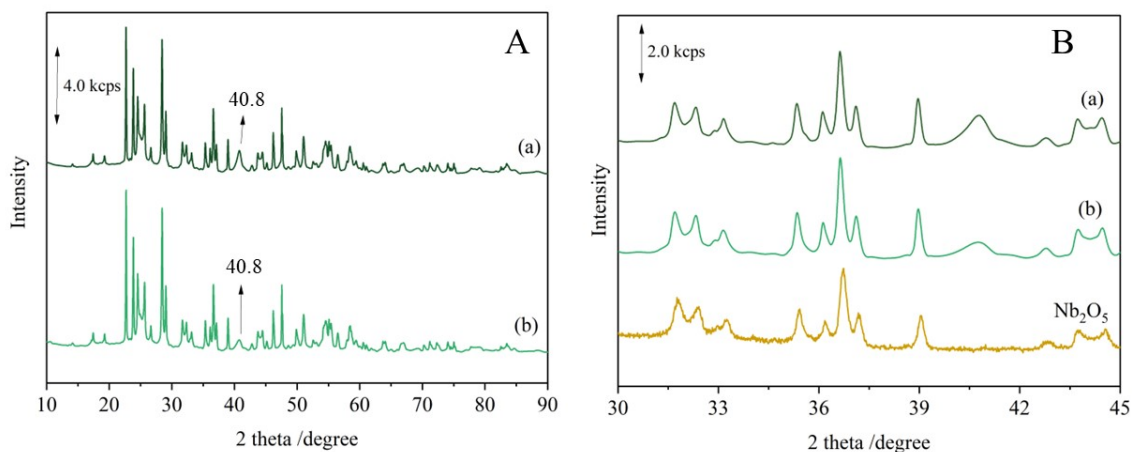
**Figure S4.** XRD peak shifts of Ir<sub>(1-x)</sub>Pd<sub>x</sub>/Nb<sub>2</sub>O<sub>5</sub> catalysts based on Ir (111) and Pd (111) planes: *a*; lattice parameter (Å), *x*; preparation ratio of Pd, and *R*; correlation coefficient.



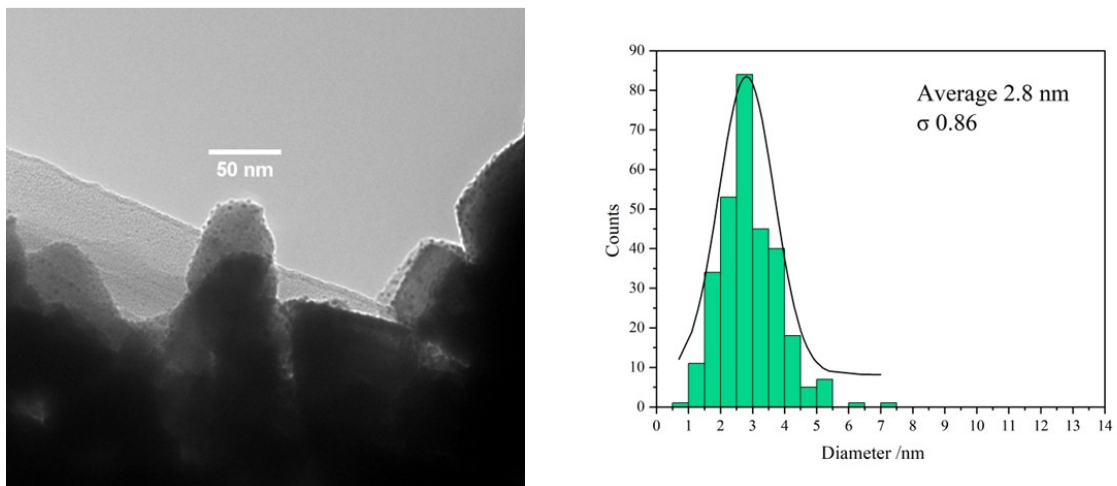
**Figure S5.** TEM images and histograms of the particle size distribution with 300 particles of  $\text{Ir}_x\text{Pd}_y$  nanoparticles on  $\text{Nb}_2\text{O}_5$  support: (a)  $\text{Ir}_{100}$ , (b)  $\text{Ir}_{75}\text{Pd}_{25}$ , (c)  $\text{Ir}_{50}\text{Pd}_{50}$ , (d)  $\text{Ir}_{25}\text{Pd}_{75}$ , and (e)  $\text{Pd}_{100}$ .



