Supporting Information

Catalytic Enhancement of Alcohol Oxidation by Electrodeposited Pt on $TiO_2$5CuxNi Modified Graphene Oxide

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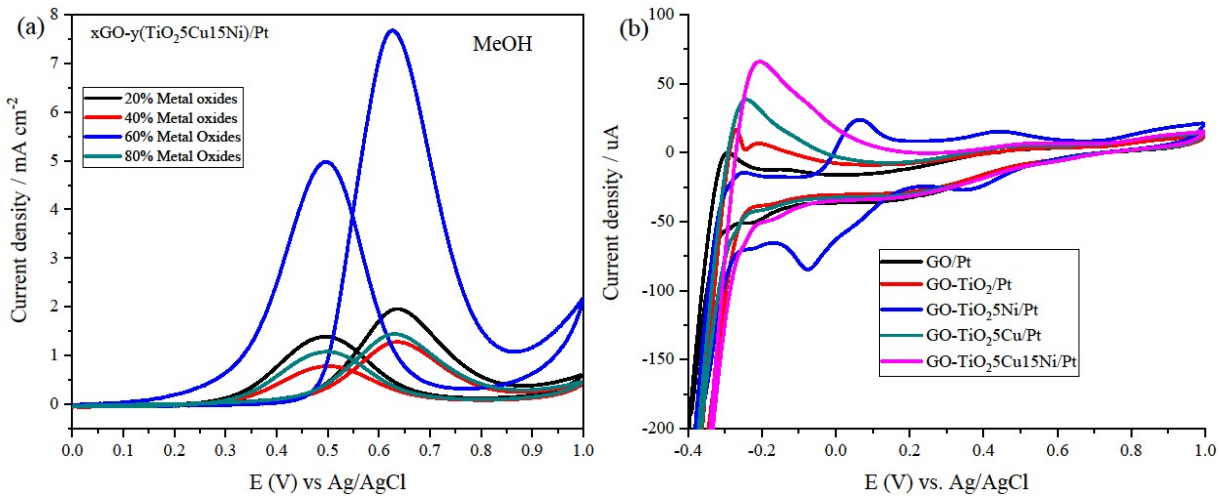


Figure SI. 1. CVs of catalysts with (a) variation of metal oxide and GO for methanol oxidation and (b) CVs obtained on the catalysts with various supporting materials surfaces in the rages -0.4 - 1.0 V Ag/AgCl at scan rate 0.05 V s^{-1}.

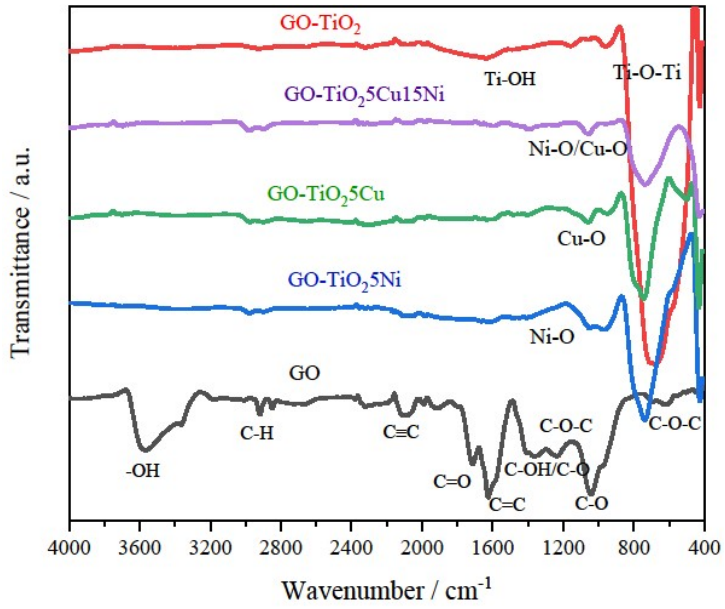


Figure SI. 2. FT-IR spectra of supporting materials.

