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High Value-added Fuel additive production from Waste bio-glycerol over a versatile nanohybrid catalyst

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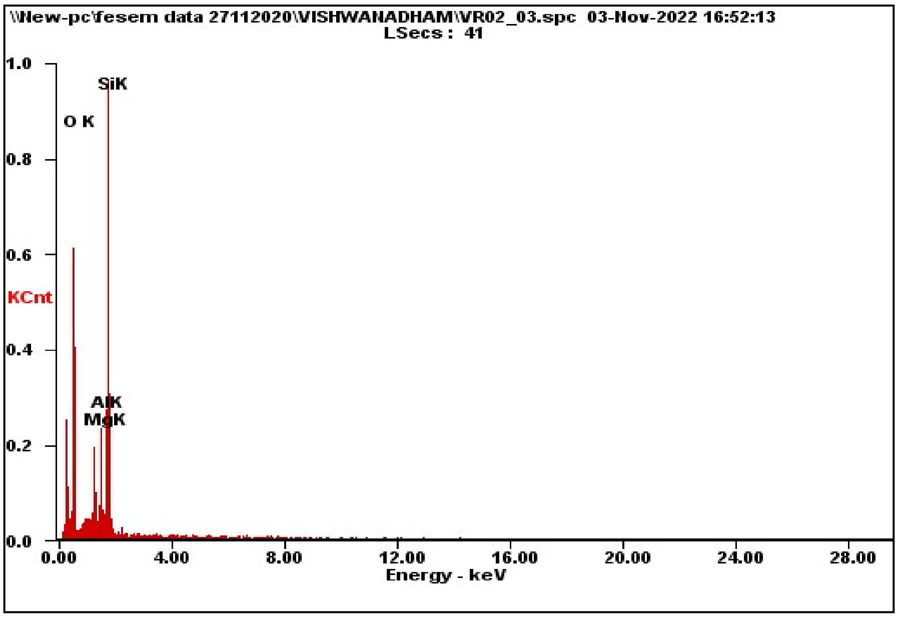

