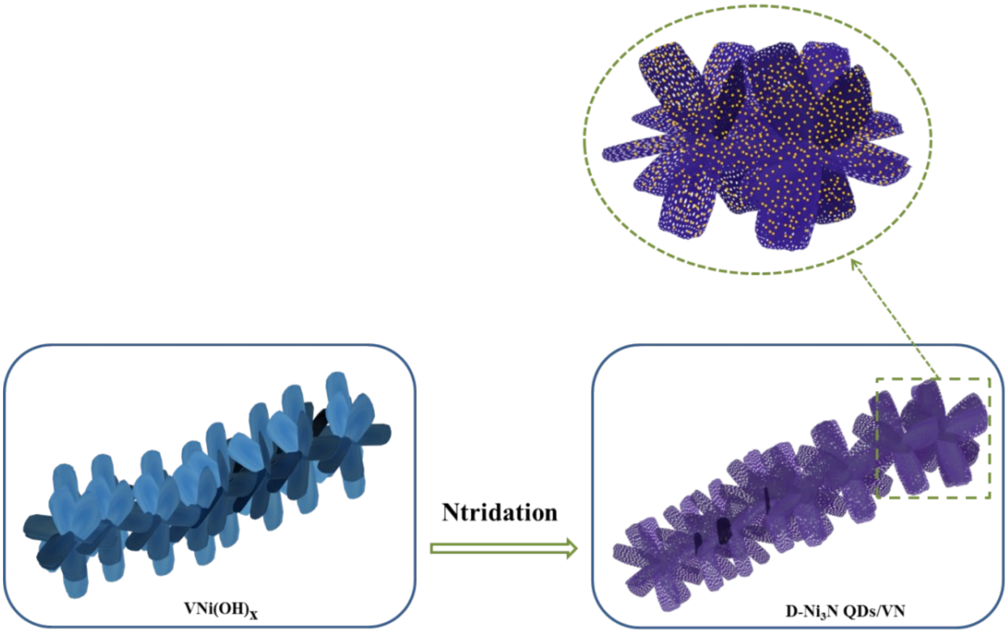
Supporting Information for

Distorted quantum dots enhancing efficient alkaline oxygen electrocatalysis

Xiaoyu Zhang[1], Weiwei Fu[1], Wu Tian[1], Jin Wan[1], Han Zhang[2*] and Yu Wang[1,2*]

[1]The School of Chemistry and Chemical Engineering, State Key Laboratory of Power Transmission Equipment & System Security and New Technology, Chongqing University, 174 Shazheng Street, Shapingba District, Chongqing City 400044, PR China.

[2]The School of Electrical Engineering, Chongqing University, 174 Shazheng Street, Shapingba District, Chongqing City 400044, PR China.



Scheme S1. Microscopic view of caterpillar-like structure.

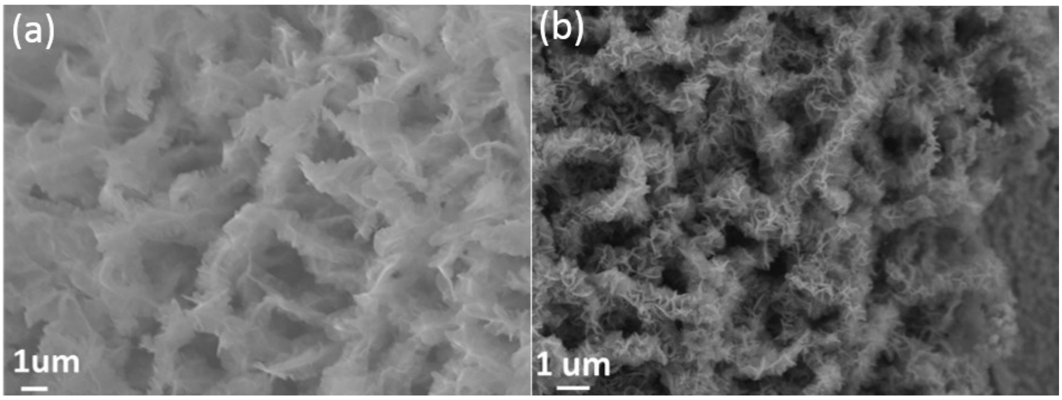


Fig. S1 (a, b) SEM images of widespread $VNi(OH)_x$ and D-Ni_3N QDs/VN structures.

