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Electronic Supplementary Information

Sustainable metal-free carbogels as oxygen reduction electrocatalysts

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Figure S1: Nitrogen sorption isotherms at -196 °C of a nitrogen doped aerogel (CN-HTC) and carbogels treated at 1000°C under either pure nitrogen atmosphere (CN-N2) or a mixture of nitrogen and oxygen (CN-1% O_2 , CN-2% O_2 , CN-4% O_2).



Figure S2: X-ray photoelectron spectra for nitrogen doped carbogels treated at 1000°C under either pure nitrogen atmosphere (CN-N₂) or a mixture of nitrogen and oxygen (CN-1% O₂, CN-2% O₂, CN-4% O₂).



Figure S3: Deconvoluted C1s (left) and O1s (right) spectra for nitrogen doped carbogels treated at 1000°C under a) either pure nitrogen atmosphere (CN-N₂) or a mixture of nitrogen and oxygen b) CN-1% O₂, c) CN-2% O₂ and d) CN-4% O₂.



Figure S4: Deconvoluted N1s spectra for nitrogen doped carbogels treated at 1000°C under a) either pure nitrogen atmosphere (CN-N₂) or a mixture of nitrogen and oxygen b) CN-1% O₂, c) CN-2% O₂ and d) CN-4% O₂.

Table S1 : Binding energy (eV)/fraction of species (%) and assignment of peaks^{1–4} for nitrogen doped carbogels treated at 1000°C under either pure nitrogen atmosphere (CN-N₂) or a mixture of nitrogen and oxygen CN-1% O₂, CN-2% O₂ and CN-4% O₂.

Peaks	CN-N ₂	CN-1% O ₂	CN-2% O ₂	CN-4% O ₂	Assigned to
C1s	284.27/78	284.21/81	284.22/74	284.32/83	C–C/C=C
	285.07/16	285.04/12	285.05/18	285.19/11	С–ОН/С–О–С
	285.93/5	285.75/5	285.84/6	285.96/5	C-N
	286.71/1	286.61/2	286.74/2	286.67/1	C-0
O1s	530.27/15	530.52/19	530.45/14	530.73/23	C=0
	532.20/55	532.06/44	532.29/48	531.87/32	C-0
	533.29/30	533.31/37	533.60/39	533.40/39	0=C-0
	-	-	-	536.03/6	adsorbed H ₂ O
N1s	397.97/30	398.10/26	398.14/31	398.26/34	Pyridinic N
	-	-	-	399.69/30	Pyrrolic N
	400.77/59	400.76/66	400.69/60	400.75/30	Graphitic N
	403.06/11	403.88/8	402.33/9	401.99/6	N-oxides



Figure S5: Nitrogen sorption isotherms at -196 °C of carbogels treated at 1000 °C doped with nitrogen (CN) and additional doping with sulfur (CN_s), boron (CN_B) and sulfur and boron (CN_{SB}).



Binding energy (eV)

Figure S6: X-ray photoelectron spectra of carbogels treated at 1000 °C doped with nitrogen (CN) and additional doping with sulfur (CN_s), boron (CN_B) and sulfur and boron (CN_{SB}).



Figure S7: Deconvoluted C1s (left) and O1s (right) spectra for carbogels treated at 1000 °C doped with a) nitrogen (CN) and additional doping with b) sulfur (CN_s), c) boron (CN_B) and d) sulfur and boron (CN_{SB}).

Table S2: Binding energy (eV)/fraction of species (%) and assignment of peaks^{1–4} for carbogels treated at 1000 °C doped with nitrogen (CN) and additional doping with sulfur (CN_s), boron (CN_B) and sulfur and boron (CN_{sB}).

Peaks	CN	CNs	CN _B	CN _{SB}	Assigned to
C1s	284.43/76	284.41/80	284.27/82	284.28/80	C–C/C=C
	285.04/19	285.12/16	285.21/13	285.09/15	С–ОН/С–О–С
	285.84/5	285.97/4	286.09/5	285.92/5	C-N/C-S
O1s	530.59/11	530.45/12	530.49/15	530.55/17	C=0
	532.31/48	532.24/48	531.89/45	532.06/45	C-0
	533.68/41	533.52/40	533.34/40	533.32/38	0=C-O
N1s	398.27/32	398.04/23	398.24/33	398.19/32	Pyridinic N
	400.68/55	400.88/65	400.64/58	400.58/58	Graphitic N
	402.28/14	402.44/12	402.17/9	402.01/10	N-oxides

Table S3: Electrochemical values derived from linear sweep voltammetry and chronoamperometry using an RRDE setup in 0.1 M KOH. Electron transfer number and H_2O_2 yield are averaged values between -0.3 V and -0.6 V.

Sample	Onset potential @ -0.1 mA/cm ² [V vs Ag/AgCl]	Limiting current @ -0.6 V [mA/cm ²]	Electron transfer number	H ₂ O ₂ yield [%]	Current after 10000 s [%]
Pt@C	0.006	-5.0	3.9	3.3	75
CN	-0.133	-3.3	3.1	44.7	85
CNs	-0.153	-2.7	3.0	48.4	80
CN _B	-0.143	-3.8	3.5	22.6	85
CN _{SB}	-0.158	-3.9	3.3	32.8	82

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