Supporting Information

1. Nitrogen adsorption isotherms

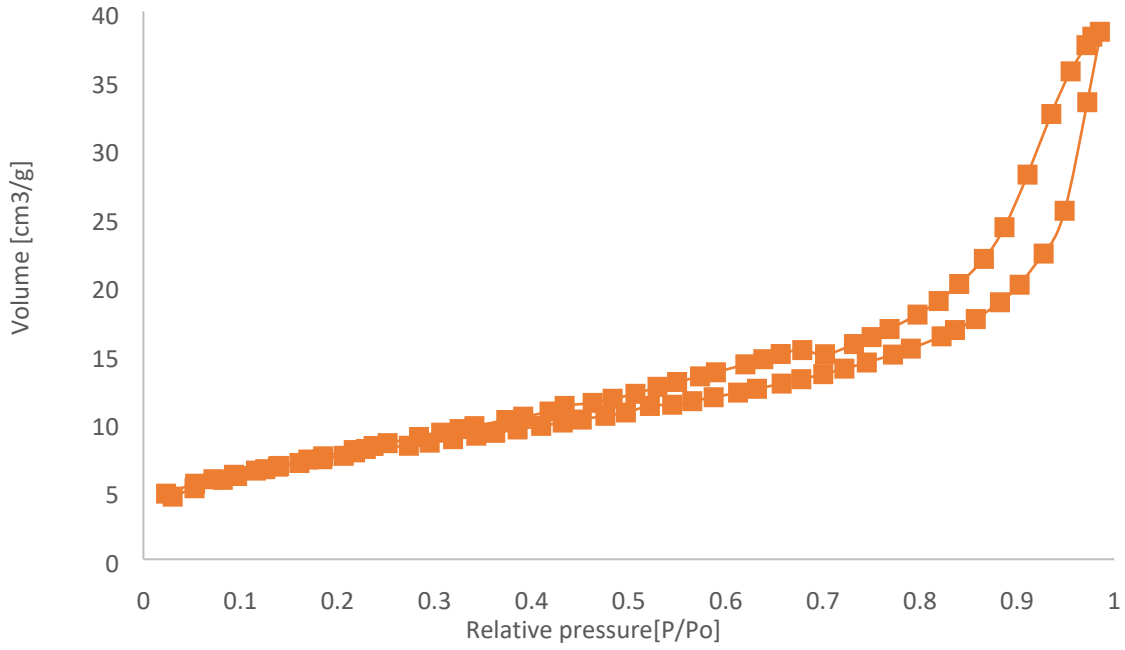

Figure S1. Nitrogen adsorption isotherm at −196.15 °C for sample Nb+N-ie.