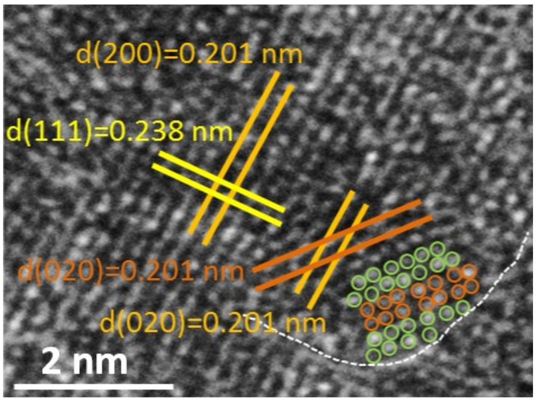


Fig. S2 High-magnification TEM image of D-Ni_3N QDs/VN.

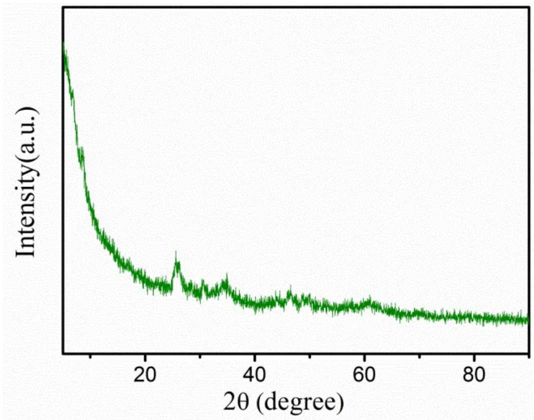


Fig. S3 XRD spectrum of $VNi(OH)_x$.

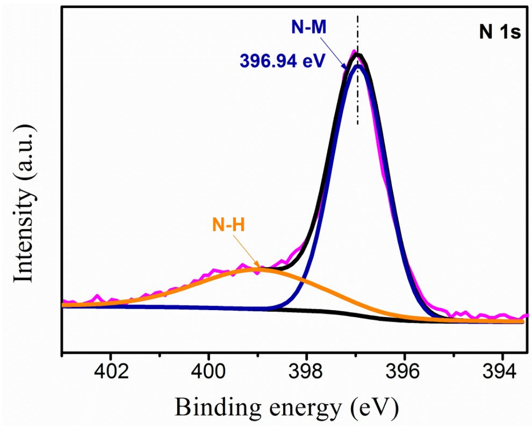


Fig. S4 High-resolution XPS spectrum of N1s.

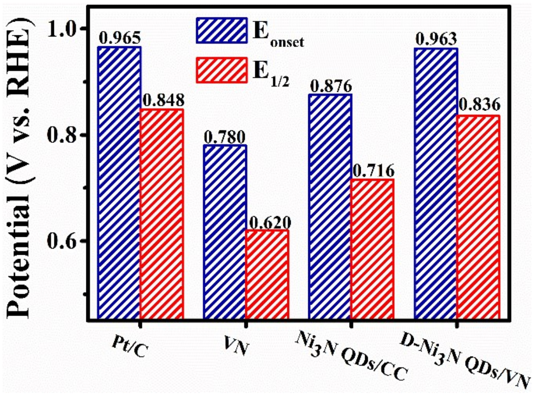


Fig. S5 Initial potentials and half-wave potentials of samples.

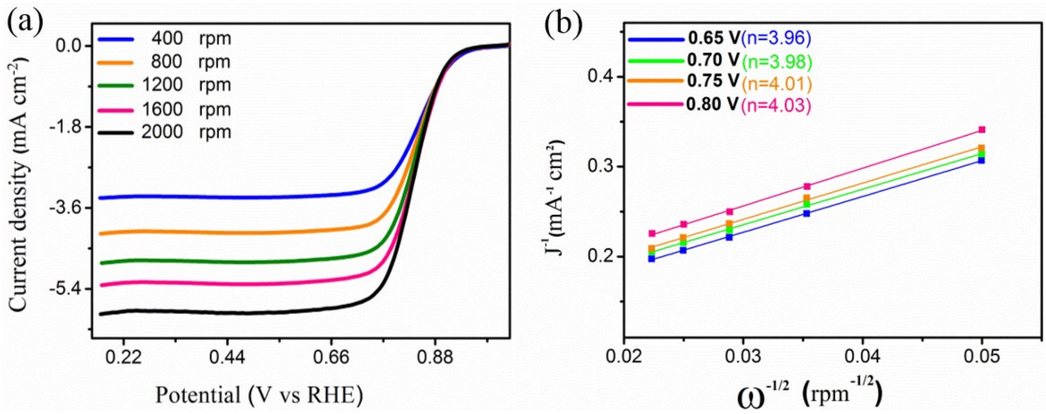


Fig. S6 (a) Polarization curves at different rotation rates of Pt/C. (b) Koutecky–Levich plots of Pt/C.

