

SUPPLEMENTARY MATERIAL

Ce-modified Co-Mn oxide spinel on reduced graphene oxide and carbon black as ethanol tolerant oxygen reduction electrocatalyst in alkaline media

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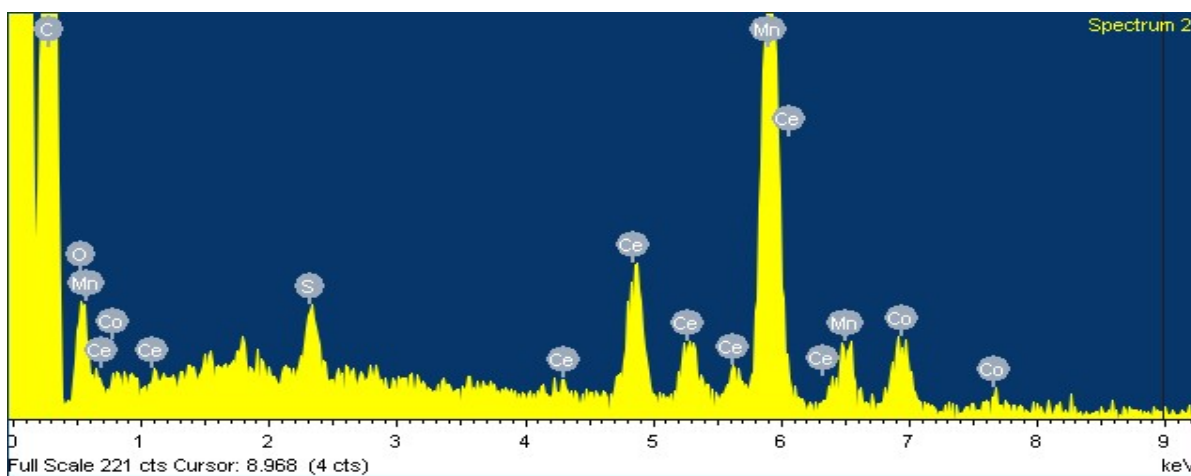
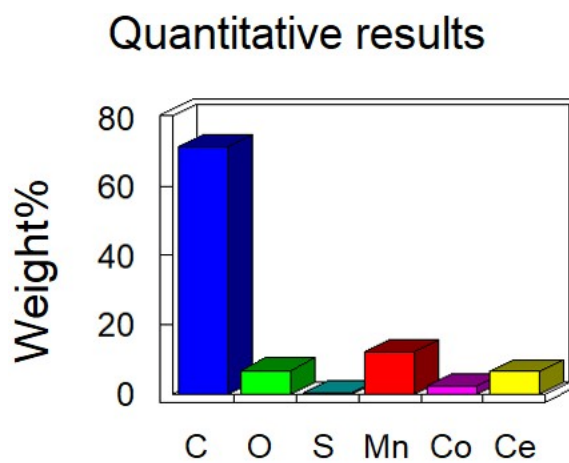
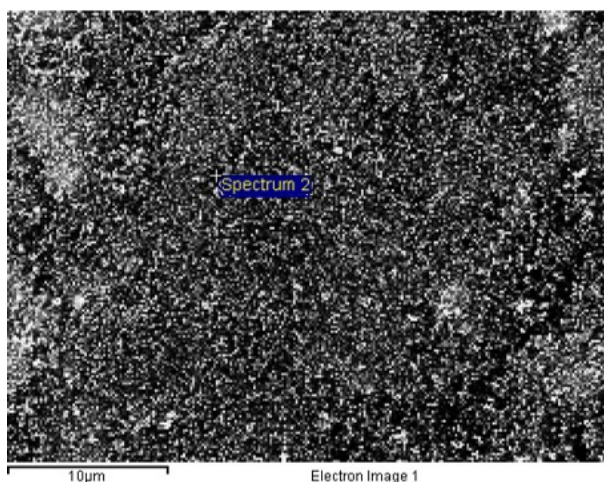


Fig. S1 EDX results of Ce-CMO/VC.