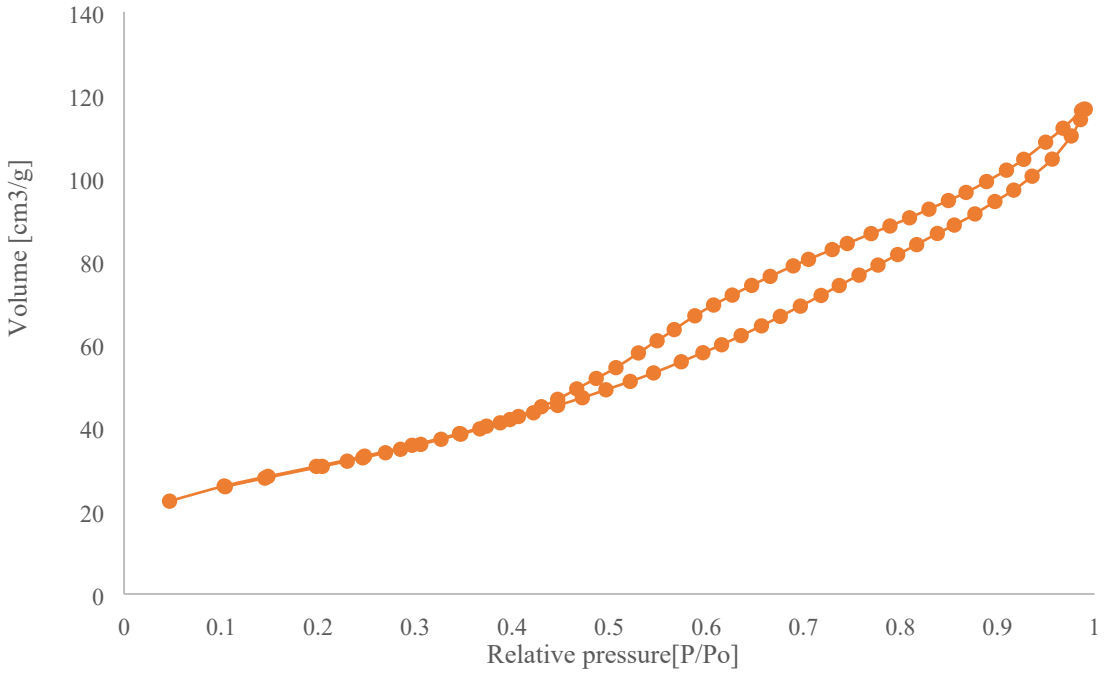

Figure S2. Nitrogen adsorption isotherm at −196.15 °C for sample Zr+N-ie.

2. Conversion of levulinic acid in the esterification with ethanol catalyzed by zirconia

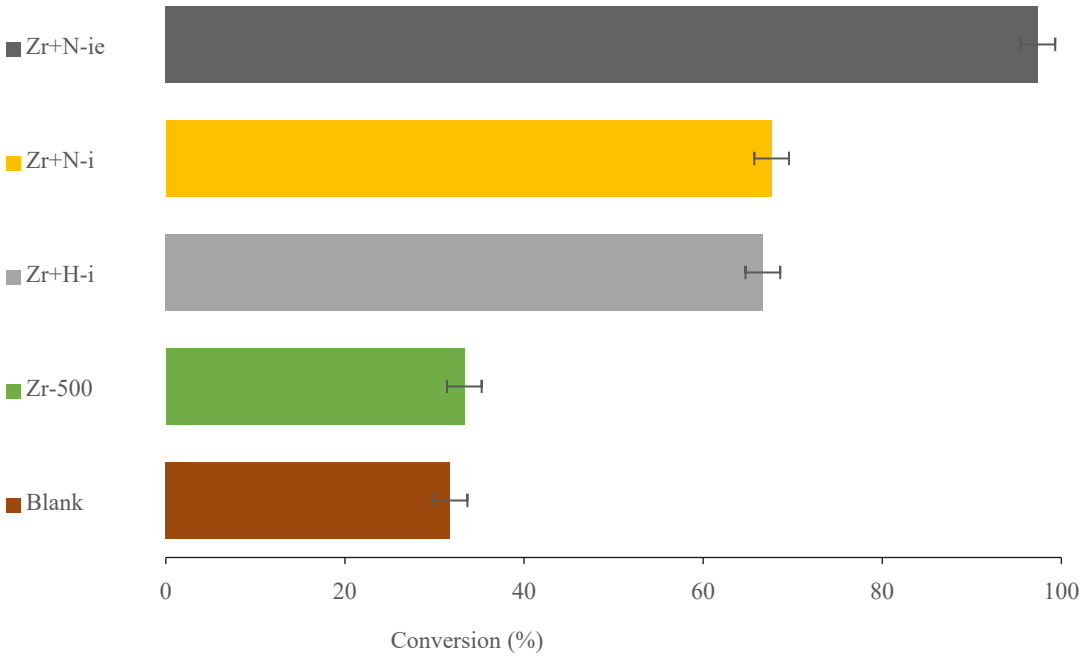

Figure S3. Conversion of LAc in the esterification with ethanol for the zirconia catalysts studied. Reaction conditions: 700 rpm, alcohol/acid molar ratio 12:1, 5 wt% catalyst relative to levulinic acid mass, for 2 hours at 140 °C.

