Electronic Supporting Information

Critical role of anions on porous biochar structure and potassium release during

potassium-assisted pyrolysis process

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Number of Figures: 5; Number of Tables: 4

Figure list

- Figure S1. Diagram of vertical fixed bed reactor for BPC preparation process
- Figure S2. Diagrams and digital pictures of as-obtained solid products
- Figure S3. Raman spectra of as-prepared biochar and their deconvolution
- Figure S4. Textural properties of porous biochars from KAc-assisted pyrolysis
- Figure S5. Potassium release rate during KAc-assisted pyrolysis



Figure S1. Diagram of vertical fixed bed reactor for potassium-assisted pyrolysis process



Figure S2. Diagrams and digital pictures of as-prepared solid products (S: solid product, $S_{Bam+KOH}$: solid product from bamboo and KOH)



Figure S3. Raman spectra of as-prepared biochar and their deconvolution.

(a) $C_{Bam+KOH}$, (b) $C_{Bam+K2CO3}$, (c) $C_{Bam+KAc}$, (d) $C_{Bam+KCi}$, (e) $C_{Bam+KOx}$



Figure S4. Textural properties of porous biochars from KAc-assisted pyrolysis



Figure S5. Potassium release rate during KAc-assisted pyrolysis (N. D.: Not Detected)

Table list

Table S1. Biomass compositions analysis

Table S2. Selected potassium additives and their added amounts

Table S3. Yields and textural properties of porous biochars from compith with larger dosage of additives

Table S4. Yields and textural properties of porous biochars from different biomassraw materials via KAc-assisted pyrolysis

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Ash (wt.%),		Biochemical composition (wt.%), dry basis							
dry basis		Cellulose H		emicellulose		Lignin ^a Extractives		actives	
5.47		40.36		23.05		28.47	2.65		
1.19		43.19		18.83		12.89	2	23.90	
3.83		31.81		14.41		45.15	2	4.80	
3.1	14 36.5			15.67		31.25	1	3.38	
10.	36	42.73		22.09		0.23	2	4.59	
17.	05	38.14		18.73	20.32		5	5.76	
Inorganic composition (%) as oxide from XRF									
K_2O	CaO	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cl ₂ O	Fe ₂ O ₃	
36.23	7.14	14.02	2.62	9.23	11.71	15.44	n. d.	0.59	
1.71	53.09	35.69	n. d.	1.96	2.52	4.21		0.24	
14.00	27.92	22.52	4.42	10.38	9.26	7.29	1.87	0.82	
30.51	27.94	9.06	2.24	3.87	11.59	11.74	2.37	0.58	
27.27	27.41	3.63	3.40	21.49	8.06	1.95	5.36	1.15	
1.80	0.88	n. d.	n. d.	96.36	n. d.	0.55	n. d.	0.24	
	Ash (w dry b 5.4 1.1 3.8 3.1 10. 17.4 K ₂ O 36.23 1.71 14.00 30.51 27.27 1.80	Ash (wt.%), dry basis 5.47 1.19 3.83 3.14 10.36 17.05 IrK ₂ OCaO 36.23 7.14 1.71 53.09 14.00 27.92 30.51 27.94 27.27 27.41 1.80 0.88	Ash (wt.%), dry basisE $dry basis$ Cellulo 5.47 40.36 1.19 43.19 3.83 31.81 3.14 36.56 10.36 42.73 17.05 38.14 K_2O CaO K_2O CaO MgO 36.23 7.14 14.00 27.92 22.52 30.51 27.94 9.06 27.27 27.41 3.80 0.88 $n.d.$	Ash (wt.%), dry basis Biochem 5.47 40.36 1.19 43.19 3.83 31.81 3.14 36.56 10.36 42.73 17.05 38.14 Inorganic compos K_2O CaO MgO 36.23 7.14 14.02 2.62 1.71 53.09 35.69 n. d. 14.00 27.92 22.52 4.42 30.51 27.94 9.06 2.24 27.27 27.41 3.63 3.40 1.80 0.88 n. d. n. d.	Ash (wt.%), dry basisBiochemical comp demical comp 5.47 40.3623.05 1.19 43.1918.83 3.83 31.8114.41 3.14 36.5615.67 10.36 42.7322.09 17.05 38.1418.73Inorganic composition (%)K2OCaOMgOAl2O3 36.23 7.1414.022.62 12.32 7.1414.022.62 14.00 27.9222.524.42 14.00 27.949.062.24 30.51 27.943.633.40 1.80 0.88n. d.n. d. 90.6 2.243.87 27.27 27.413.633.40 21.49 0.88n. d.n. d. 90.6 0.88n. d.n. d.	Ash (wt.%), dry basisBiochemical composition Hemicellulose 5.47 40.3623.05 1.19 43.1918.83 3.83 31.8114.41 3.14 36.5615.67 10.36 42.7322.09 17.05 38.1418.73Inorganic composition (%) as oxide K_2O CaOMgOAl $_2O_3$ SiO $_2$ P_2O_5 36.237.1414.022.629.23 11.71 53.0935.69n. d.1.962.52 14.00 27.9222.524.4210.389.26 30.51 27.949.062.243.8711.59 27.27 27.413.633.4021.498.06 1.80 0.88n. d.n. d.96.36n. d.	Ash (wt.%), dry basisBiochemical composition (wt.%), or HemicelluloseLignina 5.47 40.36 23.05 28.47 1.19 43.19 18.83 12.89 3.83 31.81 14.41 45.15 3.14 36.56 15.67 31.25 10.36 42.73 22.09 0.23 17.05 38.14 18.73 20.32 Inorganic composition (%) as oxide from XI K_2O CaOMgO Al_2O_3 SiO_2 P_2O_5 SO_3 36.23 7.14 14.02 2.62 9.23 11.71 15.44 1.71 53.09 35.69 n. d. 1.96 2.52 4.21 14.00 27.92 22.52 4.42 10.38 9.26 7.29 30.51 27.94 9.06 2.24 3.87 11.59 11.74 27.27 27.41 3.63 3.40 21.49 8.06 1.95 1.80 0.88 n. d.n. d. 96.36 n. d. 0.55	Ash (wt.%), dry basisBiochemical composition (wt.%), dry basis $dry basisCelluloseHemicelluloseLignina5.4740.3623.0528.4721.1943.1918.8312.8923.8331.8114.4145.1543.1436.5615.6731.25110.3642.7322.090.23217.0538.1418.7320.325Inorganic composition (%) as oxide from XRFK2OCaOMgOAl2O3SiO2P2O5SO3Cl2O36.237.1414.022.629.2311.7115.44n. d.1.7153.0935.69n. d.1.962.524.21114.0027.9222.524.4210.389.267.291.8730.5127.949.062.243.8711.5911.742.3727.2727.413.633.4021.498.061.955.361.800.88n. d.n. d.96.36n. d.0.55n. d.$	