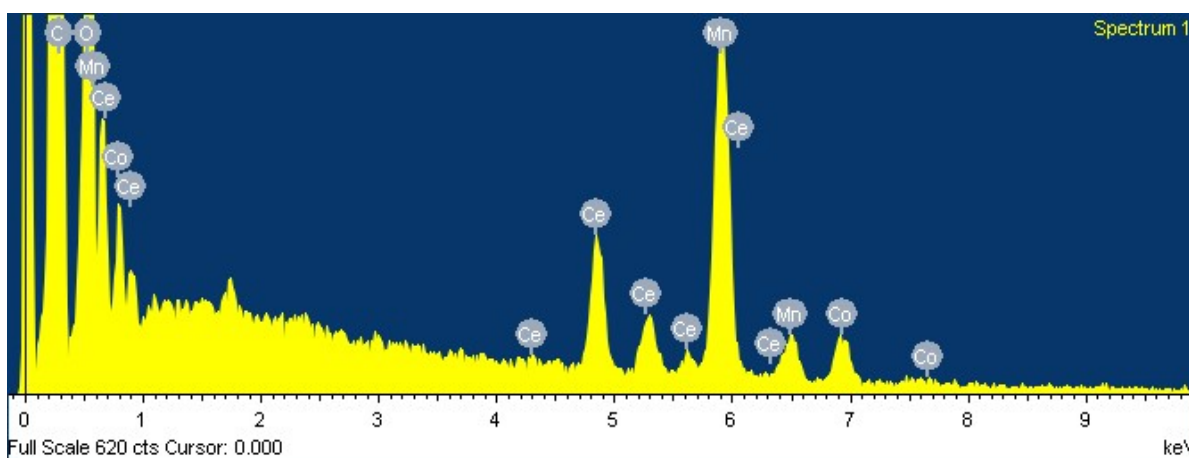
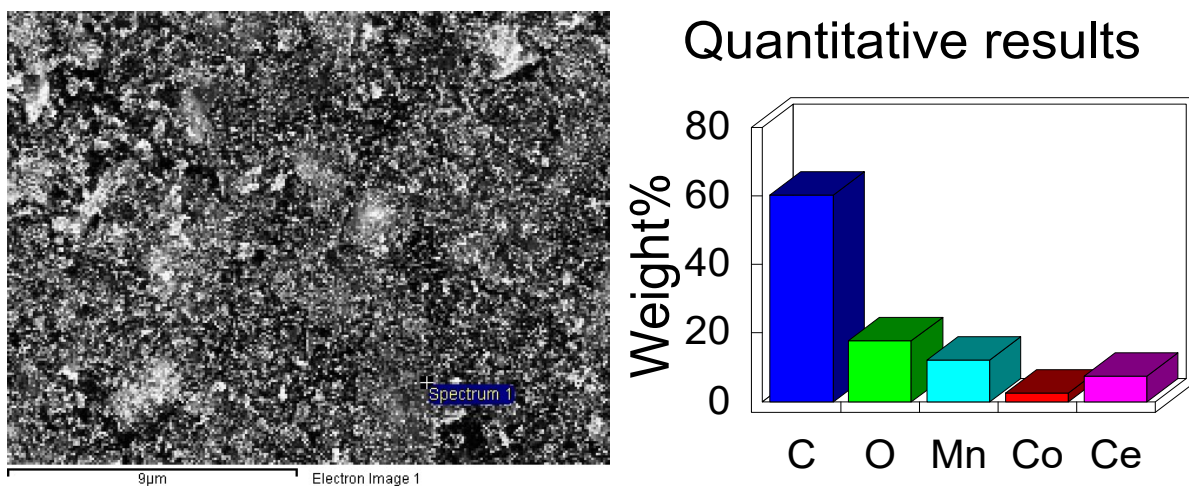


Fig. S2 EDX results of Ce-CMO/rGO-VC.