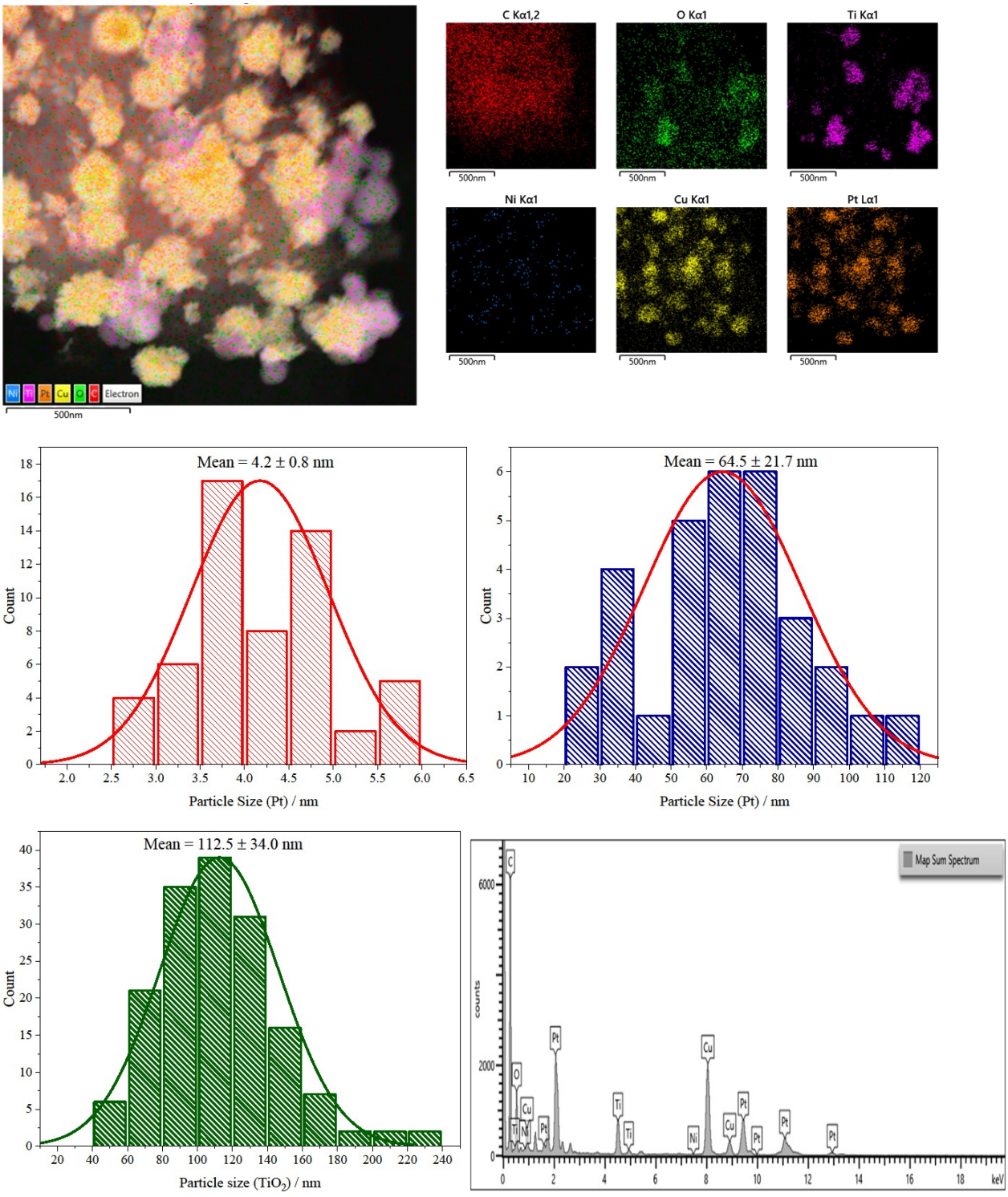


Figure SI. 3. TEM mapping images, histogram distributions and Energy-dispersive X-ray spectroscopy (EDX) spectrum of selected catalysts.

