Electronic supplementary information

HYBRID MAGNETICALLY SEPARABLE CATALYST FOR THE HYDROGENATION OF LEVULINIC ACID TO γ-VALEROLACTONE

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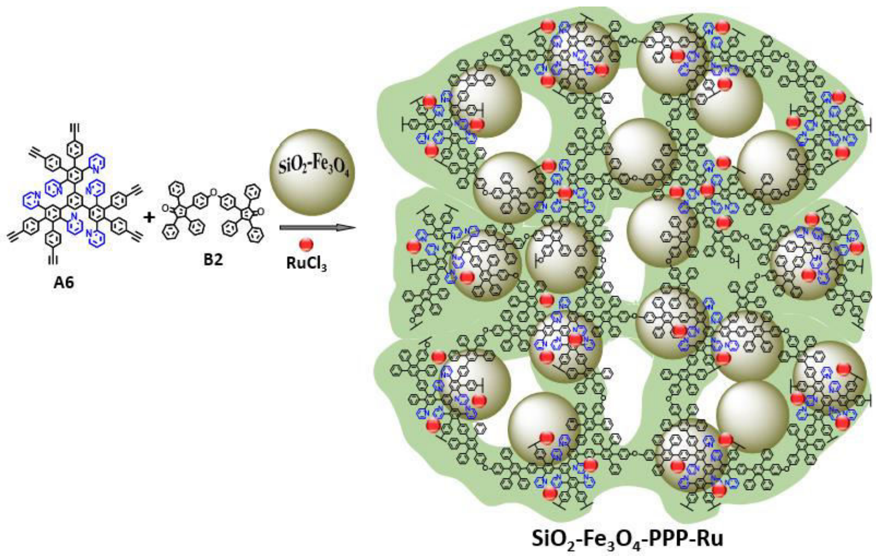

Figure S1. Synthesis of the hybrid organic–inorganic catalyst SiO_2–Fe_3O_4–HPP–Ru

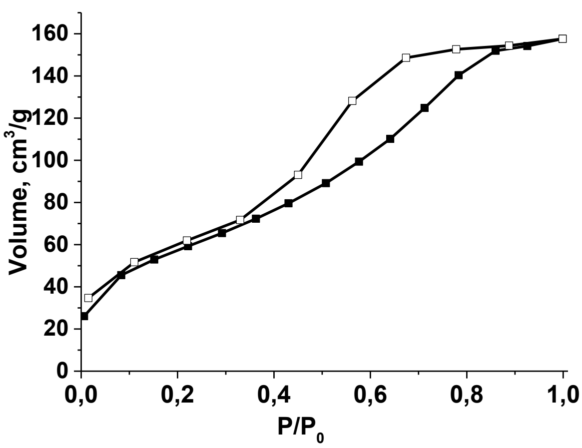

Figure S2. Liquid nitrogen adsorption–desorption isotherms of the SiO_2–Fe_3O_4–HPP–Ru

