Supporting information

Additional figures and tables that are referenced in the text have been included. These contain information on SEM images and size distributions of the ACs, Boehm titration results of these carbons, oxalate and *p*CBA affinity toward GAC and SPAC, change in zeta potential with pH, change in hydrodynamic diameter with dose, pH and dissolved ozone changes during ozonation, and R_{ct} comparisons between carbon types.

Table S1 R_{ct} comparisons among carbons and H_2O_2 in ozonation process

Catalyst	Carbon dose (mg/L)	$[O_3]_0$ (mM)	R_{ct}	Reference
No carbon	0	90	4.0×10^{-11}	This study
GAC	200	90	1.6×10^{-10}	This study
SPAC	200	55	5.3×10^{-08}	This study
SPAC	100	100	3.2×10^{-09}	This study
SPAC	20	100	1.2×10^{-10}	This study
NL-70	20	160	2.9×10^{-08}	[1]
CT-70	20	160	3.4×10^{-08}	[1]
H_2O_2	160 μM	160	4.3×10^{-08}	[1]
F400	850	20	5.7×10^{-08}	[2]
F400	500	60	4.7×10^{-08}	[2]

Notes: NL-70: multi-walled carbon nanotubes (MWCNTs) from CheapTubes.com oxidized with 70% HNO_3; CT-70: MWCNTs from Nanolabs, Inc oxidized with 70% HNO_3; F400: commercial activated carbons, Filtrasorb 400

Table S2 XPS analysis of new and used GAC, 100–160 mesh AC and SPAC

XPS	Atom (%)				C1s (%)			
	C1s	O1s	N1s	C/O	C-C	C-O	C = O	O-C = O
GAC	87.86	11.01	1.13	7.98	64.67	16.40	10.11	8.82
100–160 mesh AC	85.94	12.73	1.33	6.75	65.68	15.24	9.61	9.47
SPAC	86.74	11.99	1.27	7.23	71.20	12.21	9.14	7.45
Used-GAC	86.34	12.33	1.33	7.00	73.61	10.71	8.00	7.68
Used 100–160 mesh AC	82.18	16.32	1.50	5.04	71.13	9.07	11.21	8.58
Used-SPAC	77.54	20.75	1.71	3.74	69.32	9.78	11.42	9.47

Table S3 Boehm titration results for SPAC, 100–160 mesh AC and GAC

Sample	Carboxyl (mmol/g)	Lactone (mmol/g)	Hydroxyl (mmol/g)
SPAC	0.613 ± 0.090	0.311 ± 0.014	0.047 ± 0.006
100–160 mesh AC	0.448 ± 0.019	0.187 ± 0.103	0.027 ± 0.006
GAC	0.453 ± 0.15	0.162 ± 0.100	0.022 ± 0.003