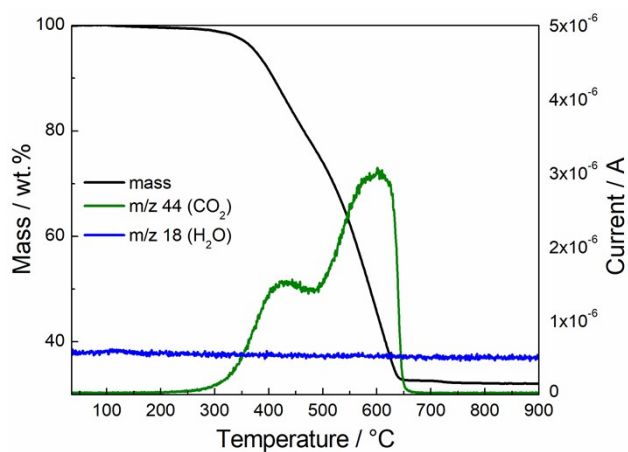


Fig. S3 Thermogravimetric behavior and mass spectrometry results of CMO/VC in O₂/Ar atmosphere.

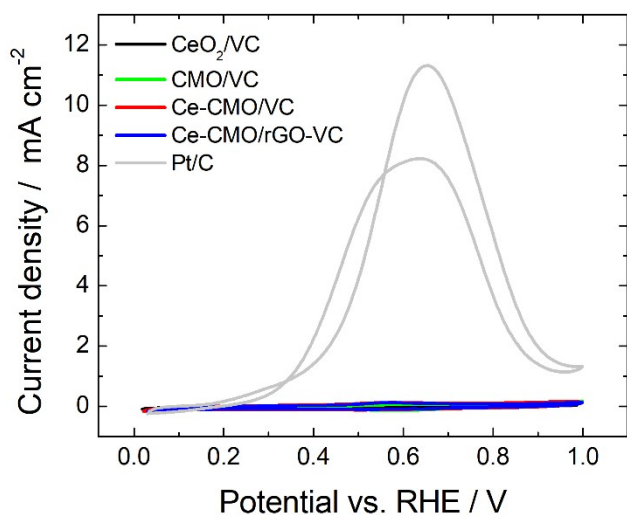


Fig. S4 CVs of Ce-CMO/VC, Ce-CMO/rGO-VC, CeO₂/VC, CMO/VC and Pt/C catalysts at 10 mV s⁻¹ in de-aerated 1 M KOH/1 M EtOH.

