Electronic Supplementary Material (ESI) for New Journal of Chemistry.

Ultrafine VN Quantum Dots Modified with Nitrogen Doped Reduced Graphene Oxide Anode Material for Enhanced Rate Capability and Lifespan of Lithium-ion Batteries

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1.Supporting figures and tables

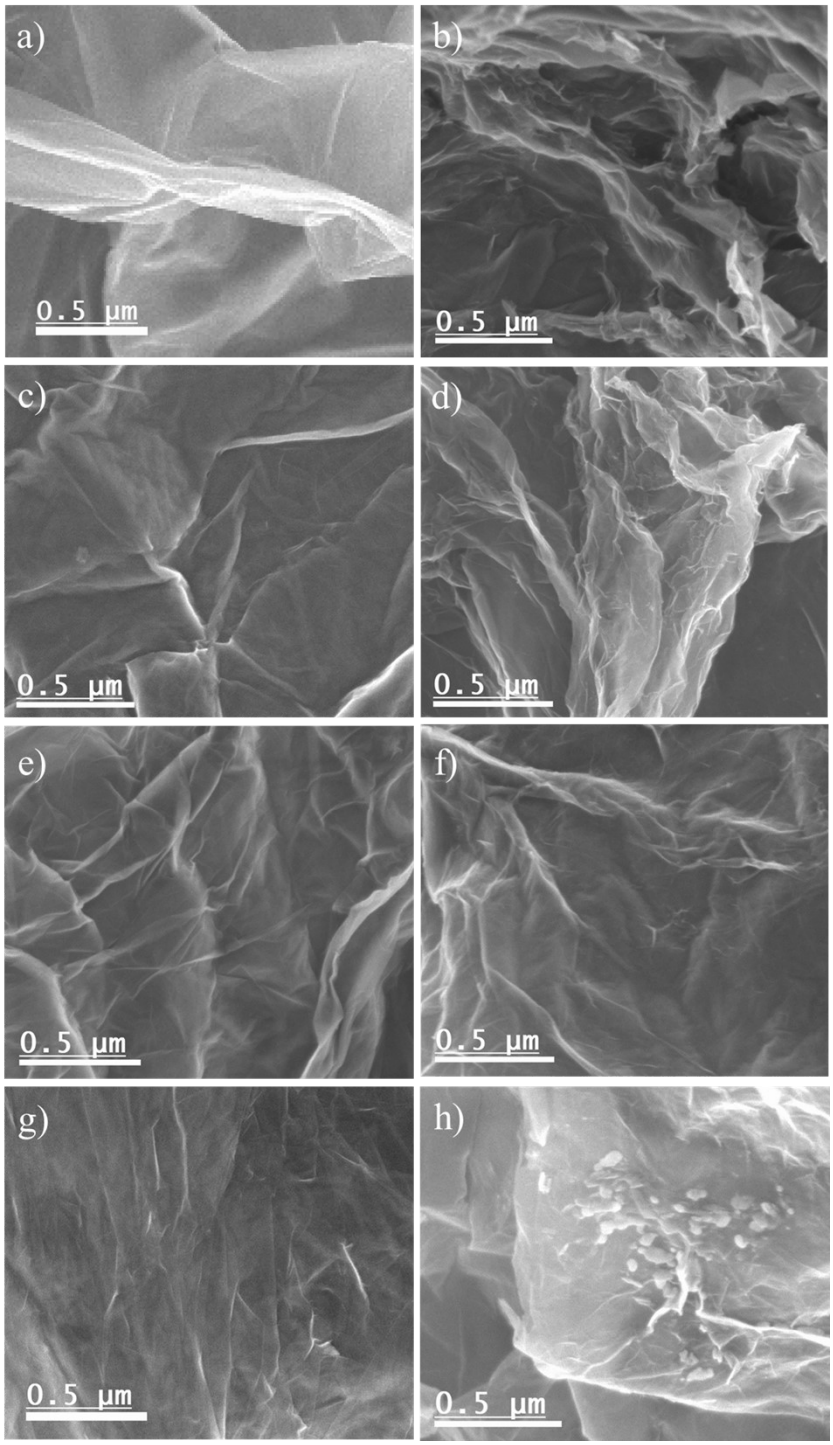

Figure S1 SEM images of a) GO, b) NrGO, c) V_xO_yQDs@GO-1, d) VNQDs@NrGO-1, e) V_xO_yQDs@GO-5, f) VNQDs@NrGO-5, g) V_xO_yQDs@GO-10, and h) VNQDs@NrGO-10.