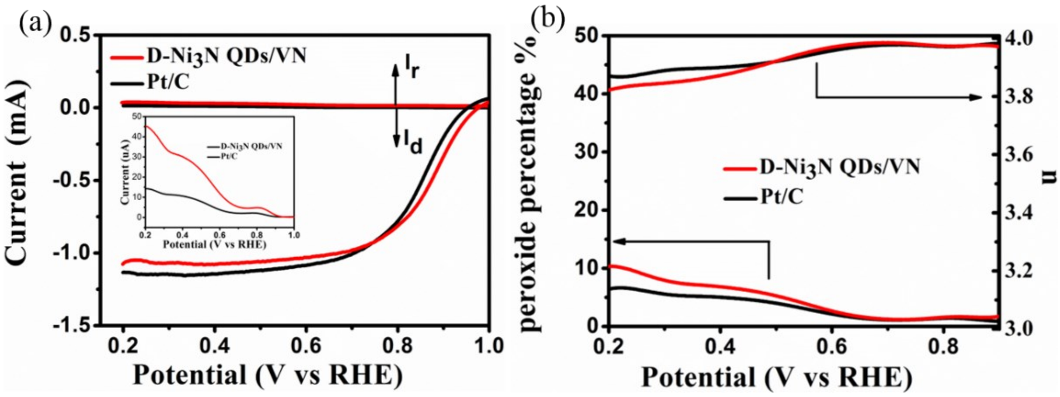


Fig. S7 (a) RRDE test on D-Ni_3N QDs/VN and Pt/C in O-saturated 0.1 M KOH solution, respectively. (b) Corresponding peroxide percentage and electron transfer number of ORR. The H_2O_2 yield of D-Ni_3N QDs/VN is 1.2-10%, slightly higher than Pt/C (1-6.8%) in the same range of ORR test. The electron transfer number (n) of ORR on D-Ni_3N QDs/VN is 3.83-3.98, whereas the n value of Pt/C is 3.86-3.98. The result demonstrates a 4-electron oxygen reduction pathway on the surface of D-Ni_3N QDs/VN.[1] We use the following equation to calculate the electron transfer number (n) and the peroxide percentage.[2]

$$n = 4 * \frac{I_d}{I_d + I_r/N}$$

$$H_2O_2\% = 200 * \frac{I_r/N}{I_d + I_r/N}$$

Where I_d is the disk current, I_r is the ring current, and N is the collection efficiency (0.37) of the ring electrode.[3]

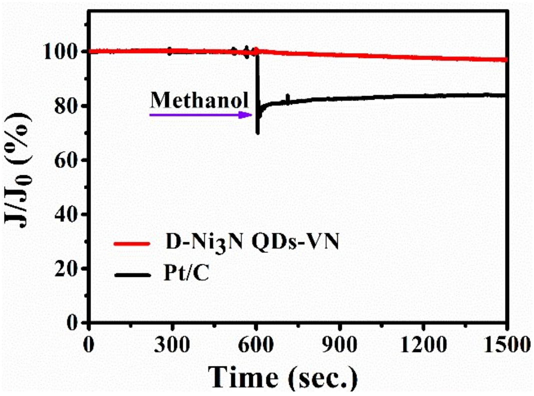


Fig. **S8** Methanol tolerance test of D-Ni_3N QDs/VN and Pt/C.

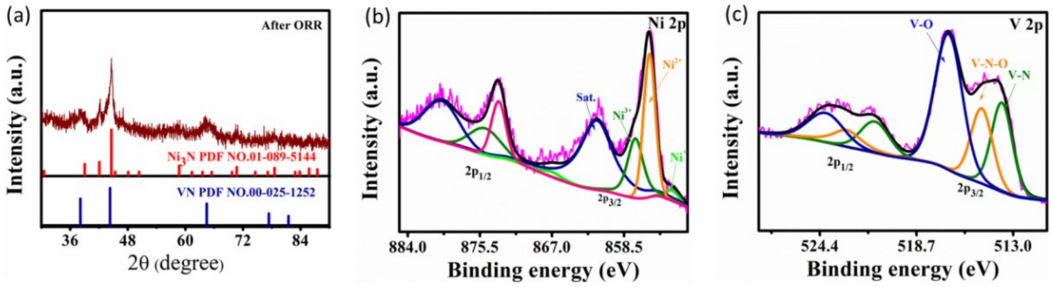


Fig. S9 (a) The XRD spectrum of D-Ni_3N QDs/VN after ORR test. (b, c) High-resolution XPS spectra of Ni 2p and V 2p for post-test D-Ni_3N QDs/VN.