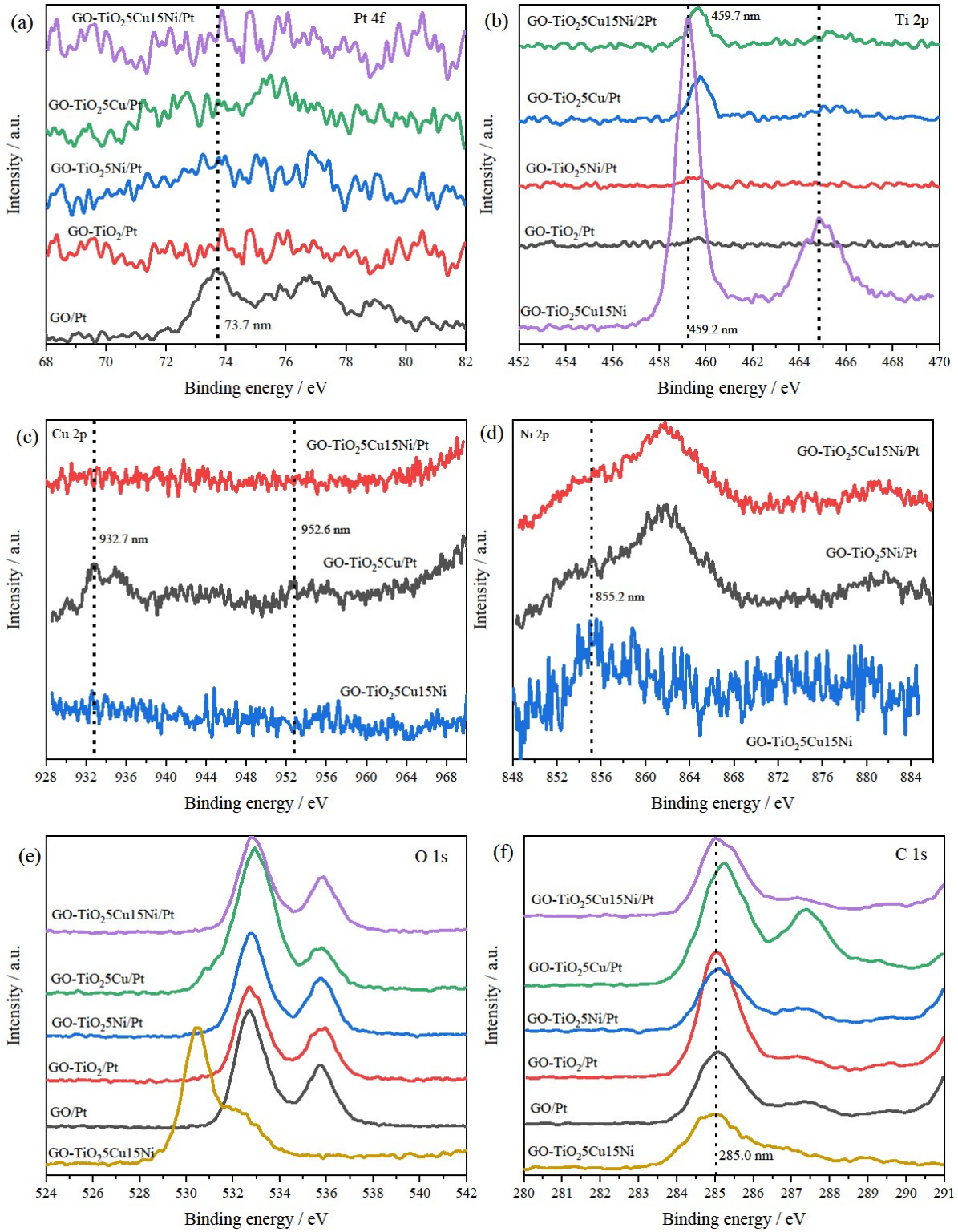


Figure SI. 4. XPS spectra of (a) Pt 4f, (b) Ti 2p, (c) Cu 2p, (d) Ni 2p, (e) O 1s and (f) C 1s the as-prepared catalysts.

