

**Transfer hydrogenation of biomass-derived levulinic acid to
 γ -valerolactone over supported Ni catalysts**

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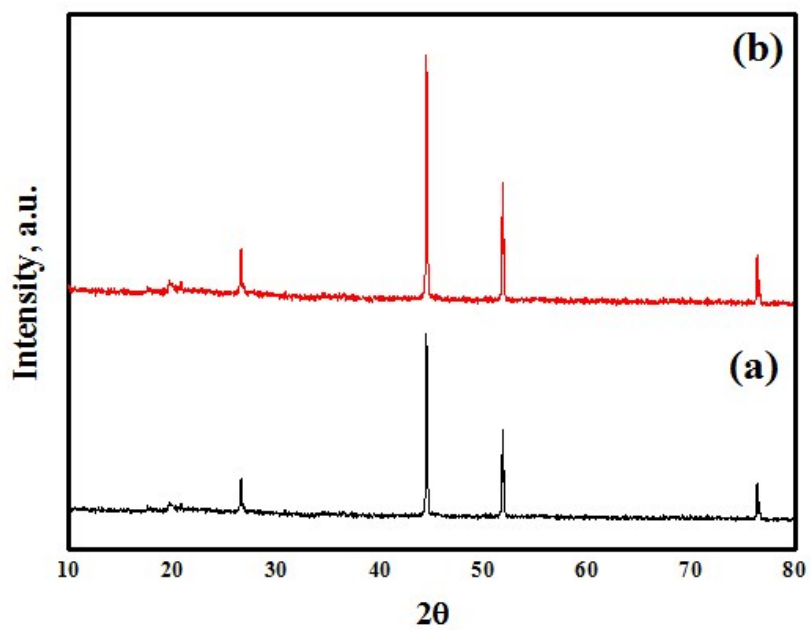


Figure S1. XRD of 50%-Ni/MMT synthesized by calcination and hydrogenation of Ni^{2+} adsorbed on MMT. (a) fresh and (b) used

