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Nitrogen-doped carbon sheets derived from chitin as non-metal bifunctional electrocatalysts for oxygen reduction and evolution

Haoran Yuan[a,c], Lifang Deng [a, c*], Xixi Cai[b], Shungui Zhou[b], Yong Chen[a,d], and Yong Yuan[b*]

[a] Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences, Guangzhou 510640, China

[b]Guangdong Key Laboratory of Agricultural Environment Pollution Integrated Control, Guangdong Institute of Eco-Environmental and Soil Sciences, Guangzhou 510650, China;

[c] Key Laboratory of Renewable Energy, Chinese Academy of Sciences, Guangzhou 510640, China

[d]Guangzhou division Academy, Chinese Academy of Sciences, Guangzhou 510070, China

*** To whom Correspondence should be addressed:**

Email: denglf@ms.giec.ac.cn (F. Deng); Tel: 86-20-87013240; Fax: 86-20-87013240

Email: yuanyong@soil.gd.cn (Y. Yuan); Tel: 86-20-87025872; Fax: 86-20-87025872

Table S1 Summary of electrochemical performance of the as-prepared catalysts for ORR

Samples	CV peak potential (V vs. SCE)	CV peak current density (mA/cm^2)	Resistance (Ω)	
			R_s	R_{ct}
Pt/C	– 0.20	1.63	36 ±2	31 ± 5
ACS	– 0.24	1.88	48 ±2	37 ± 2
CS	– 0.29	1.48	49 ±2	45 ± 3

Table S2 Comparison of the ORR performance of Carbon-based cathodes catalysts

Cathode Catalyst	ORR onset potential (vs. RHE) (V)	OER onset potential(vs. RHE) (V)	≈*n*	Ref.
Plain AC	0.71	---	2.6	[1]
Ultracapacitor AC	0.61		3.0	
Non-AC	0.31		2.1	
Pt/C	0.76		3.9	
Ammonia treated peat-based AC	0.77	---	3.9	[2]
Untreated peat-based AC	0.75		---	
Treated bituminous coal AC	0.73		3.9	
Untreated bituminous coal AC	0.69		--	
Treated wood coal AC	0.64		---	
Pt/C	0.97		---	
Cellulose phosptate-800	0.77	---	---	[3]
Cellulose phosptate-900	0.79			
Cellulose phosptate-1000	0.82			
Cellulose phosptate-1100	0.89			
Pt/C	0.89			
GSH [a]	0.75	1.54	3.2	[4]
NGSH [b]	0.78	1.47	2.5	
Pt/C	0.88	1.58	-	
CG-CoO[c]	0.85	1.55	3.0	[5]
N-CG-CoO	0.90	1.30	4.0	
Pt/C	0.93	---	---	
ACS	0.86	1.06	3.7	**This study**
CS	0.79	1.64	2.5	
Pt/C	0.88	1.62	3.8	

[a] graphene / single-walled hybrid(GSH);

[b] N-doped graphene / single-walled hybrid (NGSH);

[c] crumpled graphene (CG)

RHE= SCE+0.2438 V+0.0591×pH at 25℃

Ref.

1. H. Dong, H. B. Yu, and X.Wang, *Environ. Sci. Technol,* 2012, **46**, 13009-13015
2. V. J. Watson, C.N. Delgado, B. E. Logan, *J. Power Source,* 2013, **242**, 756-761
3. Q. Liu, S. L. Chen, Y. Zhou, S. Q. Zheng, H. Q. Hou and F. Zhao, *J. Power Source,* 2014, **261**, 245-248
4. G. L. Tian , M. Q. Zhao , D. S. Yu , X. Y. Kong , J. Q. Huang, Q. Zhang and F. Wei, *small,* 2014, **10**, 2251-2259
5. S. Mao, Z. H. Wen, T. Z. Huang, Y. Hou and J. H. Chen, *Energy Environ. Sci.,* 2014, **7,** 609-616

Table S3 Characterization of metal impurities in the ACS samples treated by HCl

Sample	Fe (wt%)	Co (wt%)	Cu (wt%)	Ni (wt%)
ACS (1 mol/L HCl)	0.0322	0.01129	0.00018	0.01933
ACS (6 mol/L HCl)	0.0105	0.00521	0.00012	0.00744

Table S4 Metal impurities in the electrolytes measured by ICP-MS

Metal impurities (ppb)	Electrolyte before ORR measurements	Electrolyte after ORR measurements
Mn	4.66	4.25
Fe	8.85	6.63
Ni	0.46	0.15
Cu	0.86	1.28
Co	0.04	0.15
Zn	7.98	<0.01
Se	0.15	0.46
As	20.63	19.04
Cd	0.04	0.15
Sn	3.66	1.35
Hg	14.77	3.5

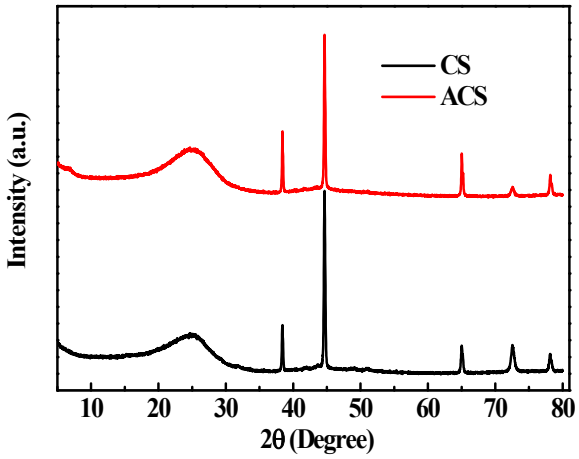

Figure S1 XRD patterns of the resultant CS and ACS.