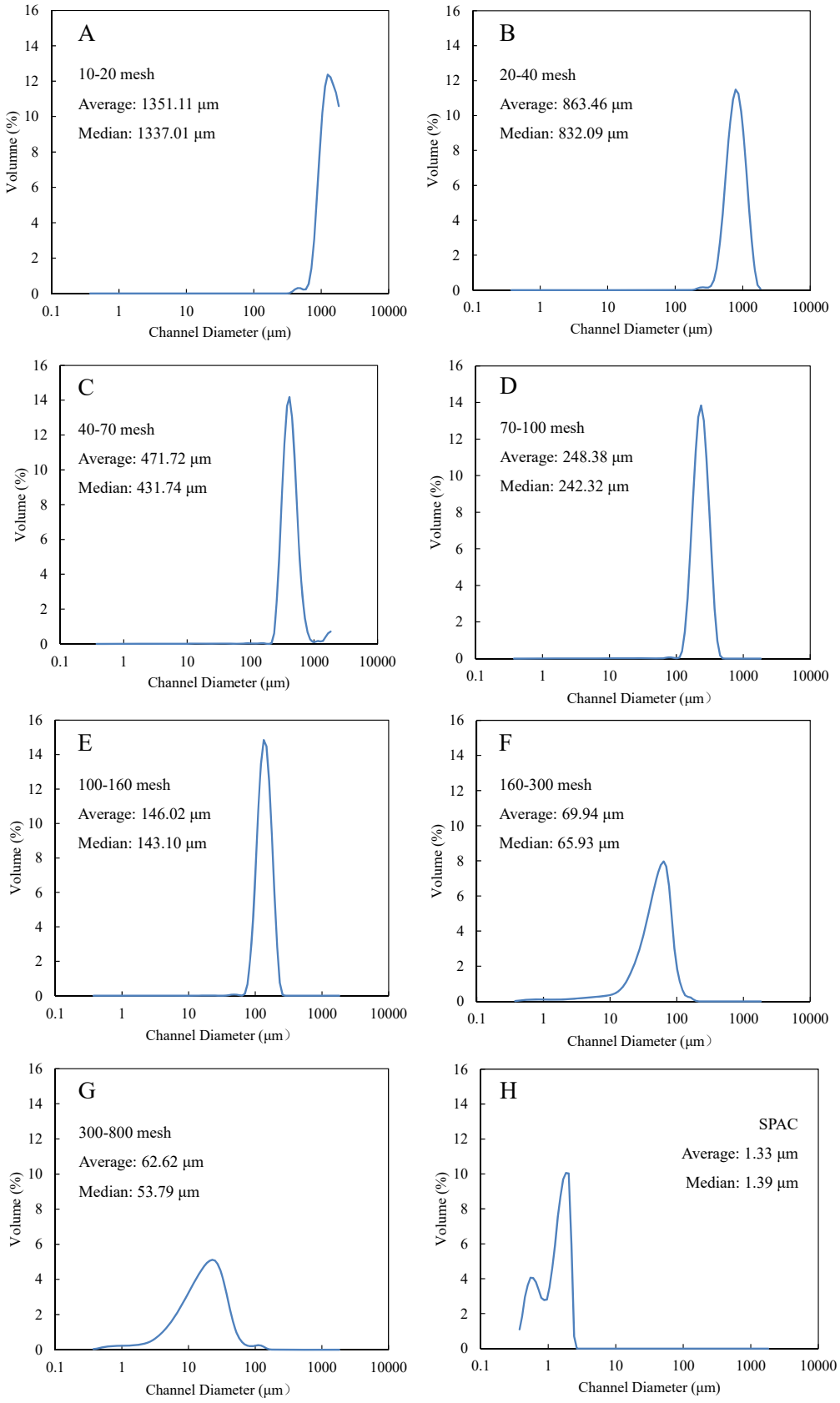

Fig. S1 Size distributions of 10–20, 20–40, 40–70, 70–100, 100–160, 160–300, and 300–800 mesh ACs