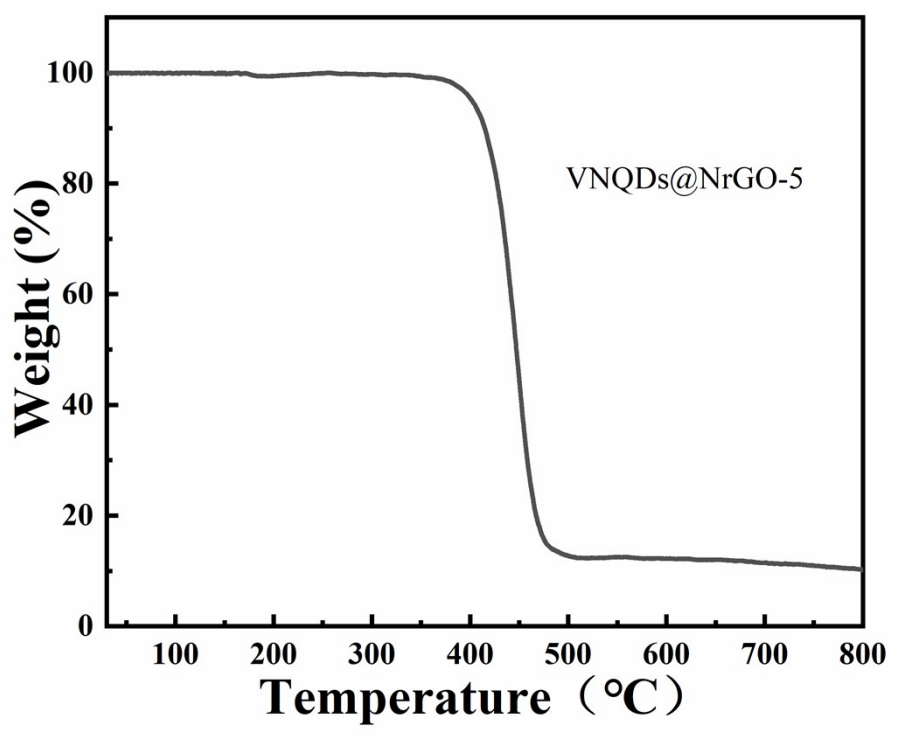

Figure S2 TGA date of VNQDs@NrGO-5.

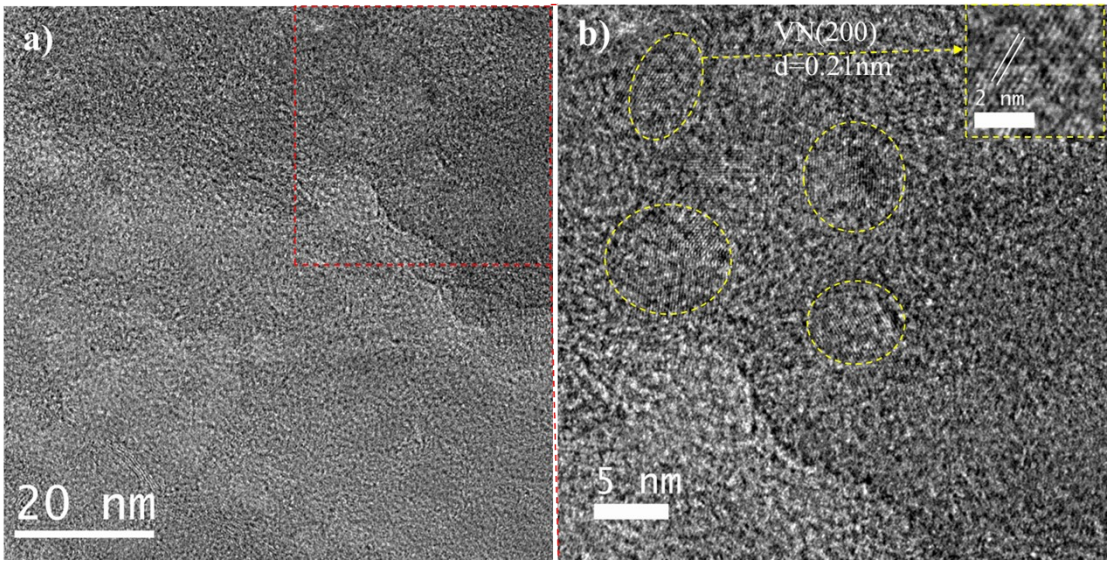

Figure S3 a) TEM and b) HRTEM images of the discharged products on VNQDs@NrGO-5 at 2 A g^{-1} after 500 cycles.