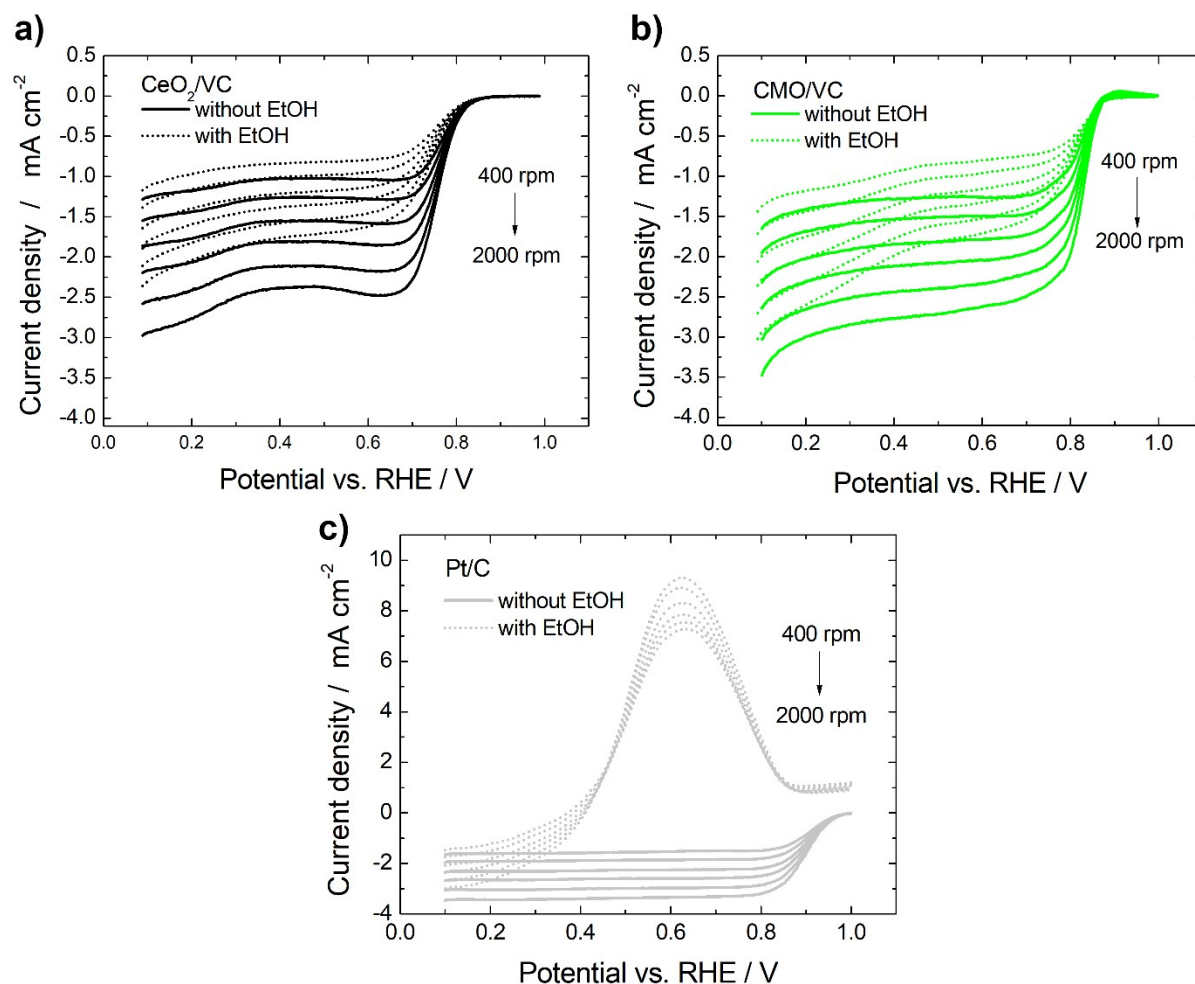


Fig. S5. Potentiodynamic ORR curves of CeO₂/VC (a), CMO/VC (b) and comm. Pt/C (c) in O₂-saturated 1 M KOH or 1 M KOH/1 M EtOH at 10 mV s⁻¹ at different rotation rates.

Table S1. Comparison of Ce-CMO/C with other catalysts combining cerium, manganese and cobalt oxides.