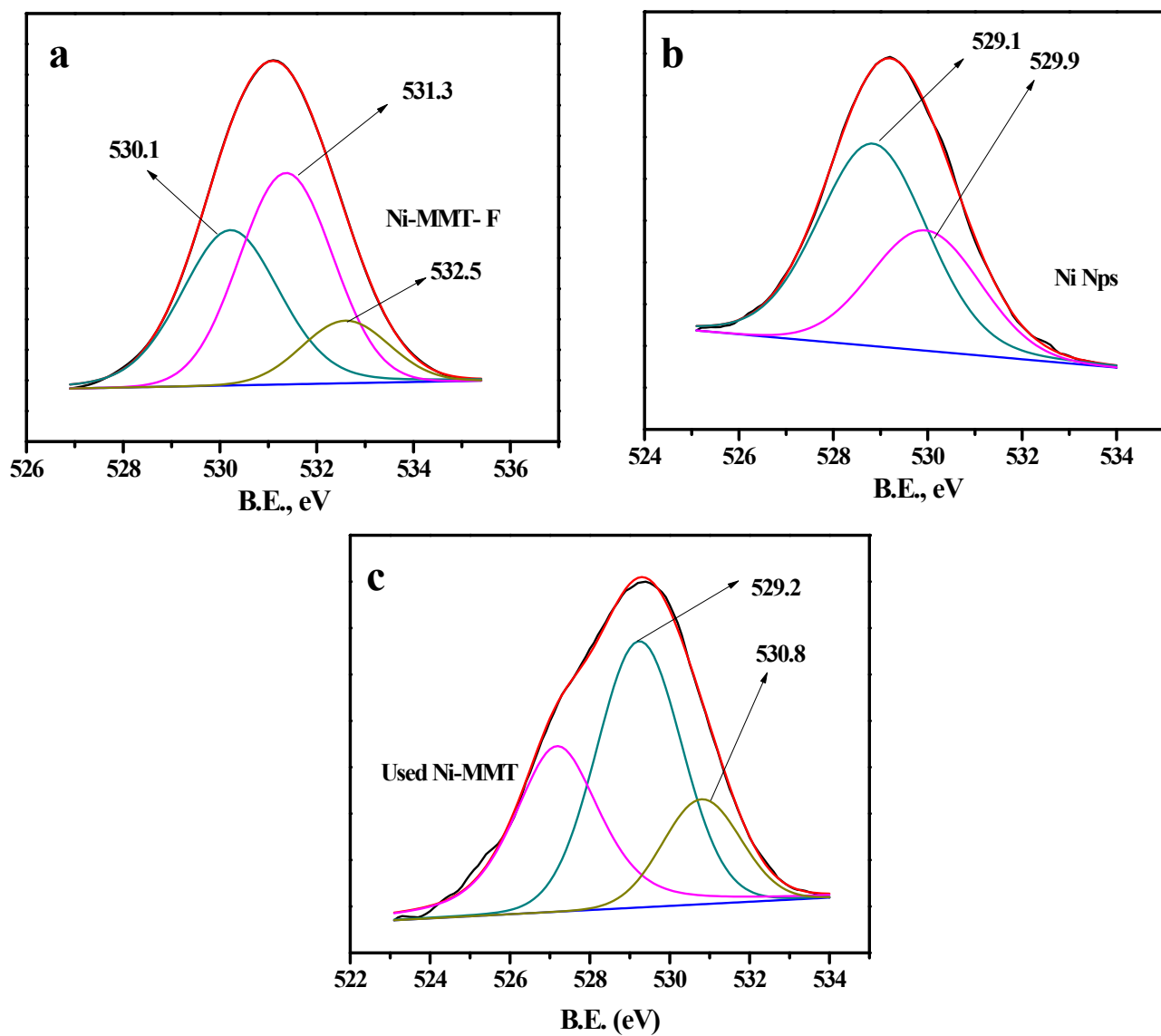


Figure S2. XPS study of oxygen (a) fresh 50%-Ni/MMT (b) Ni NP's and (c) used 50%-Ni/MMT