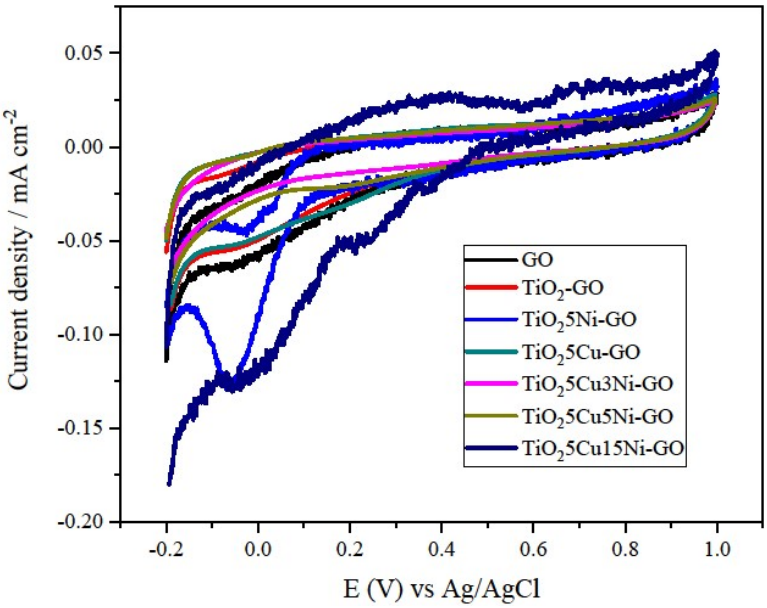


Figure SI. 5. CVs of supported materials in 0.5 M H_2SO_4 solution with scan rate 0.05 V s^{-1}.