 Table S1. Biomass compositions analysis

a- by difference, Lignin (wt.%) = 100– Ash- Cellulose- Hemicellulose- Extractives (wt.%).

n. d.: not detected.

Potassium additive	Abbraviation	Content of potassium	Added amount ^a	
	Abbieviation	mol/g	g	
Potassium Hydroxide (85%)	KOH	0.01515	0.34	
Potassium Carbonate	K2CO3	0.01447	0.35	
Potassium Acetate (92%)	KAc	0.00937	0.54	
Potassium Citrate Monohydrate	KCi	0.00925	0.55	
Potassium Oxalate Monohydrate	KOx	0.01086	0.47	

Table S2. Selected potassium additives and their added amounts

a- the added amount was determined by 5 mmol potassium content in a chemical.

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Sample ^a	Yield	SSA	V _t	V _{mic} ^b	V_{mic}/V_t	V _{mes}
	wt.%	m ² g ⁻¹	cm ³ g ⁻¹	cm ³ g ⁻¹	%	cm ³ g ⁻¹
C _{CP+KOH}	1.8	1762	0.90	0.62	69	0.28
C _{CP+K2CO3}	12.4	1720	0.76	0.64	84	0.12
C _{CP+KAc}	20.0	1521	0.71	0.56	79	0.15
C _{CP+KCi}	16.4	1462	0.64	0.48	75	0.16
C _{CP+KOx}	14.2	1440	0.76	0.64	84	0.12

Table S3. Yields and textural properties of porous biochars from compith with larger dosage of additives

a- Biochar samples were prepared from cornpith pyrolysis with 10 mmol potassium additive.

b- $V_{mic}, V_{mic}/V_t$ and V_{mes} were calculated by t-plot method.

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Sample	Yield	SSA	V _t	V _{mic} ^b	V_{mic} / V_t	V _{mes}
	wt.%	m ² g ⁻¹	cm ³ g ⁻¹	cm ³ g ⁻¹	%	cm ³ g ⁻¹
C_{SD}^{a}	21.6	1997	1.11	0.62	56	0.49
C_{PS}	28.1	1954	0.99	0.63	64	0.36
C _{CS}	17.7	1822	0.97	0.56	58	0.41
C _{CP}	15.7	1975	1.06	0.59	56	0.47
C_{RH}	23.0	1916	1.15	0.61	51	0.54

Table S4. Yields and textural properties of porous biochars from different biomass

 raw materials via KAc-assisted pyrolysis

a- for C_X , X indicates the precursor, C_X s were prepared from pyrolysis of various biomass raw materials with 10 mmol KAc under 800 °C at heating rate of 15 °C min⁻¹;

b- V_{mic} , V_{mic} / V_t and V_{mes} were calculated by t-plot method.