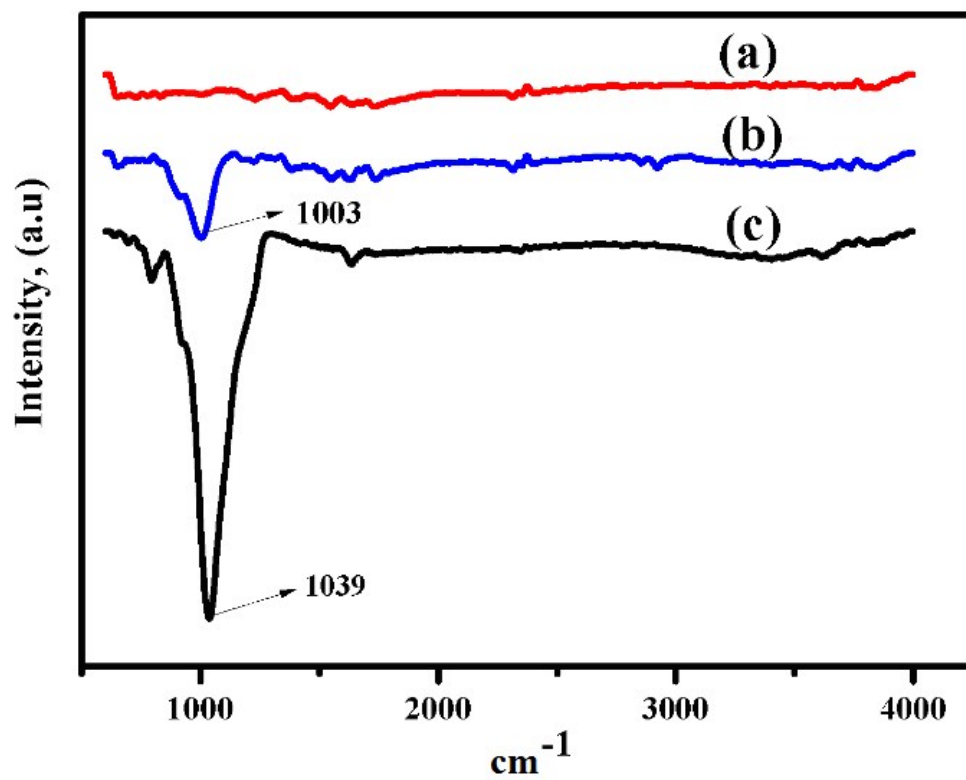


Figure S3. FTIR study of Ni catalysts (a) Ni NP's, (b) 50%-Ni/MMT and (c) Na-MMT

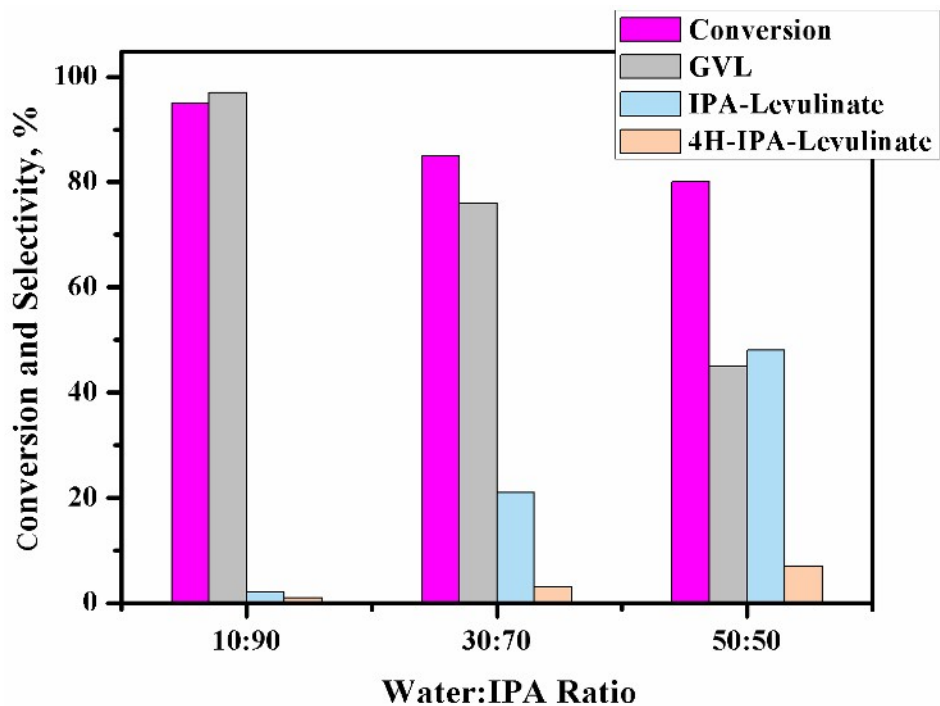


Figure S4. Effect of water and IPA ratio on CTH of LA.

Reaction conditions: LA (5 mL); IPA: Water (95 mL); Metal Loading, 50%; temperature, 200 °C; N₂ atm; catalyst, 0.5 g; reaction time, 1h.