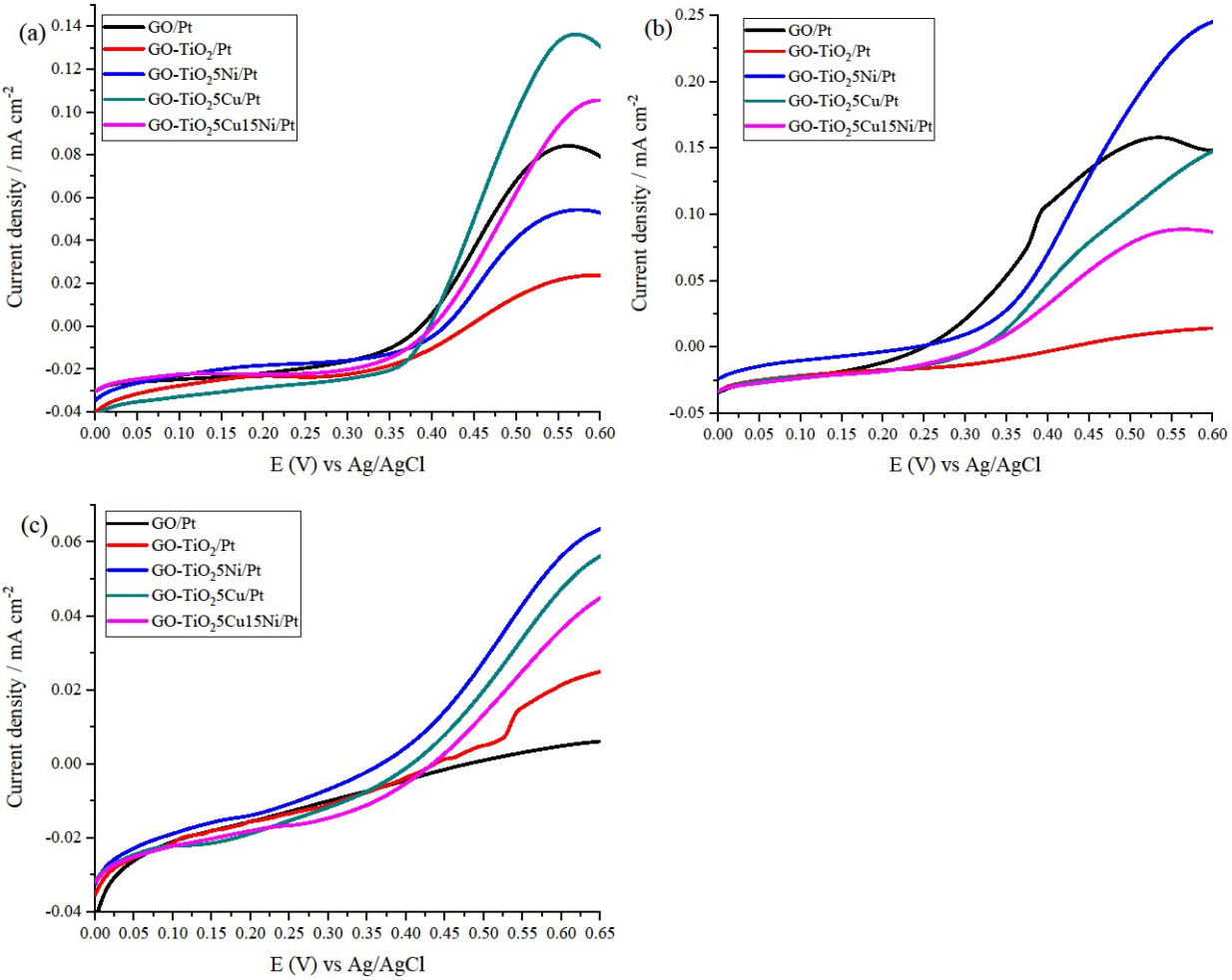


Figure SI. 6. LSV of (a) methanol, (b) ethanol and (c) n-propanol