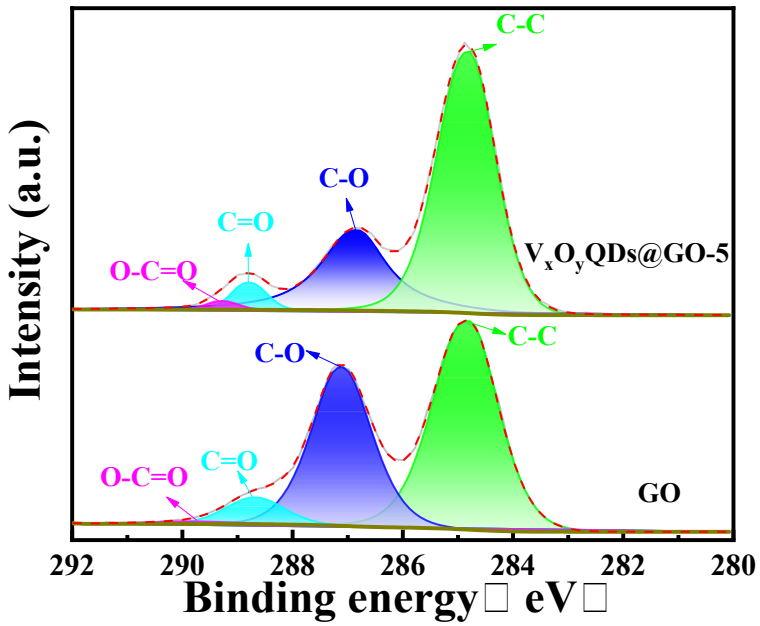

Figure S4 C 1s spectra of the GO and V_xO_yQDs@GO-5.