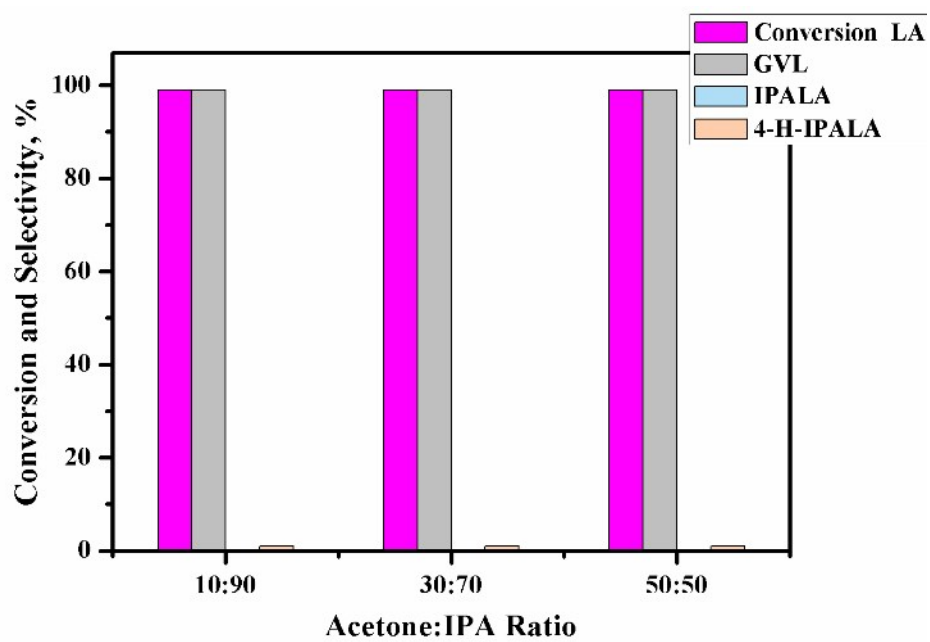


Figure S5. Effect of acetone and IPA ratio on CTH of LA.

Reaction conditions: LA (5 mL); IPA:Acetone (95 mL); Metal loading, 50%; temperature, 200 °C; N₂ atm; catalyst, 0.5 g; reaction time, 1h.

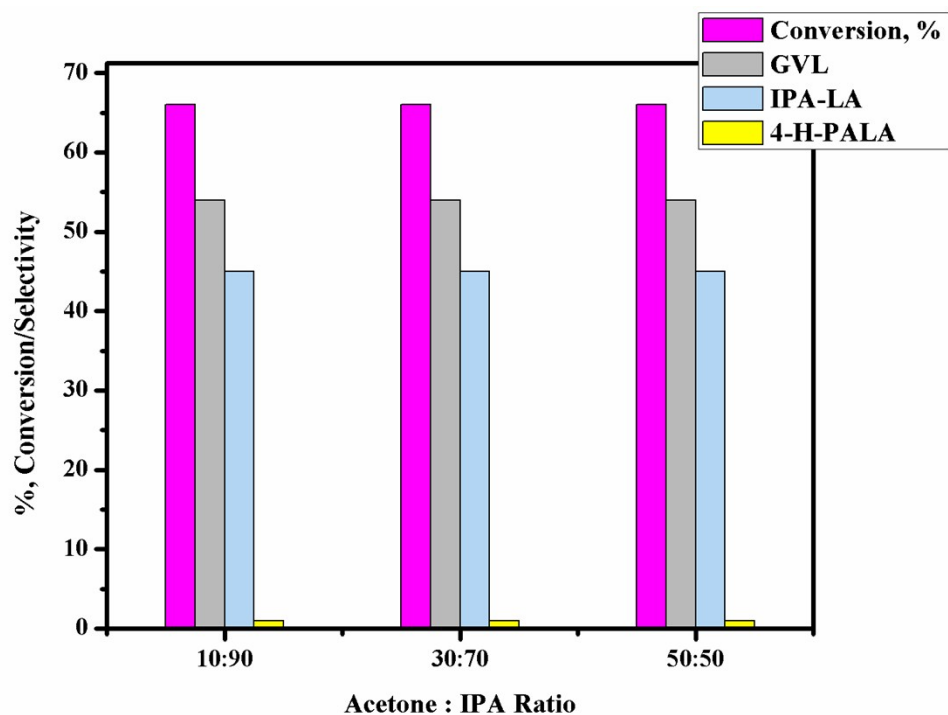


Figure S6. Effect of acetone and IPA ratio on CTH of LA at lower LA conversion. Reaction conditions: LA (5 mL); IPA:Acetone (95 mL); Metal loading, 50%; temperature, 200 °C; N₂ atm; catalyst, 0.5 g; reaction time, 0.5 h.

