Nitrogen containing ordered mesoporous carbon sphere: an efficient metal-free catalyst for Oxygen Reductive Reaction

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Table S1. Nitrogen content and surface nitrogen states

Sample	N content(wt%)[a]	N1[c]	N2[c]	N3[c]	N4[c]
N-OMCS-0	0				
N-OMCS-0.5	1.48	37.9%	31.6%	14.8%	15.6%
N-OMCS-1.5	2.16	40.4%	27.7%	16.5%	15.4%
N-OMCS-2.5	3.44	37.2%	26.9%	19.8%	16.0%
N-OMCS-4.0	3.66	41.3%	32.9%	14.2%	11.6%

a The nitrogen content was obtained by the Element analysis.

b N1 means Pyridinic-N, N2 means Pyrrolic-N, N3 means Quaternary-N, N4 means Pyridinic-N-oxides.

c The relative content of different N species to total N.

Table S2. The texural properties of N-OMCS-x

Sample	BET surface area(m^2/g)[a]	Pore size (nm) [b]	Pore volume (cm^3/g)
OMCS	722	3.0	0.55
N-OMCS-0.5	592	6.9	0.50
N-OMCS-1.5	553	4.4	0.35
N-OMCS-2.5	541	3.3	0.32
N-OMCS-4.0	520	6.3	0.39

a The surface area obtained by BJH model.

b average pore size.

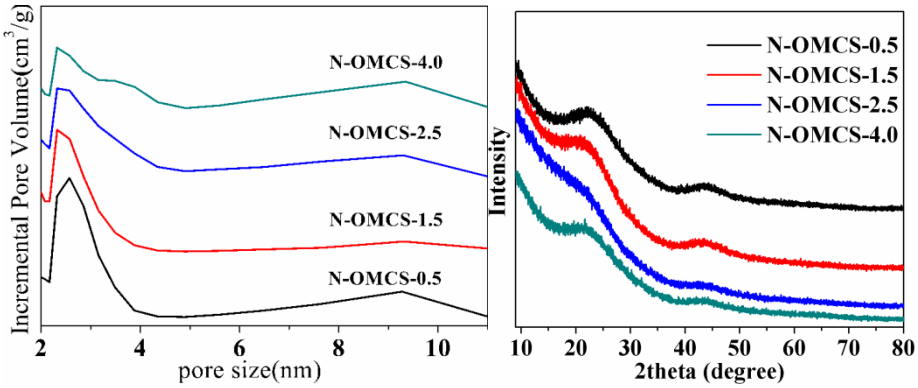

Figure S1. Pore size distribution and WXRD of N-OMCS-0.5, 1.5, 2.5, 4.0.

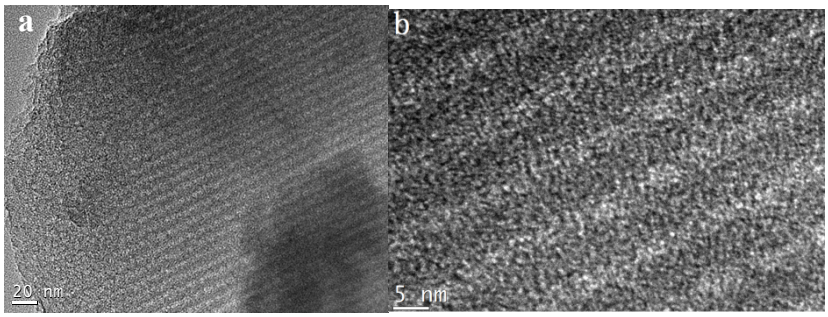

Figure S2 HRTEM images of N-OMCS-2.5

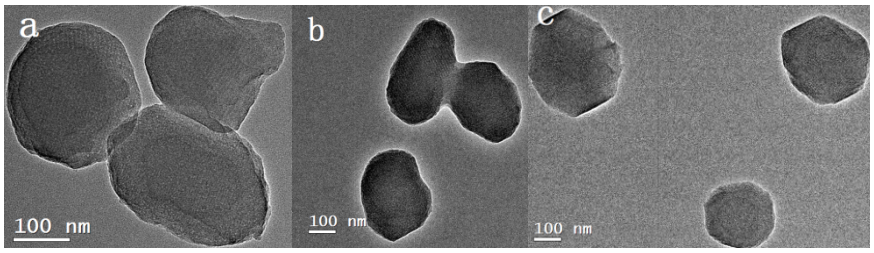

Figure S3. TEM images of N-OMCS-1.5-700, 800, 900 respectively.

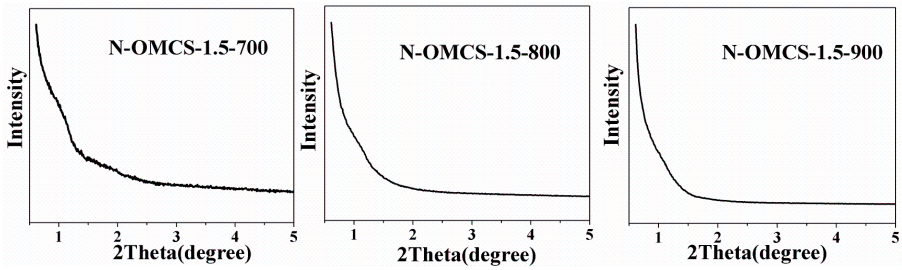

Figure S4. SXRD images of N-OMCS-1.5-700, 800, 900 respectively.