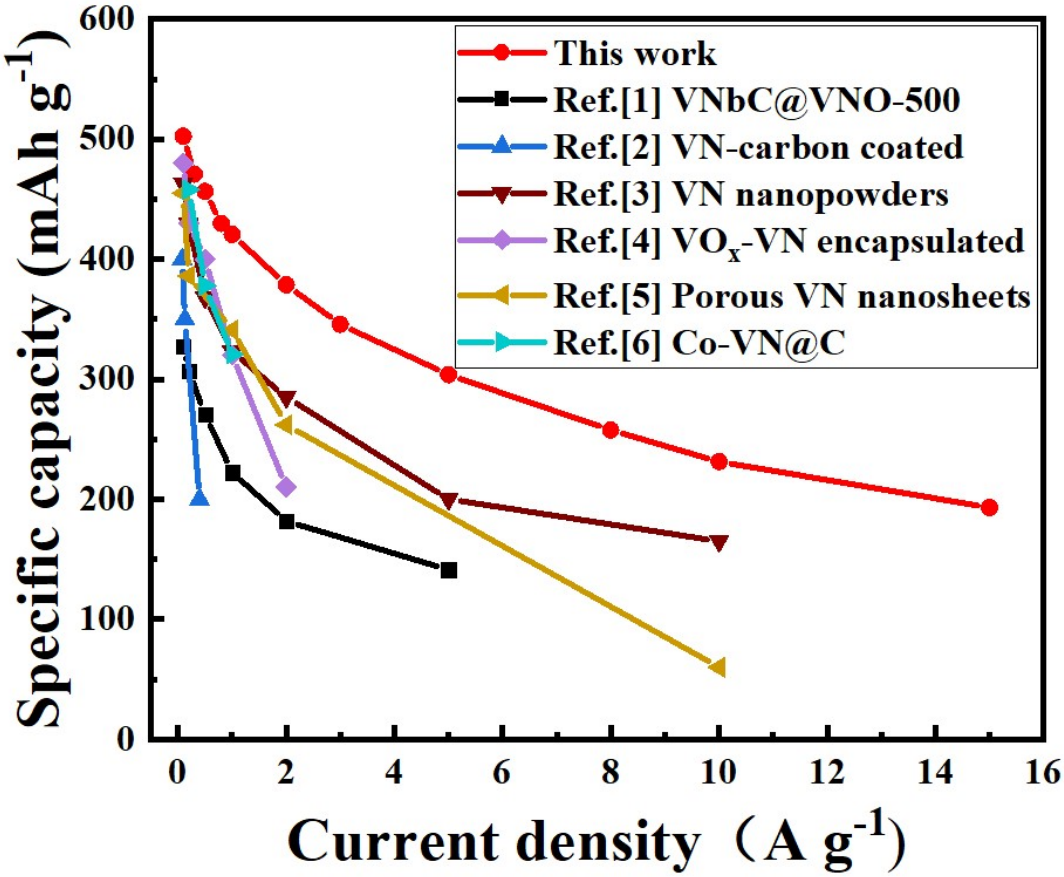

Figure S5 Rate comparison of the VNQDs@NrGO-5 and previously reported vanadium-based nitrides for LIBs.[1-6]

Table S1 The d-spacing and degree of the neat GO, rGO, V_xO_yQDs@GO-5, and VNQDs@NrGO-5

Samples	d(Å)	2θ (°)	Samples	d(Å)	2θ (°)
GO	8.9948	9.825	NrGO	3.3947	26.230
V_xO_yQDs@GO-1	8.5262	10.367	VNQDs@NrGO-1	3.4578	25.743
V_xO_yQDs@GO-5	7.4080	11.937	VNQDs@NrGO-5	3.4866	25.526
V_xO_yQDs@GO-10	7.2124	12.262	VNQDs@NrGO-10	3.5013	25.418

Table S2. The ratio of ID to IG for the investigated sheets, where ID and IG are the Raman intensities of the D and G peaks

Samples	ID：IG
GO	0.94
V_xO_yQDs@GO-5	0.97
NrGO	1.13
VNQDs@NrGO-5	1.16

Table S3 The atom percentage of elements (C, N, O, and V) in the XPS data

Samples	C (%)	O (%)	N (%)	V (%)
GO	71.74	28.26		
V_xO_yQDs@GO-5	73.13	20.37		6.49
NrGO	84.36	13.10	2.53	
VNQDs@NrGO-5	80.96	10.02	5.62	3.41

Table S4 The atom percentage of C-C, C-O, C=C, and C=O according to the C 1s and the percentage of V-O/V-N according to the V 2p peak in the obtained XPS spectra

Samples	C-C (%)	C-N（%）	C-O (%)	C=O (%)	O-C=O (%)	V-O（%）	V-O-N (%)	V-N (%)
GO	54.31		38.51	6.24	0.94			
V_xO_yQDs@GO-5	68.93		23.00	4.29	3.78	100		
NrGO	52.82	25.55	15.86	2.82	2.95			
VNQDs@NrGO-5	45.74	32.95	9.33	2.92	9.06	39.72	30.37	29.89

Table S5 Resistance elements of four samples derived from the Nyquist plots.

Samples	R_s (Ω)	R_{ct} (Ω)	W_o (Ω)
NrGO	1.649	215.8	228.4
VNQDs@NrGO-1	2.184	206.1	220.7
VNQDs@NrGO-5	1.236	81.84	72.62
VNQDs@NrGO-10	2.056	136.7	155.5

Table S6 Comparison of the electrochemical performance of VNQDs@NrGO-5 and various metal nitride electrodes in LIB applications.

Samples	Whether to use dangerous ammonia atmosphere	Current density (A g^{-1})	Cycling number	Specific capacity (mAh g^{-1})	Ref.
VNbC@VNO-500	No	0.1	100	400	1
		5	1000	324	
VN-carbon coated	No	0.065	100	400	2
VN nanopowders	Yes	0.1	250	634	3
VO_x-VN encapsulated	No	0.5	200	380	4
		2	/	220	
Porous VN nanosheets	Yes	0.1	200	455	5
		1	250	341	
Co-VN@C	Yes	0.5	500	336	6
		1	200	324	
VNQD@NrGO-5	No	0.1	10	492	This work
		2	10000	324	

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