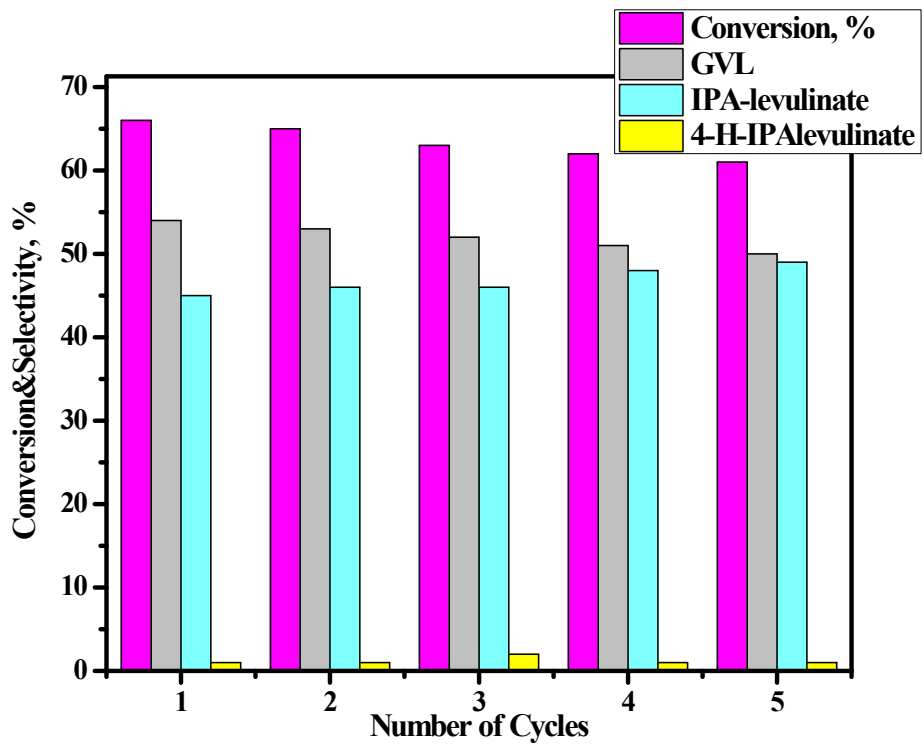


Figure S7. Reusability studies for CTH of LA to GVL.

Reaction conditions: LA (5 mL); IPA (95 mL); Ni loading, 50%; temperature, 200°C; N₂ atm; catalyst, 0.5 g; reaction time, 0.5 h.