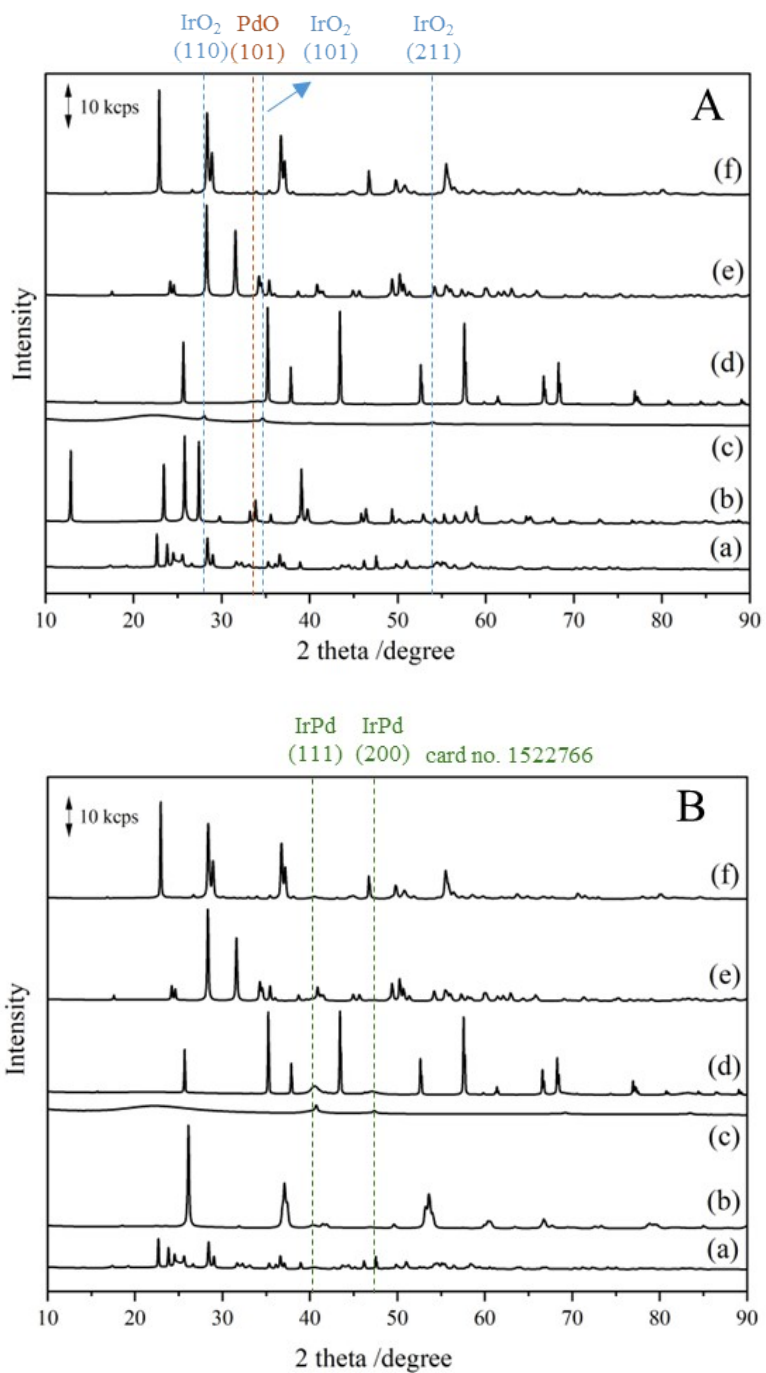
**Figure S6.** STEM-EDX spot-analysis results for several ratios of IrPd NPs loaded on Nb<sub>2</sub>O<sub>5</sub>: (A) Ir<sub>75</sub>Pd<sub>25</sub>, (B) Ir<sub>50</sub>Pd<sub>50</sub> and (C) Ir<sub>25</sub>Pd<sub>75</sub>.