Fig. S1 EDX spectrum of MAZ hybrid catalyst sample

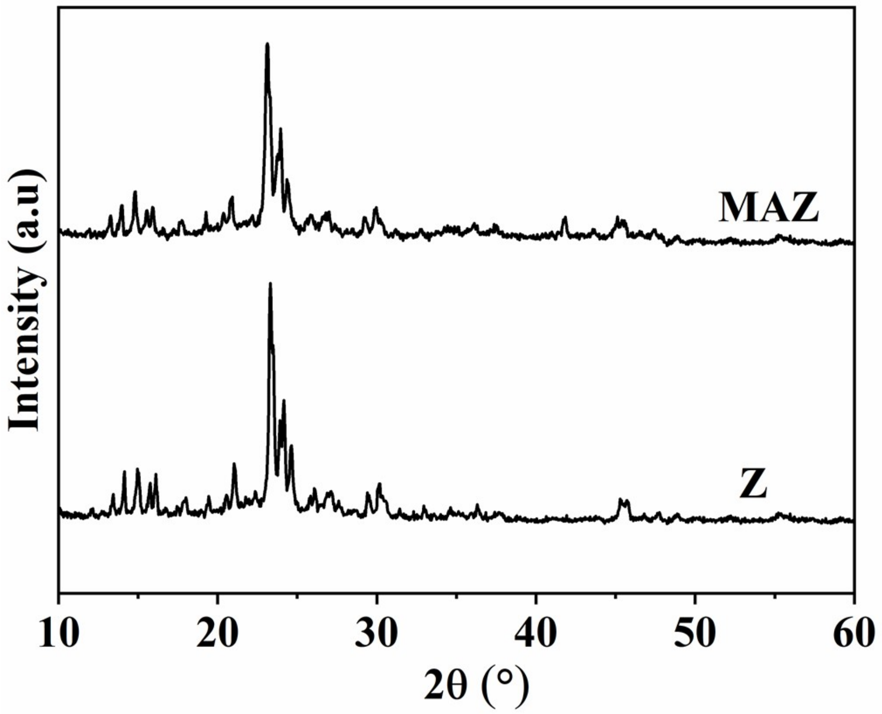

Fig. S2 XRD diffractogram of catalyst samples

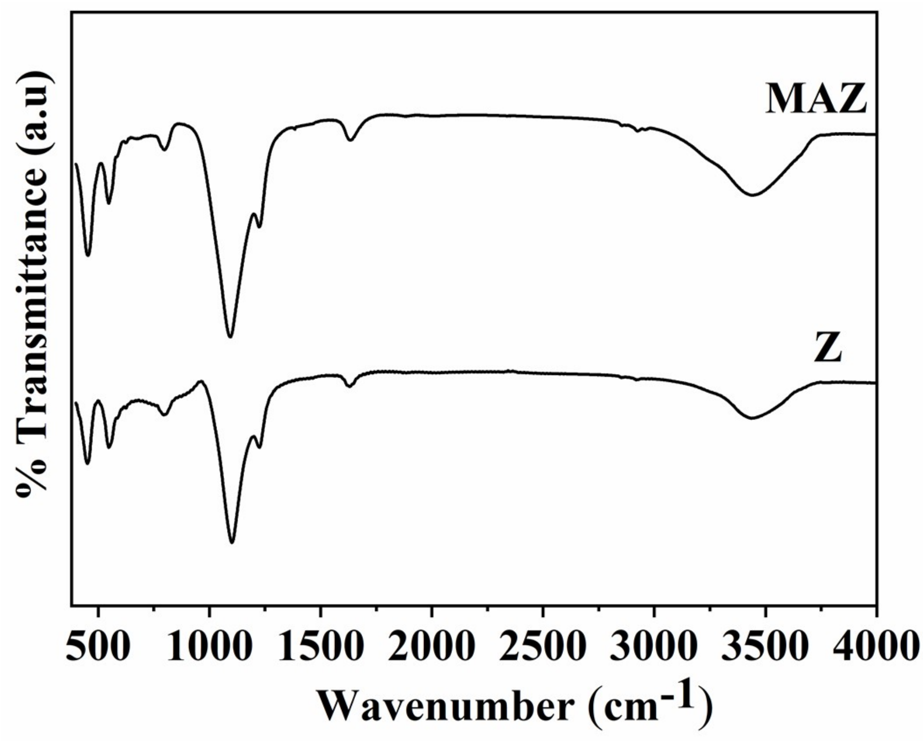

Fig. S3 FT-IR patterns of catalyst samples

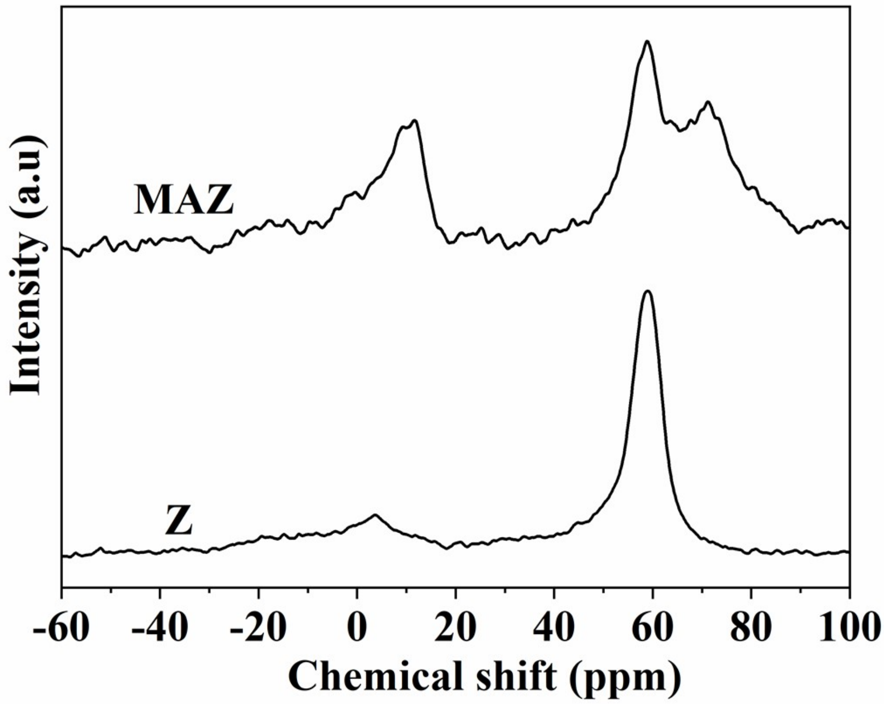

Fig. S4 ^{27}Al NMR spectra of catalyst samples

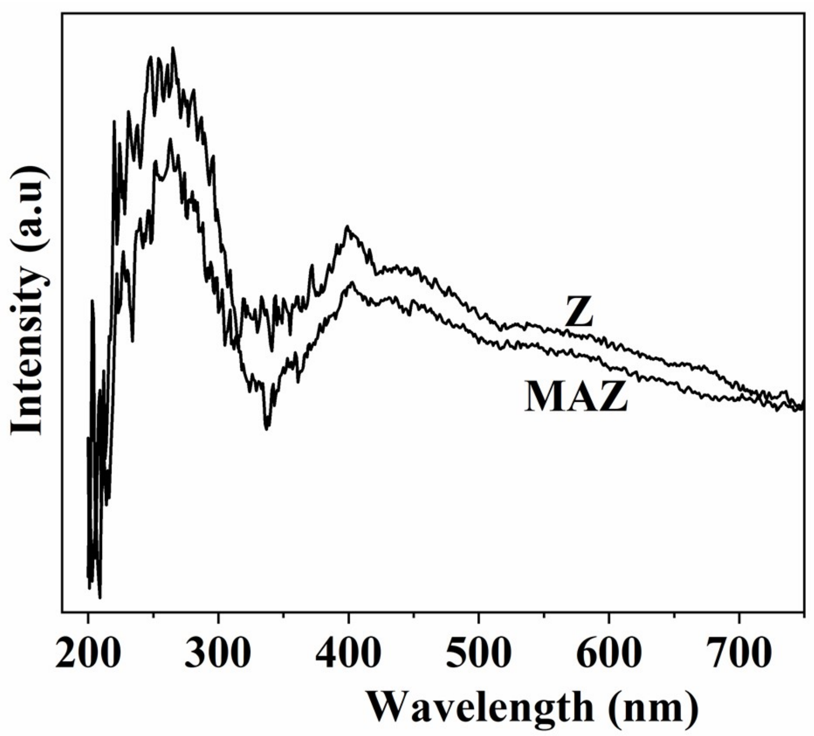

Fig. S5 UV-Vis spectra of catalyst samples

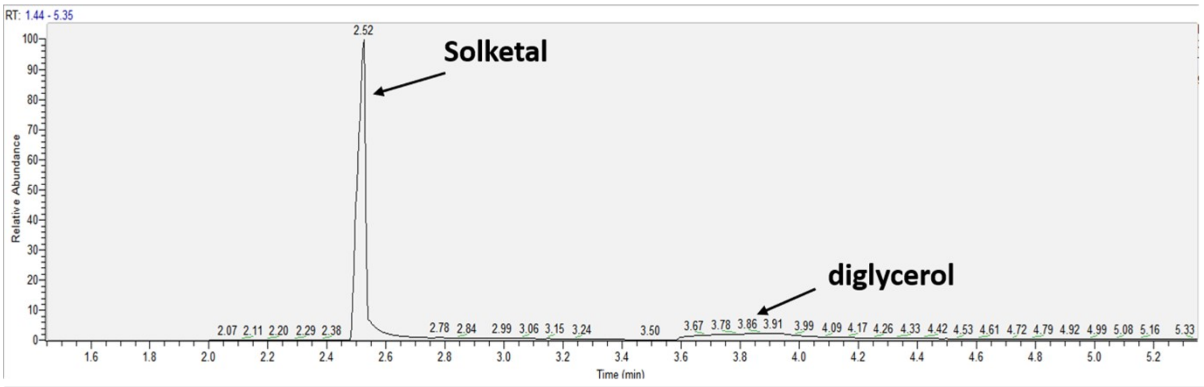

Fig. S6 GC-MS spectrum of a liquid product obtained with MAZ nanohybrid catalyst

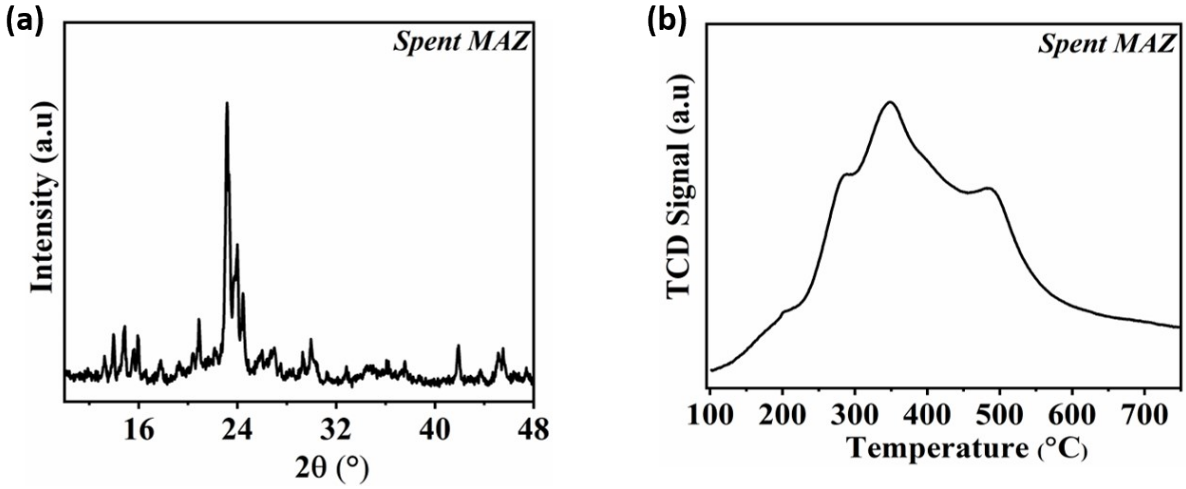

Fig. S7 Spent catalyst results (A) XRD patterns, and (B) NH_3-TPD profile

Table S1 Comparison of literature reports with the present study

S. No	Catalyst	Reaction conditions (Temperature/time)	Conversion (%)	Yield (%)	Ref.
1	$NbO_2(OH)$	70 ^oC/60 min	42	-	[1]
2	Hydrophobized $NbO_2(OH)$	70 ^oC/60 min	65	-	[1]