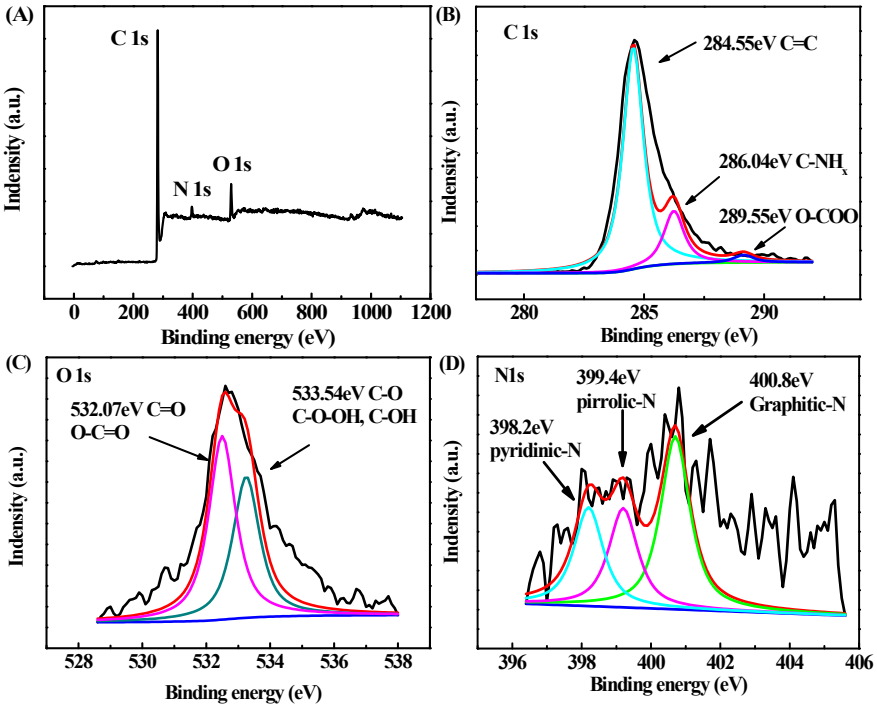

Figure S2 XPS survey of the CS showing C, O and N were the main elements; B) The XPS C1s spectra; C) O1s spectra; D) N 1s spectra.

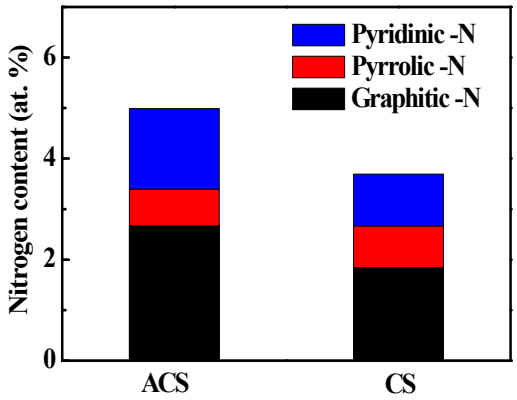

Figure S3 Fraction of different nitrogen groups in ACS and CS.