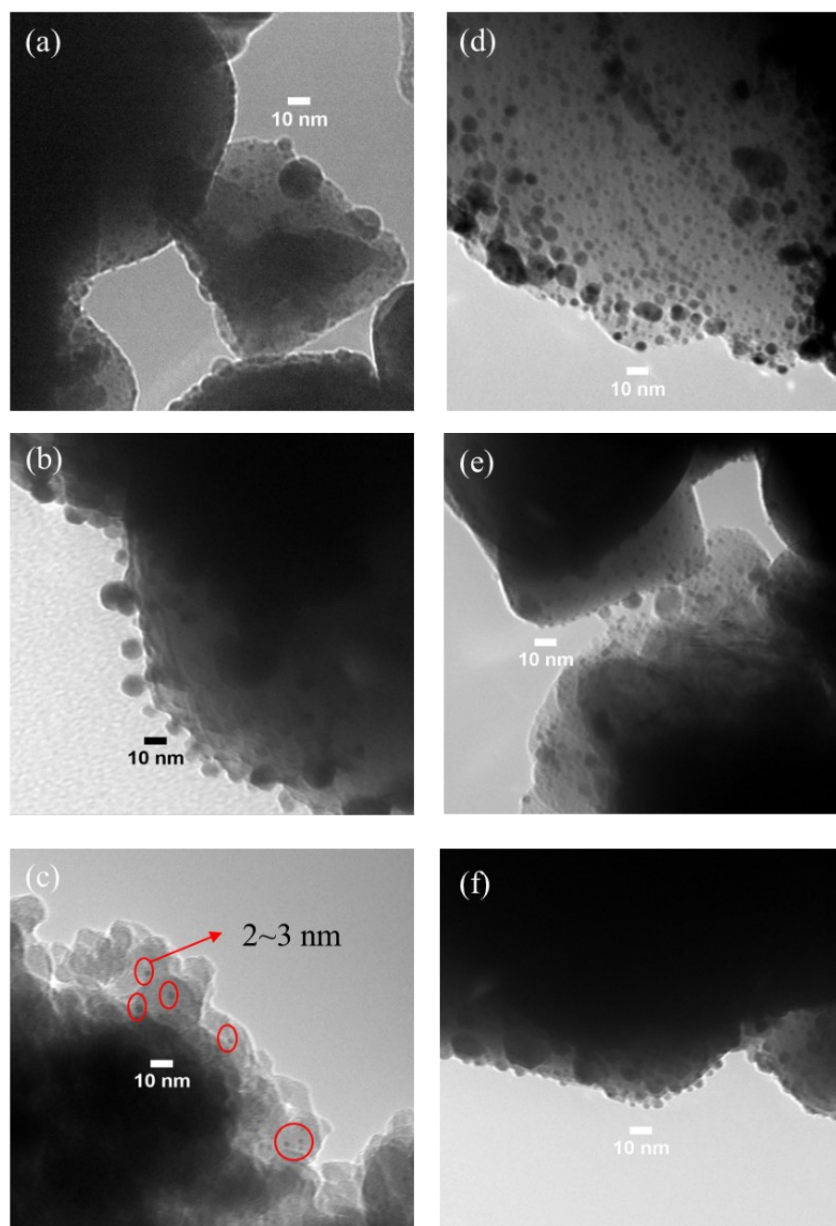
**Figure S7.** XRD patterns of (a) spent (after 3<sup>rd</sup> reuse test) and (b) fresh (as-prepared) Ir<sub>75</sub>Pd<sub>25</sub>/Nb<sub>2</sub>O<sub>5</sub> at the range of (A) 10–90 degrees, and (B) 30–45 degrees.