3. Chromatographic analysis of reactants and products

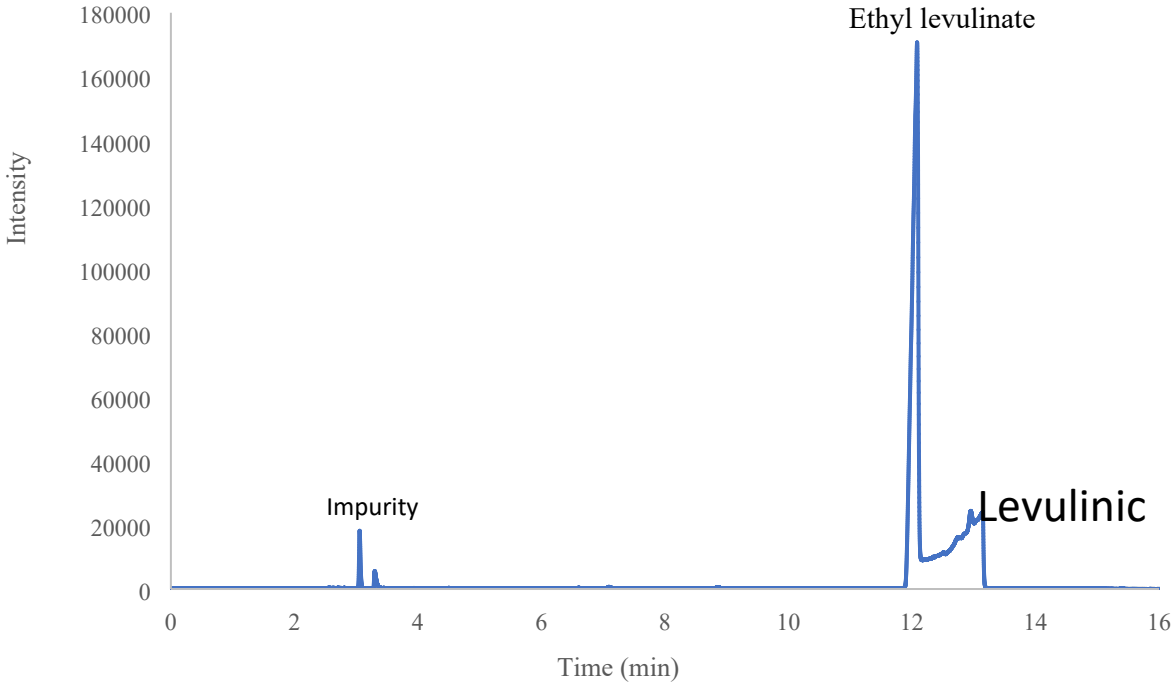

Figure S4. Chromatogram of the reaction product at 140 °C catalyzed with Nb+N-ie.