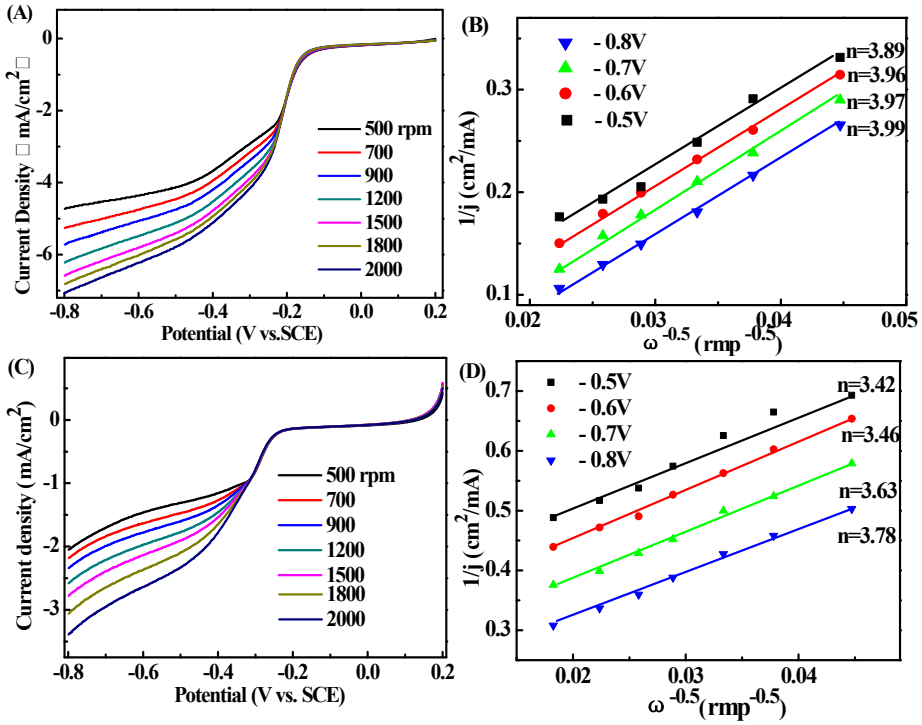

Figure S4 (A and C) Rotating – disc electrode voltammograms of the Pt/C and CS in O_2-saturated 0.1 M KOH with a sweep rate of 10 mV S^{-1} at various rotation speeds; (B and D) corresponding Koutecky-Levich plots (j^{-1} *versue* $\omega^{-0.5}$) of (A) and (C) at different potentials.

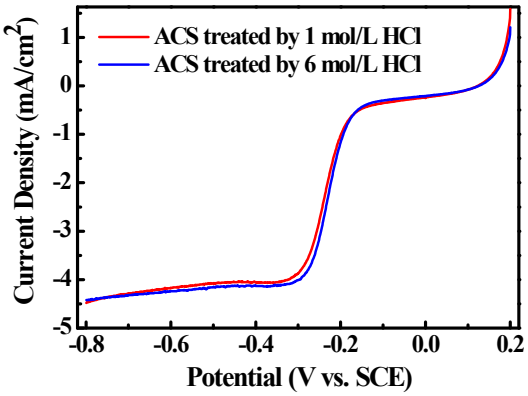

Figure S5 ORR of the ACS treated by 1mol/L and 6 mol/L HCl, respectively.

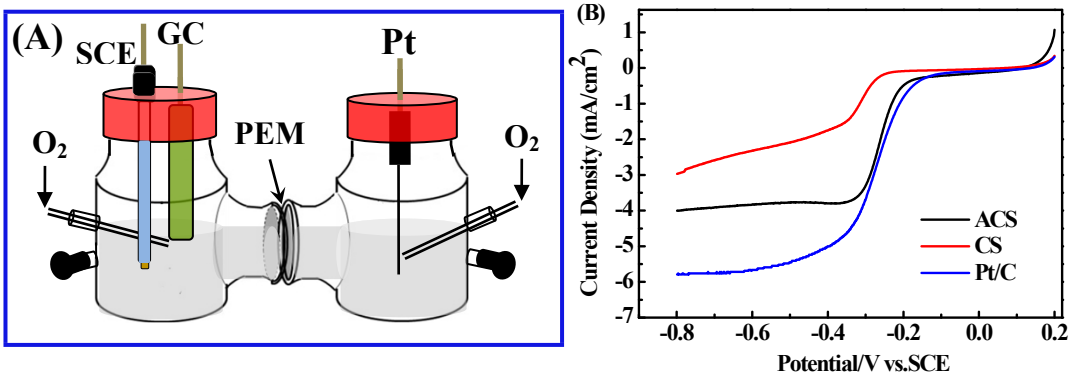

Figure S6 (A) Schematic diagram of a two-compartment electrochemical cell for ORR measurements; (B) ORR of CS, ACS and Pt/C conducted in the two-compartment electrochemical cell.

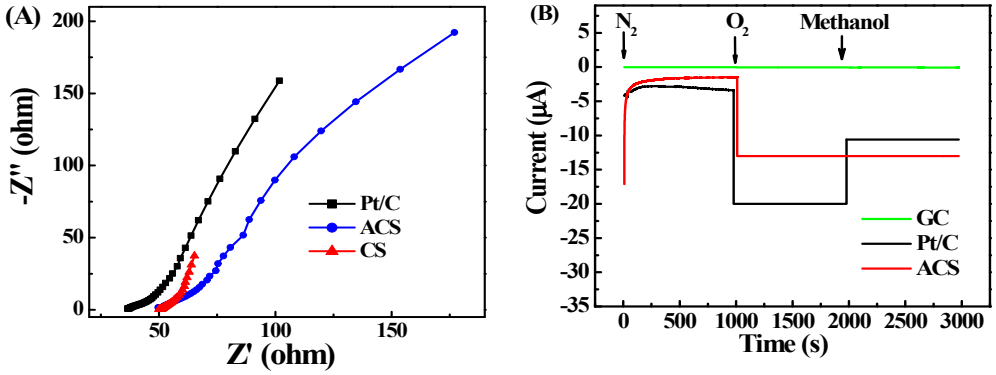

Figure S7 (A) Nyquist curves of the EIS data for the different cathodes; (B) Amperometrical curves for GC, ACS and Pt/C in the absence and presence of 1M methanol.