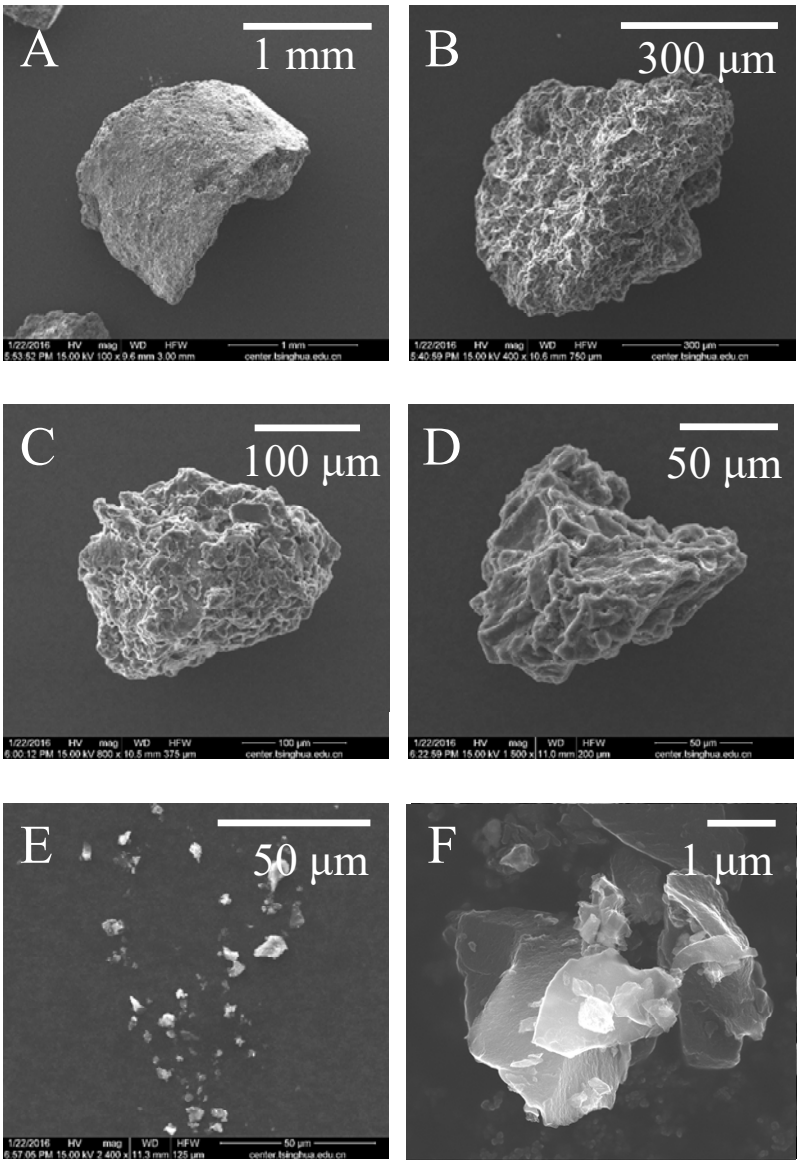

Fig. S2 SEM images of different sized activated carbon. (a) 830–1700 μm by 100 × , (b) 210–380 μm by 400 × , (c) 150–210 μm by 800 × , (d) 95–150 μm by 1500 × , (e) SPAC by 2400 × , (f) SPAC by 15000 ×