Table S3. The texural properties of N-OMCS-1.5-x

Sample	BET surface area[a]	Pore size(nm)	Pore volume (cm^3/g)
N-OMCS-1.5-700	574	5.1	0.38
N-OMCS-1.5-800	649	3.7	0.39
N-OMCS-1.5-900	888	4.1	0.53

Table S4. Nitrogen content and surface nitrogen states

Sample	N content(atom%)[a]	N1[b]	N2[b]	N3[b]	N4[b]
N-OMCS-1.5-700	2.98%	33.0%	25.38%	28.89%	12.70%
N-OMCS-1.5-800	2.26 %	35.59%	20.24%	30.14%	14.02%
N-OMCS-1.5-900	1.98 %	26.20%	18.28%	37.97%	17.54%

a The nitrogen content was obtained by XPS analysis.

b The relative content of different N species to total N.

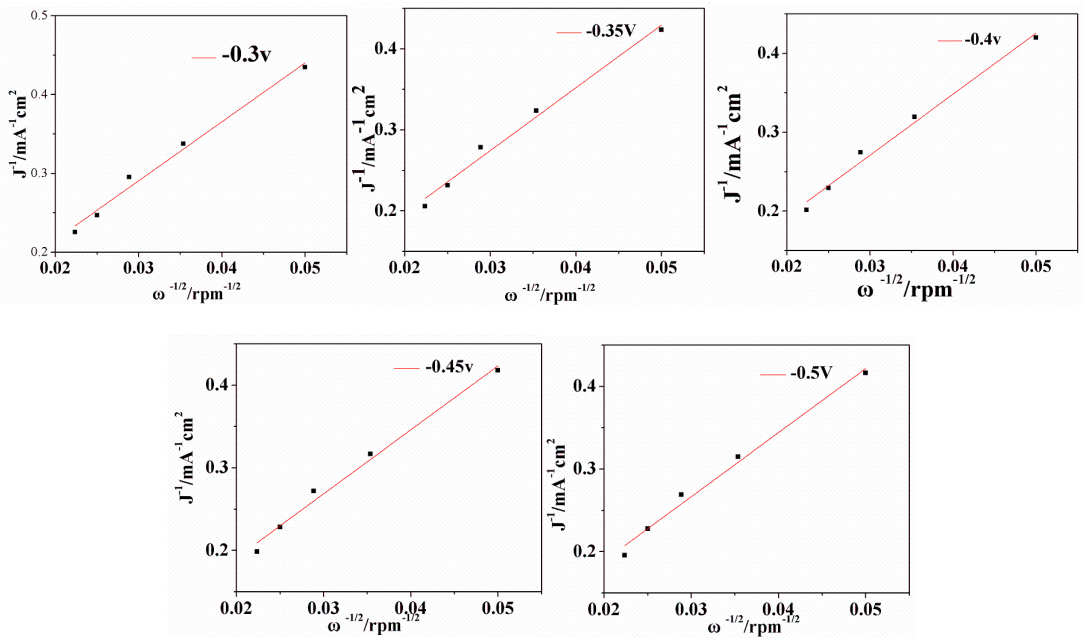

Figure S5. K-L plots N-OMCS-1.5-900

Table S5. Comparison of catalytic activity of N-OMCS-1.5-900 towards ORR with other metal-free carbon-based materials.

Material	Onset potential (V vs. Ag/AgCl)	Cathodic ORR peak (V vs. Ag/AgCl)	Max. current density(mA cm^{-2})	Scan rate (mv s^{-1})	Rotation rate (rpm)	Reference
N-OMCS-1.5-900	-0.11	-0.21	4.3	10	1600	This work
N-doped ordered mesoporous graphitic array	-0.13	-0.26	5.9	10	1600	Angew Chem Int Ed 2010, 49, 565.
Ordered macroporous graphitic C_3N_4/carbon composite	-0.14	-0.30	4.8	5	1500	Angew. Chem. Int. Ed. 2012, 51, 3892.
N-doped carbon sub-micrometer sphere	-0.10	-0.22	5.8	10	1600	Adv. Mater. 2013, 25, 998.
Nitrogen-doped graphene/carbon nanotube nanocomposite	0.10	----	3.3	20	1600	Adv. Mater. 2013, 25, 3192
Nitrogen-doped graphene nanoribbon	-0.10	-0.21	3.6	10	1600	ACS Appl. Mater. Interfaces 2014, 6, 4214.
3D Hierarchically Porous Nitrogen-Doped Carbons	-0.133	-0.168	4.54	10	1600	Angew Chem Int Ed, 2014, 53, 9503
N-doped mesoporous carbon sphere	-0.11	-0.21	6.2	10	1600	Angew Chem Int Ed, 2015, 54, 588.