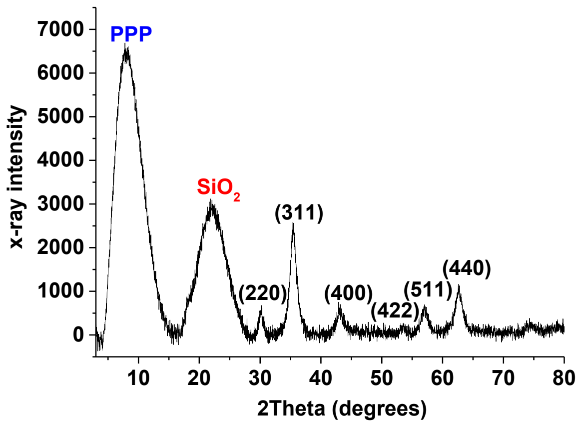

Figure S3. XRD pattern of the SiO_2–Fe_3O_4–HPP–Ru sample

Table S1. Deconvolution parameters of the Ru 3d and C 1s XPS spectra

	Pos.	FWHM	% Area
Ru $3d_{5/2}$ ($Ru(OH)_3$)	281.30	1.31	2.50
Ru $3d_{3/2}$ ($Ru(OH)_3$)	285.47	1.57	1.64
Ru $3d_{5/2}$ ($Ru(OH)_3$) Satellite	283.20	1.31	1.19
Ru $3d_{3/2}$ ($Ru(OH)_3$) Satellite	287.57	1.57	0.80
C 1s (C-C (sp^2))	284.72	1.13	49.99
C 1s (C-N)	285.39	1.25	16.71
C 1s C-O-C	286.20	1.76	8.01
C 1s (C (π-π))	291.85	2.50	5.44
C 1s -COOH	289.59	2.50	2.14
Ru $3d_{5/2}$ ($RuCl_3$)	282.36	1.34	4.66
Ru $3d_{3/2}$ ($RuCl_3$)	286.53	1.60	3.14
Ru $3d_{5/2}$ ($RuCl_3$) Satellite	284.26	1.34	2.27
Ru $3d_{3/2}$ ($RuCl_3$) Satellite	288.63	1.60	1.51

Table S2. Activity of different catalysts in the hydrogenation of LA

Catalyst	**Solvent**	**Reaction conditions**	**LA conv. (%)**	**GVL yield (%)**	**Ref.**
5%Ru/TiO_2–SiO_2	ethanol	130 °C, H_2 3 MPa, 0.1 g of the catalyst, 6 h	96	84	[1]
$RuCl_3$	ethanol	100 °C, H_2 2 MPa, 0.5 mol % of the catalyst, 6 h	61	2	[1]
$RuCl_3$/PPh_3	ethanol	100 °C, H_2 2 MPa, 0.5 mol % of the catalyst, 6 h	89	17	[1]
5%Ru/C	dioxane	265 °C, H_2 1 bar, 1 g of the catalyst, 50 h	100	98.6	[2]
1%Ru/TiO_2	H_2O	70 °C, H_2 5 MPa, 0.3 g of the catalyst, 1 h	99	95	[3]
Fe-Re(1:2)/TiO_2,	H_2O	180 °C, H_2 4 MPa, 0.023 g of the catalyst, 4 h	100	95	[4]
1%Ru/TiO_2	H_2O	150 °C, H_2 3.2 MPa, 0.4 mol % of the catalyst, 5 h	100	93	[5]
5% Ru/Zr/Al–SBA–15	-	400 °C, H_2 0.1 MPa, 0.5 g of the catalyst, 6h	90	15	[6]
0.5%Ru/SiO_2	H_2O	130 °C, H_2 4 MPa, 0.1 g of the catalyst, 3 h	80	79	[7]
Ru-PVA	H_2O	140 °C, H_2 5 MPa, 0.03 mol % catalyst, 1 h	71	69.2	[8]
Ru/SiO_2	H_2O	90 °C, H_2 4.5 MPa, 0.4 mol % catalyst, 6 h	26	14	[9]
Ru_{40}-DENs	H_2O	150 °C, H_2 1 MPa, 0.5 mol % Ru, 5 h	100	99	[10]
5%Ru/ZrO_2	H_2O	130 °C, 2 MPa, 0.025 g of the catalyst, 2 h	100	99.5	[11]
1%Ru/zeolite-β	2-ethyl-hexanoic acid	200 °C, H_2 4 MPa, 0.3 g of the catalyst, 4 h	100	88	[12]
1%Ru/ZSM-5	2-ethyl-hexanoic acid	200 °C, H_2 4 MPa, 0.3 g of the catalyst, 4 h	100	90	[12]
5%Ru/ZrO_2	H_2O	70 °C, H_2 0.5 MPa, 0.5 mol % Ru, 4 h	69	67	[13]
5%Ru/MCM-41	H_2O	70 °C, H_2 0.5 MPa, 0.5 mol % Ru, 4 h	89	84	[13]

1%Ru/OMC/H_3PO_4	H_2O	70 °C, H_2 0.7 MPa, 0.1 mol % Ru, 6 h	98	92	[14]
1%Ru/OMC/H_3PO_4	H_2O	200 °C, H_2 4 MPa, 0.1 mol % Ru, 6 h	99	67	[14]
3.5%G2–dendr–SiO_2–Ru	H_2O	120 °C, H_2 3 MPa, 2 h	84	78	[15]
SiO_2–Fe_3O_4–PPP–3%Ru	H_2O	130 °C, 2 MPa, 0.01 g of the catalyst, 4 h	100	99.5	this work

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