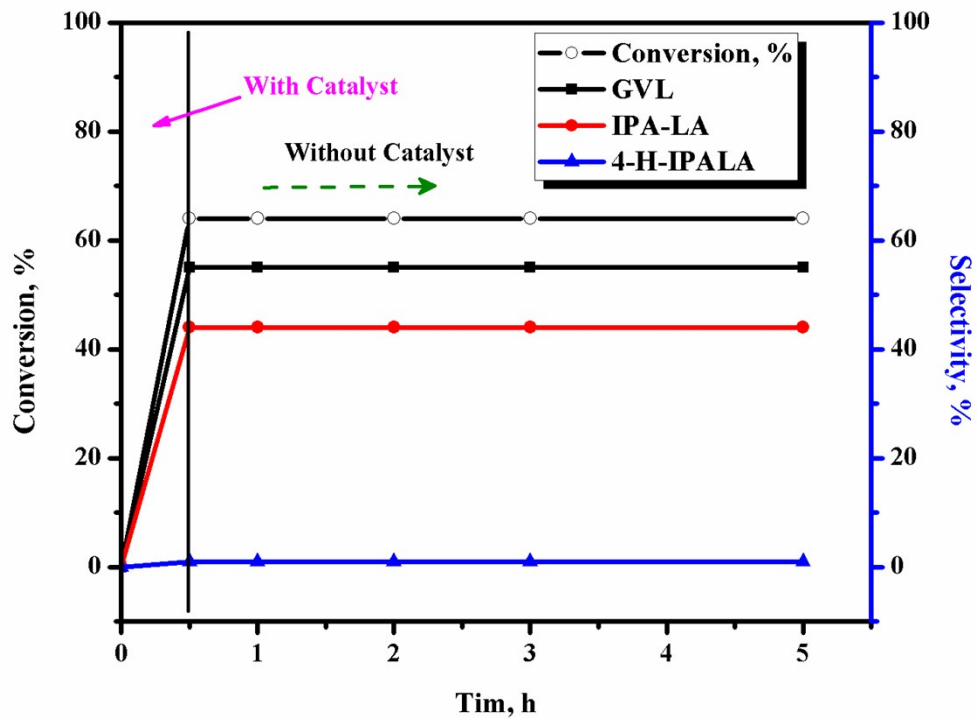


Figure S8. Metal leaching test by hot filtration

Reaction conditions: LA (5 mL); IPA (95 mL); Metal loading, 50%; temperature, 200 °C;

N₂ atm; catalyst, 0.5 g; reaction time, 5 h.

Table S1. XPS composition study of Ni-MMT catalyst

Sample	Species		
Fresh 50%-Ni-MMT	Ni⁰	NiO	Ni (OH)₂
BE	852.4	855.2	856.6
%	9.31	64.37	26.31
Bare Ni NP's	Ni⁰	NiO	Ni (OH)₂
BE	852.1	854.2	855.4
%	18.5	54.17	27.29
Used 50%-Ni-MMT	Ni⁰	NiO	Ni (OH)₂
BE	852.9	855.4	856.8
%	35.99	40.05	23.94

Table S2. Solvent screening for CTH of LA to GVL over 50%-Ni/MMT catalyst

Solvent	% Conversion	Levulinic esters	GVL	Others
Methanol	99	99	1	<0.01
Ethanol	99	98	2	<0.01
n-Propanol	99	95	4	1
n-Butanol	99	90	7	3
Isoproanol	99	<0.01	99	1
Isobutanol	99	<0.01	99	1

Reaction conditions: LA (5 mL); solvent, (MeOH, EtOH, n-PrOH, n-BuOH, IPA and isobutanol) (95 mL); Metal loading, 50%; temperature, 200 °C; N₂ atm; catalyst, 0.5 g; reaction time, 1 h.

Table S3. H₂-TPR results and metal dispersion of screened catalysts for CTH of LA.

Catalyst	Total H ₂ consumed (mmol/g)	Temperature regions H ₂ consumed (mmol/g)			Metal dispersion (%)
		50-200 °C	200-400 °C	400-700 °C	
50%-Ni-MMT	6.9	--	--	6.9	23
50%-Ni/Al ₂ O ₃	10.7	--	--	10.7	17
50%-Ni-ZnO	8.9	--	--	8.9	19
50%-Ni/SiO ₂	7.8			7.8	9

Table S4. NH₃-TPD results of screened catalysts for CTH of LA.

Catalyst	Total NH ₃ desorbed (μmol/g)	Temperature regions NH ₃ desorption (μmol/g)		
		50-200 °C	200-400 °C	400-700 °C
Ni-MMT	0.458	0.019	0.0152	0.424
50%-Ni/Al ₂ O ₃	0.248	0.0341	0.214	-
50%-Ni-ZnO	0.135	0.014	0.12	-

Table S5. Activity of fresh and used 50%-Ni/MMT for LA to GVL conversion

Entry	Catalyst	Conversion (%)	Selectivity (%)		
			GVL	IPA- levulinate	4-H-IPA- levulinate
1	Fresh	99	99	0.01	1
2	Used*	99	99	0.01	1

*After 1st run

Reaction conditions: LA (5 mL); IPA (95 mL); Ni loading, 50%; temperature, 200°C; N₂ atm; catalyst, 0.5 g; reaction time, 1 h.