oxidation on selected catalysts.

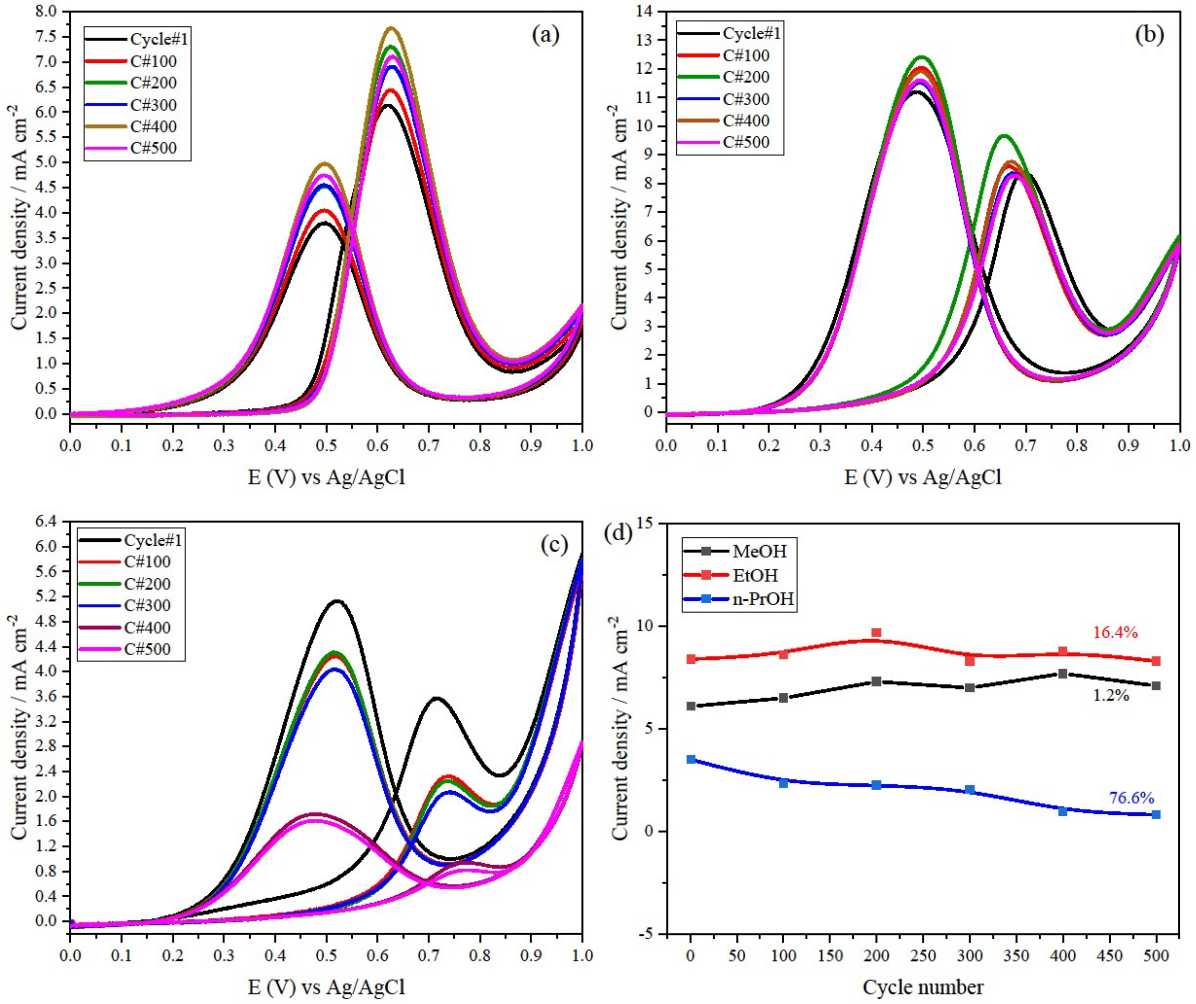
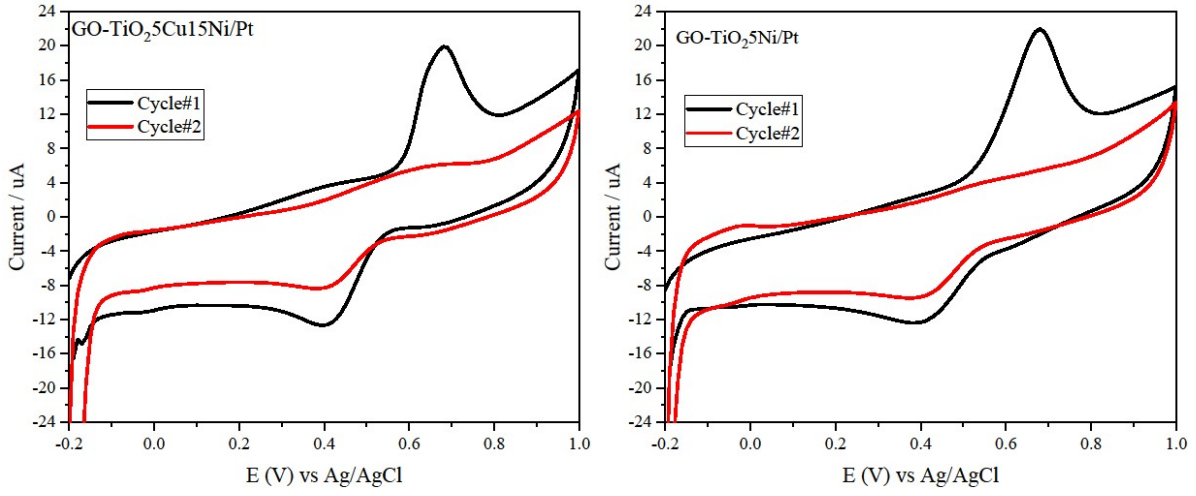