Material	c_{KOH}/M	$E_{1/2}/V_{\text{Reference}}$	$j_D/\text{mA cm}^{-2}$	$n/$	Tafel slope/ mV dec^{-1}	Reference
Ce@Co ₃ O ₄ /CNFs	0.1	0.810 V_{RHE}	-5.03	~4	85.8	1
Co ₃ O ₄ -CeO ₂ /C	0.1	~0.83 V_{RHE}	approx. -5.35	3.91	83.9	2
Co ₃ O ₄ @Z67-NT@CeO ₂	0.1	0.88 V_{RHE}	approx. -6.8	~4	66.8	3
MnOOH@CeO ₂	0.1	0.80 V_{RHE}	-5.08	3.95	111.1	4
CoO _x /CeO ₂ /RGO	0.1	0.83 V_{RHE}	approx. -5.0	3.8	54	5
MnO _x -CeO ₂ /KB	0.1	0.81 V_{RHE}	approx. -5.0	~4	94.4	6
4.8% Ce-MnO ₂ /C	0.1	0.783 V_{RHE}	approx. -5.6	3.97	90	7
0.5% Ce-Co ₃ O ₄	0.1	0.665 V_{RHE}	approx. -5.5	~4	108 and 60	8
CeOMS-2	1.0	~0.05 $V_{\text{Hg/HgO}}$	approx. -0.6**	3.4	-	9
CeO ₂ /MnWO ₄ -2	0.1	0.827 V_{RHE}	-4.2	3.1	-	10
5% Ce-MnO _x /Ag	0.1	~0.88 V_{RHE}	approx. -5.4	3.98	50	11
CeO ₂ -CoO _x /N-rGO	-	approx. -0.1 $V_{\text{Ag/AgCl}}$	approx. -6.5	4.2	-	12
Co-CeO ₂ /N-CNR	0.1	0.819 V_{RHE}^*	approx. -6.7	3.95	58.4	13
5% Mn-CeO ₂ /rGO	0.1	-0.336 $V_{\text{Ag/AgCl}}$	-4.83	3.6	-	14
α -MnO ₂ /Mn ₃ O ₄ /CeO ₂ /C	0.1	-0.24 $V_{\text{Ag/AgCl}}$	-6.63	~4	921.9	15
Ce-CMO-18%/MWCNTs	0.1	0.84 V_{RHE}^*	approx. -6.6	~4	84	16
Ce-CMO/VC	1.0	0.828 V_{RHE}	-2.84	3.27	57.2	This work
Ce-CMO/rGO-VC	1.0	0.822 V_{RHE}	-2.93	3.48	61.0	This work

c_{KOH} = KOH electrolyte concentration; $E_{1/2}$ = half-wave potential; j_D = diffusion limited current density; n = electron transfer number; * potential at 3 mA cm⁻² is given instead of $E_{1/2}$; ** j_D is given in mA instead of mA cm⁻².

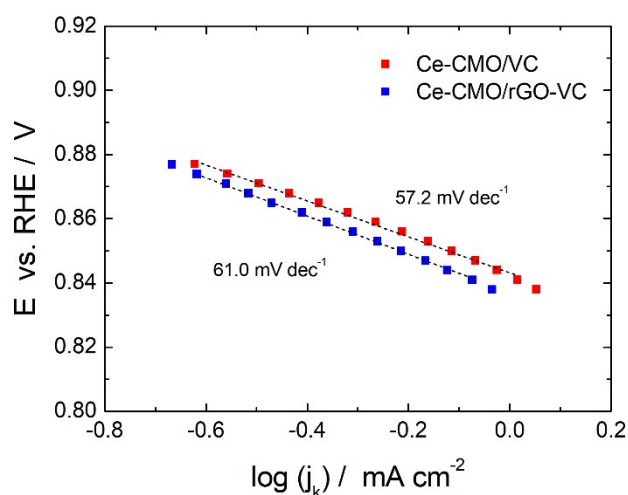


Fig. S6. Tafel plot of Ce-CMO/VC and Ce-CMO/rGO-VC.

Table S2. Limiting current density of the Ce-CMO/VC and Ce-CMO/rGO-VC catalysts, CMO/VC and CeO₂/VC without/with EtOH at different rpm.

Catalysts	400 rpm/ mA cm ⁻²	600 rpm/ mA cm ⁻²	900 rpm/ mA cm ⁻²	1200 rpm/ mA cm ⁻²	1600 rpm/ mA cm ⁻²	2000 rpm/ mA cm ⁻²
CeO ₂ /VC	-1.03/-0.84	-1.26/-1.01	-1.55/-1.21	-1.81/-1.38	-2.12/-1.58	-2.39/-1.76
CMO/VC	-1.29/-0.95	-1.54/-1.13	-1.85/-1.36	-2.12/-1.55	-2.44/-1.78	-2.77/-1.99
Ce-CMO/VC	-1.45/-1.30	-1.75/-1.53	-2.13/-1.80	-2.46/-2.03	-2.84/-2.28	-3.22/-2.58
Ce-CMO/rGO-VC	-1.52/-1.32	-1.82/-1.57	-2.20/-1.87	-2.52/-2.14	-2.93/-2.46	-3.30/-2.80

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