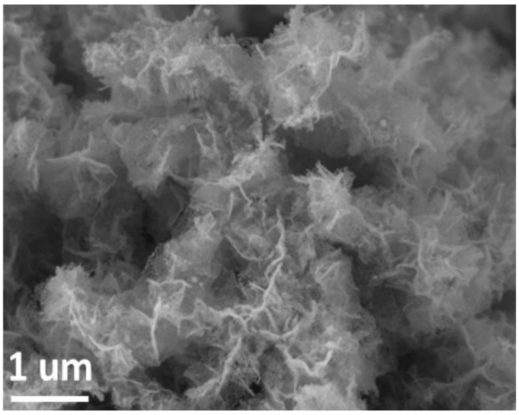


Fig. S10 SEM image of D-Ni_3N QDs/VN after ORR.

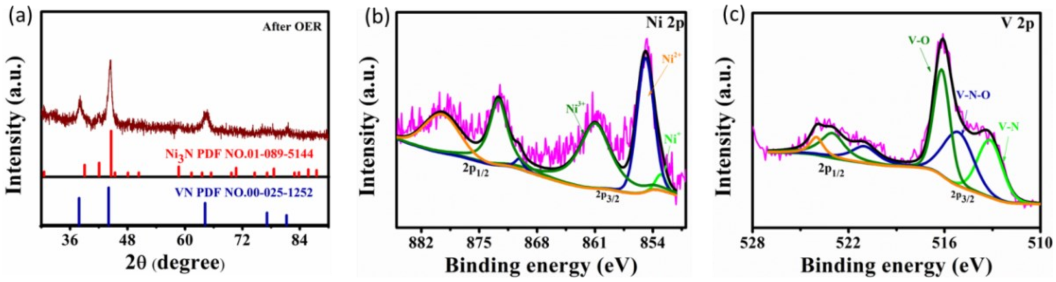


Fig. S11 (a) The XRD spectrum of D-Ni_3N QDs/VN after OER test. (b, c) High-resolution XPS spectra of Ni 2p and V 2p for post-test D-Ni_3N QDs/VN.

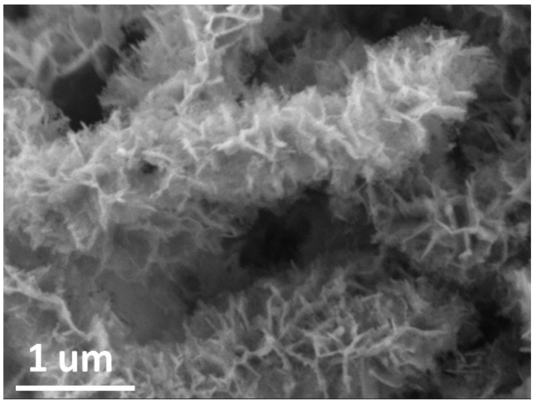


Fig. S12 SEM image of D-Ni_3N QDs/VN after OER.

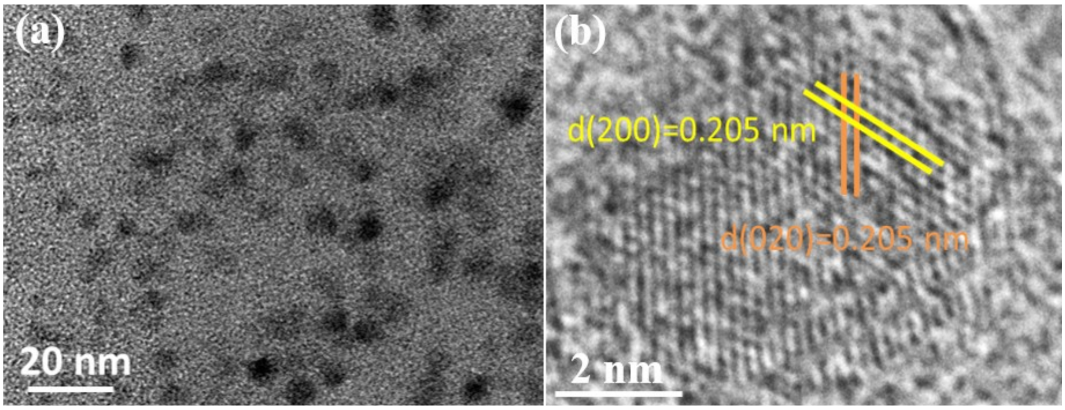


Fig. S13 (a) TEM image of widespread Ni_3N QDs/CC, (b) High-magnification TEM image of Ni_3N QDs/CC.