**Figure S8.** TEM image and histogram of the size distribution with 300 particles of Ir<sub>75</sub>Pd<sub>25</sub> nanoparticles on Nb<sub>2</sub>O<sub>5</sub> support after the 3<sup>rd</sup> reuse test.



**Figure S9.** XRD patterns of (A) calcined and (B) reduced  $\text{Ir}_{50}\text{Pd}_{50}$ /support: (a)  $\text{Nb}_2\text{O}_5$ , (b)  $\text{MoO}_3$ , (c)  $\text{SiO}_2$ , (d)  $\alpha\text{-Al}_2\text{O}_3$ , (e)  $\text{ZrO}_2$ , and (f)  $\text{Ta}_2\text{O}_5$ .



**Figure S10.** TEM images of Ir<sub>50</sub>Pd<sub>50</sub>-supported catalysts: (a) Nb<sub>2</sub>O<sub>5</sub>, (b) MoO<sub>3</sub>, (c) SiO<sub>2</sub>, (d)  $\alpha$ -Al<sub>2</sub>O<sub>3</sub>, (e) ZrO<sub>2</sub>, and (f) Ta<sub>2</sub>O<sub>5</sub>.

**Table S1.** Reagents for catalyst preparation.

Purpose	Chemical	Purity (%)	Supplier
Metal precursor	$\text{H}_2\text{IrCl}_6 \cdot n\text{H}_2\text{O}$	36.0-44.0 wt% as Ir	Sigma-Aldrich
	$\text{Pd}(\text{NO}_3)_2$	99.9	Fujifilm-Wako
	$\text{Mn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	98.0	Fujifilm-Wako
	$\text{Zn}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	99.0	Fujifilm-Wako
	$\text{HAuCl}_4 \cdot 4\text{H}_2\text{O}$	99.0	Fujifilm-Wako
	$\text{SnCl}_2 \cdot 2\text{H}_2\text{O}$	97.0	Kanto
	$\text{Ni}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	98.0	Fujifilm-Wako
	$\text{Co}(\text{NO}_3)_2 \cdot 6\text{H}_2\text{O}$	98.0	Fujifilm-Wako
	$\text{Fe}(\text{NO}_3)_3 \cdot 9\text{H}_2\text{O}$	99.9	Fujifilm-Wako
	$\text{Cu}(\text{NO}_3)_2 \cdot 3\text{H}_2\text{O}$	99.0-104.0	Fujifilm-Wako
Support	$\text{Nb}_2\text{O}_5$ (JRC-NBO-2)*	98.5	CBMM**
	$\text{Nb}_2\text{O}_5 \cdot n\text{H}_2\text{O}$ (JRC-NBO-1)	$80 \pm 5$ wt% as $\text{Nb}_2\text{O}_5$	CBMM
	$\text{MoO}_3$	99.5	Kanto
	$\text{ZrO}_2$	99.0	Kanto
	$\text{Ta}_2\text{O}_5$	99.95	Kanto
	$\text{SiO}_2$ (G-6, 3 $\mu\text{m}$ )	99.8	Fuji Silysia
	$\alpha\text{-Al}_2\text{O}_3$	99.0	Kanto

\*JRC: Japan Reference Catalyst

\*\*CBMM: Companhia Brasileira de Metalurgia e Mineraço

**Table S2.** Reagents for hydrogenation reaction and characterization.

Chemical	Purity (%)	Supplier*
Dodecanoic acid (Lauric acid)	98.0	Sigma-Aldrich
Dodecanol (Lauryl alcohol)	98.0	Sigma-Aldrich
Dodecane	99.0	Fujifilm-Wako
Hexadecanoic acid (Palmitic acid)	97.0	TCI
1-Hexadecanol	98.0	TCI
Hexadecane	98.0	TCI
Tetradecanoic acid (Myristic acid)	99.0	TCI
1-Tetradecanol	98.0	TCI
Tetradecane	99.0	TCI
Decanoic acid	98.0	TCI
1-Decanol	98.0	TCI
Decane	99.0	TCI
Naphthalene	98.0	TCI
1,4-Dioxane (super dehydrated)	99.5	Fujifilm-Wako