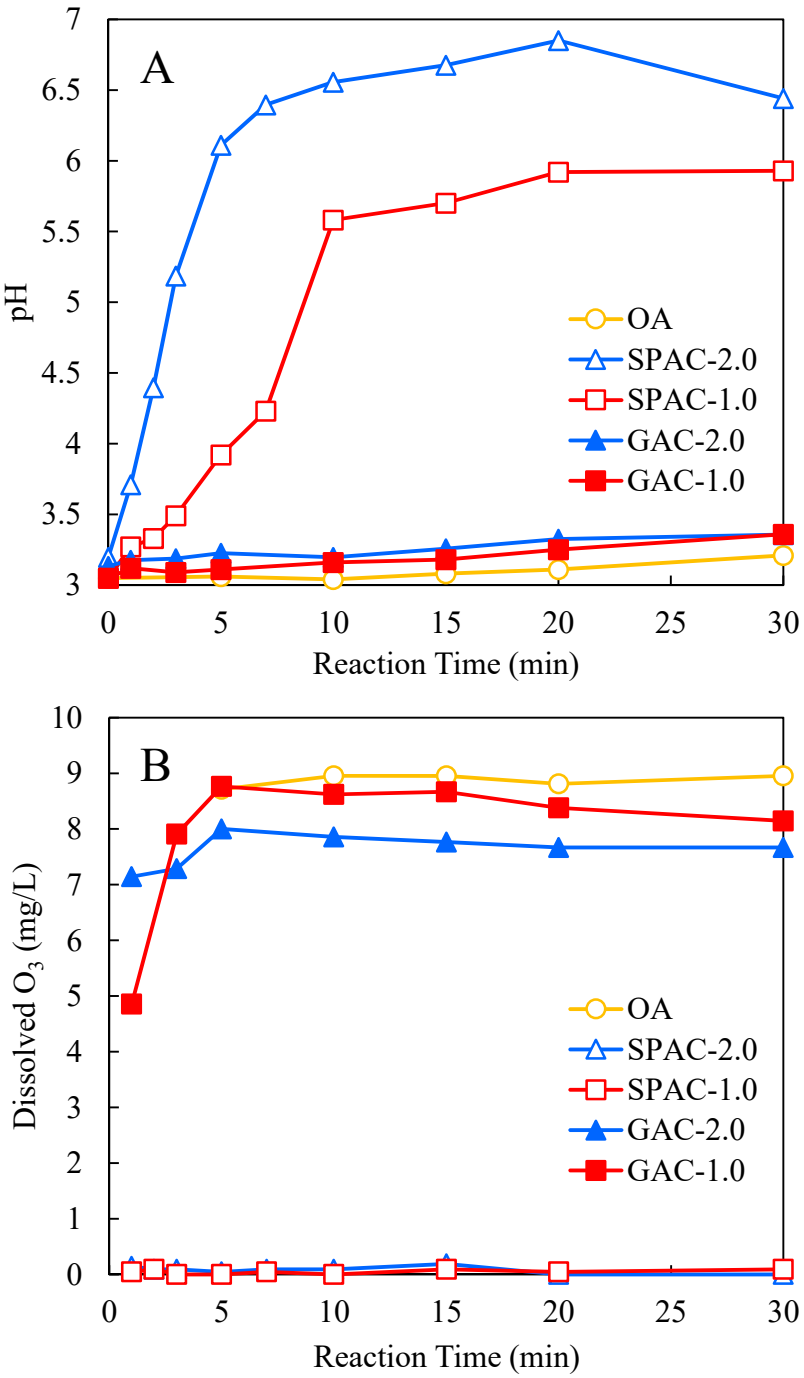

Fig. S3 (a) The pH and (b) dissolved ozone changes during ozonation for ozone along and ozone with SPAC and GAC at 1.0 g/L and 2.0 g/L

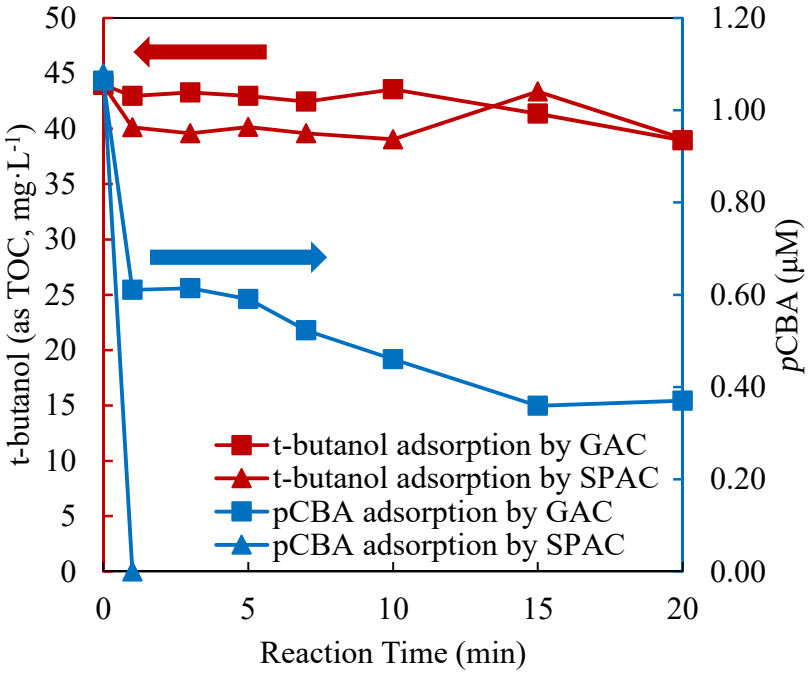

Fig. S4 Adsorption of t-butanol (measured as total organic carbon, referred to left axis) and *p*CBA (referred to right axis) by SPAC (2 g/L) and GAC (2 g/L)

The adsorption of t-butanol is very slight for both GAC and SPAC, less than 10% after 20 min. The adsorption of *p*CBA by GAC reached 60% at 20 min while SPAC adsorbed all the *p*CBA (~1 μM) within 1 min.