Table S1. Comparison of the catalytic activity of D-Ni_3N QDs/VN to the reported transition-metal-based ORR catalysts

No.	catalysts	electrolyte	$E_o$vsRHE（V）	$E_{1/2}$ (V)	b (mV/dec)	Ref.
1	Ni/N-CNCs	0.1 M KOH	0.925	0.775	-	Adv. Mater. 2017, 29, 1605083
2	$V_{0.95}Co_{0.05}N$ MFs	0.1 M KOH	0.903	0.802	-	ACS Appl. Mater. Interfaces 2018, 10, 11604−11612
3	Ni_3Fe/N-C	0.1 M KOH	-	0.810	79	J. Electroanal. Chem. 851 (2019) 113418
4	Co/Ni-N-C	0.1 M KOH	0.930	0.840	-	Appl. Catal. B 240 (2019) 112–121
5	CSV10	0.1 M KOH	0.797	0.737	120	Carbon 144 (2019) 289e300
6	Co-NiMoN	0.1 M KOH	0.890	0.730	-	ACS Appl. Mater. Interfaces 2019, 11, 27751-27759
7	$FeNi_3N$/NG	0.1 M KOH	0.880	0.790	83	J. Mater. Chem. A, 2019, 7, 1083
8	FeNC-900	0.1 M KOH	0.959	0.837	86.2	Nanoscale 2019,11, 19506-19511
9	W_2N/WC	0.1 M KOH	0.930	0.810	-	Adv. Mater. 2020, 32, 1905679
10	D-Ni_3N QDs/VN	0.1 M KOH	0.963	0.837	81	This work

Table S2. Comparison of the catalytic activity of D-Ni_3N QDs/VN to the reported transition-metal-based OER catalysts

No.	catalysts	electrolyte	η (mV)	b (mV/dec)	Ref.
1	Ni_3FeN	0.1 M KOH	$\eta_{j=10} = 355$	70	Nano Energy 39 (2017) 77–85
2	Ni_3N/NC	1.0 M KOH	$\eta_{j=10} = 310$	-	Chem. Commun., 2017, 53, 9566--9569
3	Ni_3N/NC holey sheets	1.0 M KOH	$\eta_{j=10}=260$	51	ACS Appl. Energy Mater. 2018, 1, 6774−6780
4	Ni_3Fe/N-C	1.0 M KOH	$\eta_{j=10} = 310$	58	J. Electroanal. Chem. 851 (2019) 113418
5	$NiCo_2N$	1.0 M KOH	$\eta_{j=10} = 289$	56	Adv. Mater. Interfaces 2019, 6, 1900960
6	NB-HO	1.0 M KOH	$\eta_{j=10} = 247$	79	J. Mater. Chem. A, 2019, 7, 22063
7	NiMoN-400 NRs	1.0 M KOH	$\eta_{j=10} = 294$	73	ACS Appl. Mater. Interfaces 2019,11, 27751−27759
8	N-NiVFeP/NFF	1.0 M KOH	$\eta_{j=10} = 229$	72.6	Appl. Catal. B 268 (2020) 118440
9	W_2N/WC	1.0 M KOH	$\eta_{j=10} = 320$	94.5	Adv. Mater. 2020, 32, 1905679
10	D-Ni_3N QDs/VN	0.1 M KOH	$\eta_{j=10} = 226$	54	This work

Reference

1. X. Han, W. Zhang, X. Ma, C. Zhong, N. Zhao, W. Hu and Y. Deng, *Advanced materials*, 2019, **31**, e1808281.
2. S. Wang, L. Zhang, Z. Xia, A. Roy, D. W. Chang, J. B. Baek and L. Dai, *Angewandte Chemie*, 2012, **51**, 4209-4212.
3. C. Du, P. Li, F. Yang, G. Cheng, S. Chen and W. Luo, *ACS applied materials & interfaces*, 2018, **10**, 753-761.