\*TCI: Tokyo Chemical Industry

**Table S3.** Hydrogenation reaction of dodecanoic acid over Ir<sub>50</sub>X<sub>50</sub>/Nb<sub>2</sub>O<sub>5</sub> catalysts (Ir + X = 0.30 mmol)<sup>a</sup>.

Secondary element (X)	Conversion (%)	Yield (%)	
		Dodecanol	Dodecane
Pd	96.8	67.7	23.8
none	35.1	25.7	2.2
Mn	14.0	4.7	0
Au	12.6	7.5	0
Co	9.2	3.7	0
Fe	9.0	0	0
Sn	7.3	4.6	0
Zn	6.9	0	0
Ni	4.3	3.9	0
Cu	1.8	0	0

<sup>a</sup>Reaction conditions: dodecanoic acid (0.1 g), catalyst (0.1 g), 1,4-dioxane (10 mL), H<sub>2</sub> (4.0 MPa), 150 °C, 900 rpm, 17 h.

**Table S4.** Deconvoluted XRS data of reduced Ir<sub>x</sub>Pd<sub>y</sub>/Nb<sub>2</sub>O<sub>5</sub> at the Ir 4f<sub>7/2</sub>, Nb 4s and Pd 3d<sub>5/2</sub> regions.

Nb <sub>2</sub> O <sub>5</sub> - supported Ir <sub>x</sub> Pd <sub>y</sub> catalyst	Binding energy (eV) (peak share (%))*				
	Ir 4f <sub>7/2</sub>		Nb 4s	Pd 3d <sub>5/2</sub>	
	IrO <sub>x</sub>	Ir <sup>0</sup>	Nb	Pd <sup>0</sup>	Pd <sup>δ-</sup>
Ir <sub>100</sub>	61.3 (13.9)	60.2 (86.1)	N.D.	N.A.	N.A.
Ir <sub>75</sub> Pd <sub>25</sub>	61.6 (10.1)	60.2 (89.9)	57.9 (100)	335.0 (83.7)	332.3 (16.3)
Ir <sub>50</sub> Pd <sub>50</sub>	61.8 (8.0)	60.2 (92.0)	57.8 (100)	334.9 (70.1)	332.6 (29.9)
Ir <sub>25</sub> Pd <sub>75</sub>	61.6 (9.8)	60.1 (90.2)	58.0 (100)	334.7 (85.4)	332.5 (14.6)
Pd <sub>100</sub>	N.A.	N.A.	N.A.	335.1 (100)	N.D.

N.A.: Not Applicable. N.D.: Not Detected.

\*Calculated from the area ratio in the same origin.

**Table S5.** Deconvoluted XRS data of reduced Ir<sub>x</sub>Pd<sub>y</sub>/Nb<sub>2</sub>O<sub>5</sub> at the Nb 3d<sub>5/2</sub> and O 1s regions.

Nb <sub>2</sub> O <sub>5</sub> - supported Ir <sub>x</sub> Pd <sub>y</sub> catalyst	Binding energy (eV) (peak share (%))*						
	Nb 3d <sub>5/2</sub>			O 1s			
	Nb <sup>5+</sup>	Nb <sup>4+</sup>	Nb <sup>2+</sup>	Surface adsorption	Nb <sup>5+</sup> lattice	Nb <sup>4+</sup> lattice	Nb <sup>2+</sup> lattice
Ir <sub>100</sub>	207.0 (82.8)	205.9 (17.2)	N.D.	531.5 (24.0)	530.0 (54.8)	528.5 (21.2)	N.D.
Ir <sub>75</sub> Pd <sub>25</sub>	207.1 (70.4)	205.8 (16.5)	204.1 (13.1)	531.7 (14.4)	530.0 (57.0)	528.5 (13.1)	527.1 (15.5)
Ir <sub>50</sub> Pd <sub>50</sub>	207.0 (58.7)	205.6 (20.8)	204.3 (20.4)	531.8 (7.5)	529.9 (54.0)	528.3 (16.9)	527.1 (21.7)
Ir <sub>25</sub> Pd <sub>75</sub>	207.1 (70.1)	205.9 (13.8)	204.4 (16.0)	531.9 (12.0)	530.0 (65.1)	528.5 (9.3)	527.3 (13.6)
Pd <sub>100</sub>	207.4 (81.8)	206.4 (18.2)	N.D.	531.8 (29.2)	530.3 (55.9)	529.0 (14.9)	N.D.