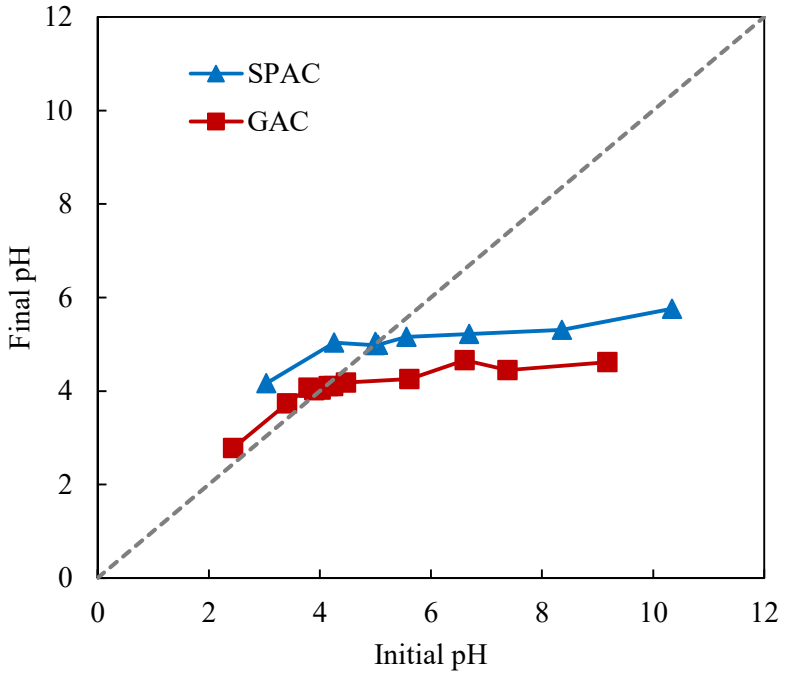

Fig. S5 pH_{pzc} for SPAC and 300–800 mesh AC. The cross between the diagonal and plots is the value of pH_{pzc}

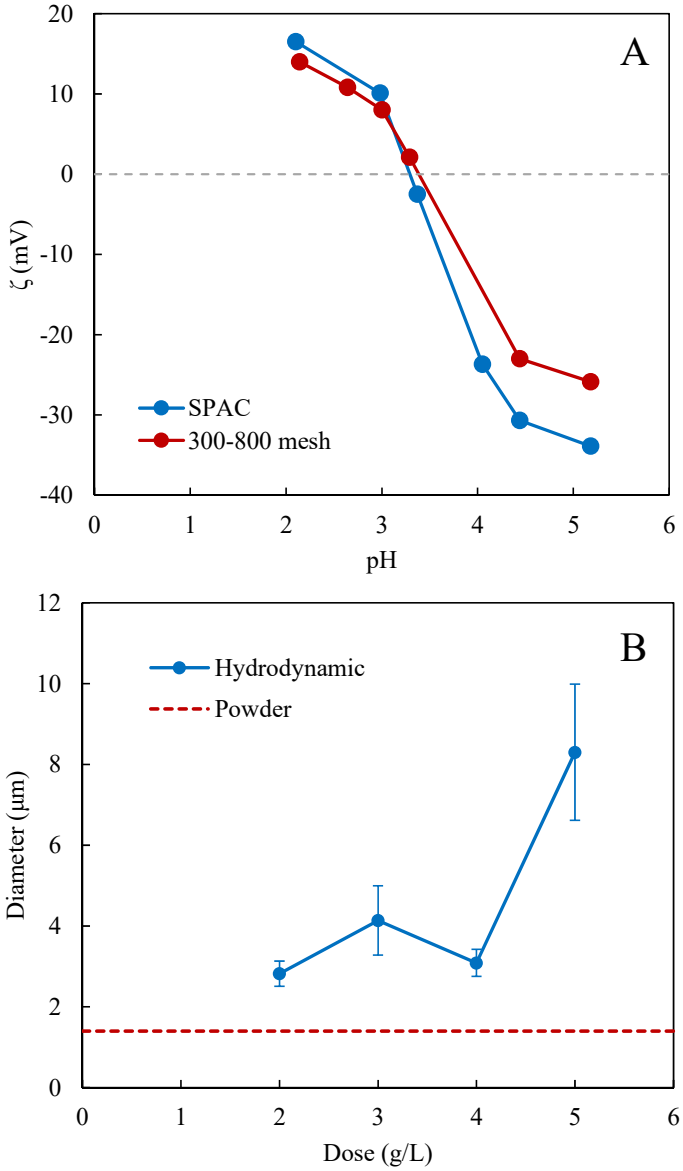

Fig. S6 (a) Zeta potential changes along with pH for SPAC and 300–800 mesh AC; (b) the changes of hydrodynamic diameter and dry powder diameter at different doses. The pH was not buffered

References

[1] Oulton R, Haase J P, Kaalberg S, Redmond C T, Nalbandian M J, Cwiertny D M. Hydroxyl radical formation during ozonation of multiwalled carbon nanotubes: performance optimization and demonstration of a reactive CNT filter. Environmental Science & Technology, 2015, 49(6): 3687–3697

[2] Sanchez-Polo M, Von Gunten U, Riverautrilla J. Efficiency of activated carbon to transform ozone into OH radicals: Influence of operational parameters. Water Research, 2005, 39(14): 3189–3198