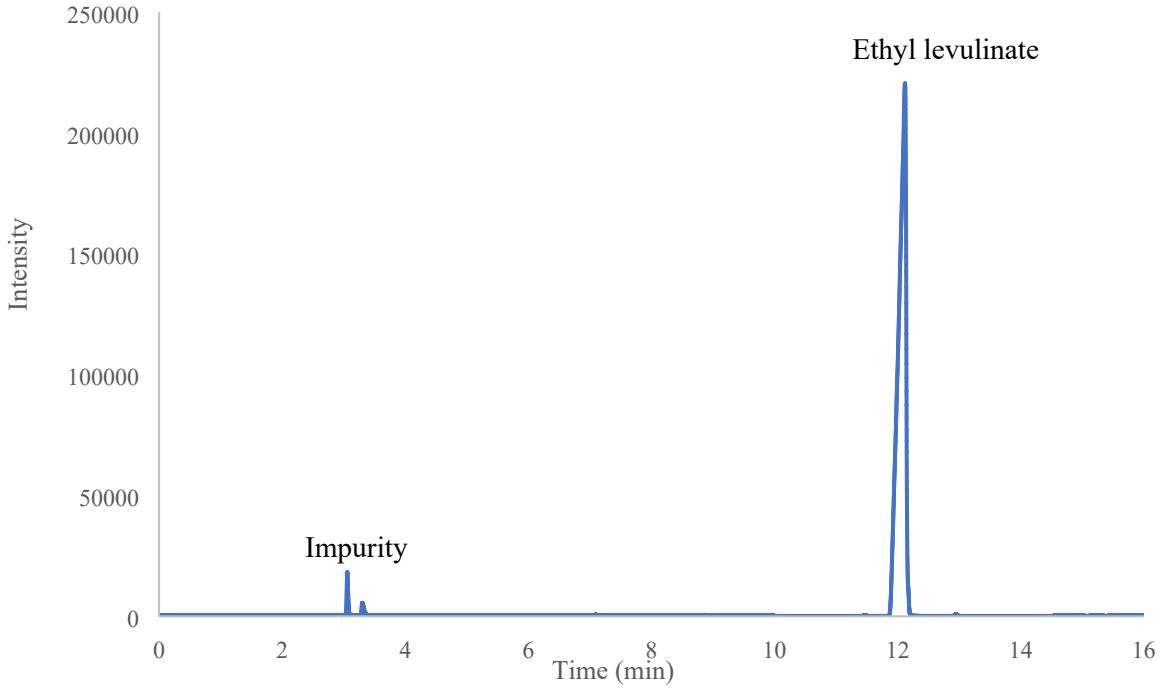

Figure S5. Chromatogram of the reaction product at 140 °C catalyzed with Zr+N-ie.

4. TOF and kinetic fitting

Table S1. TOF for the esterification of LAc with ethanol at 140 °C.

Catalyst	TOF (s^{-1})
Nb-500	1.90×10^{-3}
Nb+H-i	5.85×10^{-3}
Nb+N-i	1.00×10^{-2}
Nb+N-ie	1.34×10^{-2}
Zr-500	1.28×10^{-2}
Zr+H-i	1.86×10^{-2}
Zr+N-i	1.96×10^{-2}
Zr+N-ie	3.69×10^{-2}

Table S2. Power law kinetic model for the reactions in the absence of catalyst and catalyzed with Zr+N-ie and Nb+N-ie at 70 and 140 °C.

	T = 70 °C				T = 140 °C			
Catalyst	**η=0**	**η =1**	**η =2**	**k_{70}**	**η=0**	**η =1**	**η =2**	**k_{140}**
No Cat	0.949	0.992	0.955	3.16E-04	0.963	0.999	0.984	1.02E-03
Nb+N-IE	0.861	0.896	0.992	7.69E-04	0.667	0.868	0.995	2.90E-03
Zr+N-ie	0.924	0.935	0.995	3.95E-03	0.924	0.937	0.995	1.82E-01

Table S3. Benchmarking of sulfated zirconia- and niobia-based catalysts reported in the literature for the esterification of levulinic acid (LAc) with ethanol. The table summarizes sulfate precursor (S source), calcination

Catalyst	S source	Calcination treatment		Reaction operating conditions				Levulinic acid conversion (%)	Reference
		T (°C)	t (h)	Catalyst load (%)*	LAc/EtOH molar ratio	Temperature (°C)	Reaction time (h)		
SO_4^{2-}/Si*x*-ZrO_2	H_2SO_4	600	3	5	1:10	70	10	65	
				10				76	
SO_4^{2-}/ZrO_2		600	3	5	1:10	70	10	21	[1]
				10				26	
SO_4^{2-} /bulkZrO_2	H_2SO_4	500	3	2.5	1:5	70	8	62	[2]
SO_4^{2-} /ZrO_2(100)								74	
SO_4^{2-}/15ZrKIL-2	H_2SO_4	500	3	2.5	1:5	70	5	20	[3]
						100		70	
Zir-5/1-C@SO_4^{2-}	H_2SO_4	500	2	1.25	1:5	80	8	95	[4]
SO_4/Nb_2O_5	H_2SO_4	550	5	2.5	1:5	70	5	14	[5]
SO_4/ZrO_2	$(NH_4)_2SO_4$							9	

* Catalyst load, mass percentage with respect to levulinic acid.

References

1 Y. Kuwahara, W. Kaburagi, K. Nemoto and T. Fujitani, *Appl. Catal. A Gen.*, 2014, **476**, 186–196.

2 M. Popova, Á. Szegedi, H. Lazarova, M. Dimitrov, Y. Kalvachev, G. Atanasova, A. Ristić, N. Wilde, R. Gläser, *Reac. Kinet. Mech. Cat.,* 2017, **120**, 55-67.

3 M. Popova, Á. Szegedi, H. Lazarova, A. Ristić, Y. Kalvachev, G. Atanasova, N. Wilde, N. N. Tušar and R. Gläser, *Micropor. Mesopor. Mater.*, 2016, **235**, 50–58.

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