Figure SI. 7. CVs of GO-$TiO_2$5Cu15Ni/Pt catalysts for stability behaviour's in (a) methanol, (b) ethanol and (c) n-propanol oxidation and (d) corresponding current density (If) value of methanol (black line), ethanol (red line) and n-propanol (blue line) oxidation.



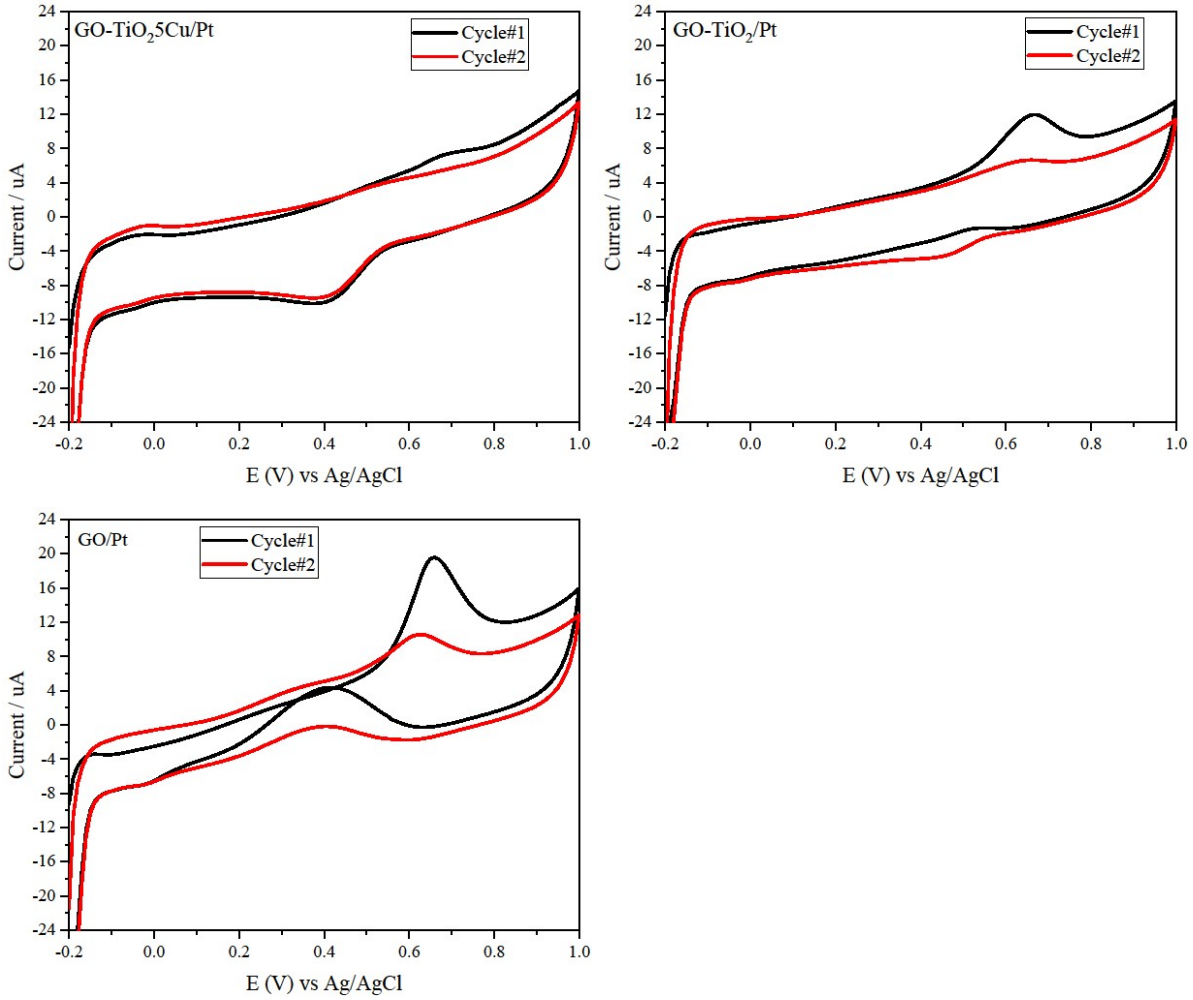


Figure SI. 8. CO stripping voltammograms of the as-prepared catalysts in 0.5 M H_2SO_4 at a scan rate of 0.05 mV s^{-1}.

Table SI. 1. The crystallite size of Pt-based catalysts calculated by the Scherrer equation.

Electrocatalyst	2θ	Crystallite size
	degree	nm
GO/Pt	39.993	9.2
GO-TiO_2/Pt	39.967	13.8
GO-5$NiTiO_2$/Pt	39.994	13.8
GO-5$CuTiO_2$/Pt	40.122	13.8
GO-15NiO5$CuTiO_2$/Pt	40.068	13.8

Table SI. 2. Extracted parameters from XPS results.

Element/ Oxidation state	Binding energy (V)	Percentage (%)	Binding energy (V)	Percentage (%)
Pt 4f		7/2		5/2
Pt^0	70.28	10.4	75.02	17.4
Pt^{2+}	71.97	19.0	76.54	20.9
Pt^{4+}	73.48	23.3	77.03	9.0
Ti 2p		3/2		1/2
Ti^{4+}	459.45	59.9	465.52	40.1
Cu 2p		3/2		1/2
Cu^0	931.42	13.3	951.27	4.5
Cu^+	932.97	30.8	952.80	28.4
Cu^{2+}	934.63	28.4	954.43	12.4
Ni 2p		3/2		1/2
Ni^0	853.78	16.8	870.99	9.6
Ni^{2+}	855.17	28.0	872.53	16.2
Ni^{3+}	856.71	19.0	873.75	10.4
O 1s		Percentage (%)		
Ti-OH/C-O	532.81	58.3		
-O-H/O-C=O	533.79	9.5		
H-O-H	535.83	32.2		

Table SI. 3. Electrochemical parameters of the as-prepared catalysts in alcohol oxidation.