3	Carbon catalyst (GC-1:2)	RT/180 min	80	-	[2]
4	Carbon catalyst (GC-1:3)	RT/180 min	80	-	[2]
5	Ar-SBA-15	70 ^oC/30 min	82	-	[3]
6	Amberlyst-15	70 ^oC/30 min	86	-	[3]
7	Nb_5-HUSY	40 ^oC/180 min	66	65	[4]
8	Nb_{15}-HUSY	40 ^oC/180 min	61	60	[4]
9	Ni-MOR	100 ^oC/15 min	93	-	[5]
10	Cu-MOR	100 ^oC/15 min	95	-	[5]
11	H-ZSM-5	50 ^oC/60 min, methanol (solvent)	85	-	[6]
12	H-Beta	50 ^oC/60 min, methanol (solvent)	86	-	[6]
13	H-USY	50 ^oC/60 min, methanol (solvent)	69	-	[6]
14	HR/Y zeolite	50 ^oC/120 min	93	72	[7]
15	HR/Y-W_{20} zeolite	50 ^oC/120 min	98	94	[7]
16	UiO-SO_3H-0.2	60 ^oC/240 min	70.3	70.1	[8]
17	ZSM-5	70 ^oC/35 min	22	-	[9]
18	*p*-toluene-sulfonic acid	70 ^oC/35 min	80	-	[9]
19	Amberlyst-15	70 ^oC/35 min	98	-	[9]
20	HZSM-5	50 ^oC/120 min	-	15	[10]

21	NaOH-pretreated HZSM-5	50 °C/120 min	-	30	[10]
22	HZSM-5 film capillary	50 °C/120 min	-	29	[10]