N.D.: Not Detected.

\*Calculated from the area ratio in the same origin.

**Table S6.** Time-dependence of reaction progress over Ir<sub>75</sub>Pd<sub>25</sub>/Nb<sub>2</sub>O<sub>5</sub> in hydrogenation of dodecanoic acid and dodecanol.

Substrate	Reaction time (h)	Conversion (%)	Yield (Selectivity) (%)	
			Dodecanol	Dodecane
dodecanoic acid <sup>a</sup>	2	17.3	10.0 (57.6)	0
	8	50.5	26.8 (53.1)	0
	17	93.0	74.3 (79.9)	12.5 (13.4)
	24	100	82.7 (82.7)	14.7 (14.7)
dodecanol <sup>b</sup>	8	<1	—	0
	17	7.2	—	5.6 (77.8)
	24	11.2	—	7.3 (65.2)

*Reaction conditions:* substrate (<sup>a</sup>0.1 g: ca. 0.5 mmol, <sup>b</sup>0.5 mmol), Ir<sub>75</sub>Pd<sub>25</sub>/Nb<sub>2</sub>O<sub>5</sub> (0.1 g), 1,4-dioxane (10 mL), H<sub>2</sub> (4.0 MPa), 150 °C, 900 rpm, 17 h.

**Table S7.** Recycling test of Ir<sub>75</sub>Pd<sub>25</sub>/Nb<sub>2</sub>O<sub>5</sub> for hydrogenating dodecanoic acid<sup>a</sup>.

Reuse	Conversion (%)	Yield (Selectivity) (%)	
		Dodecanol	Dodecane
Fresh	93.0	74.3 (79.9)	12.5 (13.4)
1 <sup>st</sup>	96.3	74.4 (77.2)	14.6 (15.2)
2 <sup>nd</sup>	81.0	66.0 (81.5)	7.5 (9.3)
3 <sup>rd</sup>	82.8	67.7 (81.8)	12.4 (15.0)

<sup>a</sup>*Reaction conditions:* dodecanoic acid (0.1 g), catalyst (0.1 g), 1,4-dioxane (10 mL), H<sub>2</sub> (4.0 MPa), 150 °C, 900 rpm, 17 h.

**Table S8.** Hydrogenation reaction of Ir<sub>50</sub>Pd<sub>50</sub>-supported catalysts<sup>a</sup>.

Ir <sub>50</sub> Pd <sub>50</sub> /Support	Conversion (%)	Yield (%)	
		Dodecanol	Dodecane
Nb <sub>2</sub> O <sub>5</sub>	96.8	67.7	23.8
MoO <sub>3</sub>	53.8	46.9	4.8
SiO <sub>2</sub>	6.2	2.5	0
$\alpha$ -Al <sub>2</sub> O <sub>3</sub>	4.4	0	0
ZrO <sub>2</sub>	2.4	0	0
Ta <sub>2</sub> O <sub>5</sub>	2.0	0	0

<sup>a</sup>Reaction conditions: dodecanoic acid (0.1 g), catalyst (0.1 g), 1,4-dioxane (10 mL), H<sub>2</sub> (4.0 MPa), 150 °C, 900 rpm, 17 h.