Electrocatalyst	Electrolyte	Onset potential	Peak current density (mA cm^{-2})		Peak Potential (V)		I_f/I_b	CA
		V	I_f	I_b	E_f	E_b		mA cm^{-2}
GO/Pt	0.5 M Methanol + 0.5 M H_2SO_4	0.341	4.74	2.80	0.623	0.493	1.69	0.035
GO-TiO_2/Pt		0.452	3.76	1.63	0.623	0.486	2.31	0.010
GO-5NiTiO_2/Pt		0.371	6.90	4.26	0.624	0.500	1.62	0.071
GO-5CuTiO_2/Pt		0.400	5.18	2.93	0.630	0.504	1.77	0.001
GO-3Ni05CuTiO_2/Pt		0.396	4.92	2.64	0.632	0.502	1.86	-
GO-5Ni05CuTiO_2/Pt		0.379	5.13	3.16	0.632	0.506	1.62	-
GO-15Ni05CuTiO_2/Pt		0.387	7.71	5.50	0.626	0.498	1.40	0.045
GO/Pt	0.5 M Ethanol + 0.5 M H_2SO_4	0.245	6.14	8.47	0.661	0.491	0.72	0.011
GO-TiO_2/Pt		0.222	4.21	5.64	0.697	0.460	0.75	0.003
GO-5NiTiO_2/Pt		0.183	7.43	10.50	0.673	0.496	0.71	0.014
GO-5CuTiO_2/Pt		0.225	6.35	8.56	0.679	0.496	0.74	0.012
GO-3Ni05CuTiO_2/Pt		0.209	6.52	7.70	0.679	0.490	0.85	-
GO-5Ni05CuTiO_2/Pt		0.223	6.46	8.80	0.683	0.496	0.73	-
GO-15Ni05CuTiO_2/Pt		0.212	8.76	11.97	0.673	0.496	0.73	0.082
GO/Pt	0.5 M n-Propanol + 0.5 M H_2SO_4	0.360	2.10	3.63	0.715	0.518	0.58	0.001
GO-TiO_2/Pt		0.335	0.91	1.83	0.764	0.478	0.50	0.003
GO-5NiTiO_2/Pt		0.319	2.00	3.40	0.731	0.506	0.59	0.008
GO-5CuTiO_2/Pt		0.343	0.72	1.41	0.766	0.458	0.51	0.004
GO-3Ni05CuTiO_2/Pt		0.278	0.93	1.70	0.771	0.478	0.55	-
GO-5Ni05CuTiO_2/Pt		0.343	0.96	1.78	0.768	0.478	0.54	-
GO-15Ni05CuTiO_2/Pt		0.287	2.33	4.27	0.737	0.576	0.55	0.007

Table SI. 4. Comparison of our catalysts with previous work on CO oxidation and Tafel plot.

Catalysts	E_{onset}	$E_{max, CO}$	$ECSA_{CO}$	Tafel slope	Ref.
	V	V	$m^2\ g^{-1}$	mV dec^{-1}	
CeOx/PtCu/CeCuOx/C	0.493	0.613	-	214 MeOH	[22]
TiO_2/Pt/CF	-	0.553	-	-	[23]
PtRu/TiO_2/	0.170	0.214	67.0	-	[24]

ONCNT-400					
Pt/TiO_2NCs-C	0.363	0.663	72	-	[25]
a-FeOx/NiOx/Pt	-	0.69	-	-	[26]
1Pt/3CuO/CNT	0.41	0.59	470	28 MeOH, 108 EtOH	[27]
f PtNDs@CoS_2-NrGO	-	-	-	55.5 MeOH	[28]
YOx/MoOx–Pt	0.50	-	-		[29]
Pt-Cu-Mo_2C-2	0.336	0.538	60.5	77 MeOH, 146 EtOH	[30]
GO-15NiO5CuTiO_2/Pt	0.54	0.68	68.9	113 MeOH, 84 EtOH, 125 n-PrOH	This work

Table SI. 5. CO-stripping results of the as-prepared catalysts.

Electrocatalyst	Onset potential	Peak current density	Peak Potential	ECSA
	V vs. Ag/AgCl	(μA)	V vs. Ag/AgCl	$m^2\ g^{-1}$
GO/Pt	0.55	30.2	0.689	50.6
GO-TiO_2/Pt	0.40	12.0	0.663	12.6
GO-5NiTiO_2/Pt	0.46	22.0	0.677	59.7
GO-5CuTiO_2/Pt	0.55	7.0	0.688	4.4
GO-15NiO5CuTiO_2/Pt	0.54	19.9	0.681	68.9