23	ZSM-5	60 °C/180 min	83	36.2	[11]
24	Z-beta	60 °C/180 min	89	52.2	[11]
25	Z-mordenite	60 °C/180 min	93	68.1	[11]
26	HZSM-5	60 °C/90 min	40	-	[12]
27	WO_3/Nb_2O_5	RT/150 min	92.3	-	[13]
28	MoO_3-ZrO_2	60 °C/10 min	90	84	[14]
29	H-Beta-1 zeolite	RT/ 60 min	86	84.7	[15]
30	$(C_3H_7)_4N^+$/PWA	30 °C /120 min	94	-	[16]
31	Hf-TUD-1	80 °C/360 min	52	-	[17]
32	H-BEA Zeolite	60 °C/60 min	72.6	-	[18]
33	BEA Zeolite	30 °C/30 min	76	-	[19]
34	1.0 M SABEA	30 °C/30 min	84	-	[19]
35	γ-Al_2O_3-IPA	25 °C/30 min	29.1	0	[20]
36	0.2 mol% $FeCl_3/\gamma$-Al_2O_3-IPA	25 °C/30 min	99.89	98.25	[20]
37	*MAZ nanohybrid*	60 °C/120 min	100	>99	*This Work*

Table S2 Composition of crude-bio-glycerol produced from bio-diesel process

Glycerol % (w/w)	86
Water % (w/w)	13
Density (g/ml)	1.23
Fatty acid esters % (w/w)	0.05
Ash % (w/w)	0.005

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