

## *Supporting Information*

### **A family of microporous carbons prepared via a simple metal salt carbonization route with high selectivity for exceptional gravimetric and volumetric post-combustion CO<sub>2</sub> uptake**

Eric Masika, Beatrice Adeniran and Robert Mokaya\*

University of Nottingham, University Park, Nottingham NG7 2RD, U. K.

*E-mail: r.mokaya@nottingham.ac.uk (R. Mokaya)*

**Supporting Table S1.** Textural properties and CO<sub>2</sub> uptake of metal salt (potassium hydrogen phthalate, KHP) derived carbon materials via carbonisation at 900 °C for 1 to 4 h.

Sample	Surface area <sup>a</sup> (m <sup>2</sup> /g)	Pore volume <sup>b</sup> (cm <sup>3</sup> /g)	Pore size <sup>c</sup> (Å)	CO <sub>2</sub> uptake <sup>d</sup> (mmol/g)		
				0.15 bar	1 bar	20 bar
CKHP900-1	1601 (1417)	0.77 (0.63)	5/6/8/12/20	1.0	3.7	13.0
CKHP900-2	2104 (1805))	1.11 (0.81)	8.5/12/16/22	0.8	3.0	12.7
CKHP900-3	1600 (1360)	0.81 (0.61)	6.5/8.5/12/21	1.1	3.8	13.7
CKHP900-4	1561 (1452)	0.81 (0.69)	6.8/8.5/12	0.9	3.5	12.6

The values in the parenthesis refer to: <sup>a</sup>micropore surface area and <sup>b</sup>micropore volume. <sup>c</sup>pore size distribution maxima obtained from NLDFIT analysis. <sup>d</sup>CO<sub>2</sub> uptake at 25 °C and various pressures (i.e., 0.15 bar, 1 bar and 20 bar).

**Supporting Table S2.** Textural properties and CO<sub>2</sub> uptake of metal salt (potassium hydrogen phthalate, KHP) derived carbon materials via carbonisation at 700 °C for 1 to 4 h.

Sample	Surface area <sup>a</sup> (m <sup>2</sup> /g)	Pore volume <sup>b</sup> (cm <sup>3</sup> /g)	Pore size <sup>c</sup> (Å)	CO <sub>2</sub> uptake <sup>d</sup> (mmol/g)		
				0.15 bar	1 bar	20 bar
CKHP700-1	932 (900)	0.44 (0.39)	7/8.5	1.6	4.2	7.9
CKHP700-2	795 (760))	0.44 (0.34))	6	1.7	4.1	6.9
CKHP700-3	1019 (991)	0.47 (0.43)	7/8.5	1.5	4.2	8.8
CKHP700-4	1014 (983)	0.47 (0.43)	6/8.5	1.5	4.4	8.9

The values in the parenthesis refer to: <sup>a</sup>micropore surface area and <sup>b</sup>micropore volume. <sup>c</sup>pore size distribution maxima obtained from NLDFT analysis. <sup>d</sup>CO<sub>2</sub> uptake at 25 °C and various pressures (i.e., 0.15 bar, 1 bar and 20 bar).

**Supporting Table S3.** CO<sub>2</sub> uptake of various porous carbons at 25 °C and 0.15 bar or 1 bar.

	CO <sub>2</sub> uptake (mmol/g)		Reference
	1 bar	0.15 bar	
Sawdust-derived activated carbon	4.8	1.2	1
KOH-activated templated carbons	3.4	~1.0	2
Hierarchical porous carbon (HPC)	3.0	~0.9	3
Petroleum pitch-derived activated carbon	4.55	~1.0	4
Activated carbon spheres	4.55	~1.1	5
Phenolic resin activated carbon spheres	4.5	~1.2	6
Poly(benzoxazine-co-resol)-derived carbon	3.3	1.0	7
Fungi-derived activated carbon	3.5	~1.0	8
Chitosan-derived activated carbon	3.86	~1.1	9
Polypyrrole derived activated carbon	3.9	~1.0	10
Soya bean derived N-doped activated carbon	4.24	1.2	11
N-doped ZTCs	4.4	~1.0	12
Activated templated N-doped carbon	4.5	1.4	13
Polyaniline derived activated carbon	4.3	1.38	14
N-doped activated carbon monoliths	5.14	1.25	15
Activated N-doped carbon	3.2	1.5	16
Activated hierarchical N-doped carbon	4.8	1.4	17
Activated N-doped carbon from algae	4.5	~1.1	18

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**Supporting Table S4.** CO<sub>2</sub> uptake at 0 °C of metal salt (potassium hydrogen phthalate, KHP) derived carbon materials via carbonisation at 800 °C for 1 to 4 h.

Sample	CO <sub>2</sub> uptake at 0 °C (mmol/g)			
	1 bar	5 bar	10 bar	20 bar
CKHP800-1	6.4	10.4	11.6	12.1
CKHP800-2	6.5	11.0	12.5	13.3
CKHP800-3	5.5	10.7	12.9	13.9
CKHP800-4	6.5	10.6	11.7	12.3

**Supporting Table S5.** CO<sub>2</sub> uptake at 0 °C of metal salt (potassium hydrogen phthalate, KHP) derived carbon materials via carbonisation at 900 °C for 1 to 4 h.

Sample	CO <sub>2</sub> uptake at 0 °C (mmol/g)			
	1 bar	5 bar	10 bar	20 bar
CKHP900-1	5.3	10.8	13.3	15.3
CKHP900-2	4.8	10.3	13.2	15.7
CKHP900-3	5.1	11.2	13.2	15.5
CKHP900-4	5.3	10.5	13.0	14.8

**Supporting Table S6.** CO<sub>2</sub> uptake at 0 °C of metal salt (potassium hydrogen phthalate, KHP) derived carbon materials via carbonisation at 700 °C for 1 to 4 h.

Sample	CO <sub>2</sub> uptake at 0 °C (mmol/g)			
	1 bar	5 bar	10 bar	20 bar
CKHP700-1	5.7	7.9	8.5	8.8
CKHP700-2	5.1	6.6	7.1	7.4
CKHP700-3	6.2	8.8	9.5	9.8
CKHP700-4	6.3	8.8	9.5	9.9

**Supporting Table S7.** Textural properties of unwashed CKHP carbon products

Sample	Surface area <sup>a</sup> (m <sup>2</sup> /g)	Pore volume <sup>b</sup> (cm <sup>3</sup> /g)	Pore size <sup>c</sup> (Å)
CKHP700-2-UW	2 (1)		
CKHP800-2-UW	69 (68))	0.20 (0.03)	
CKHP900-2-UW	597 (467)	0.39 (0.22)	6.4/8.5/11.5
CKHP1000-2-UW	461 (395)	0.26(0.19)	6.5/8.5/11.5

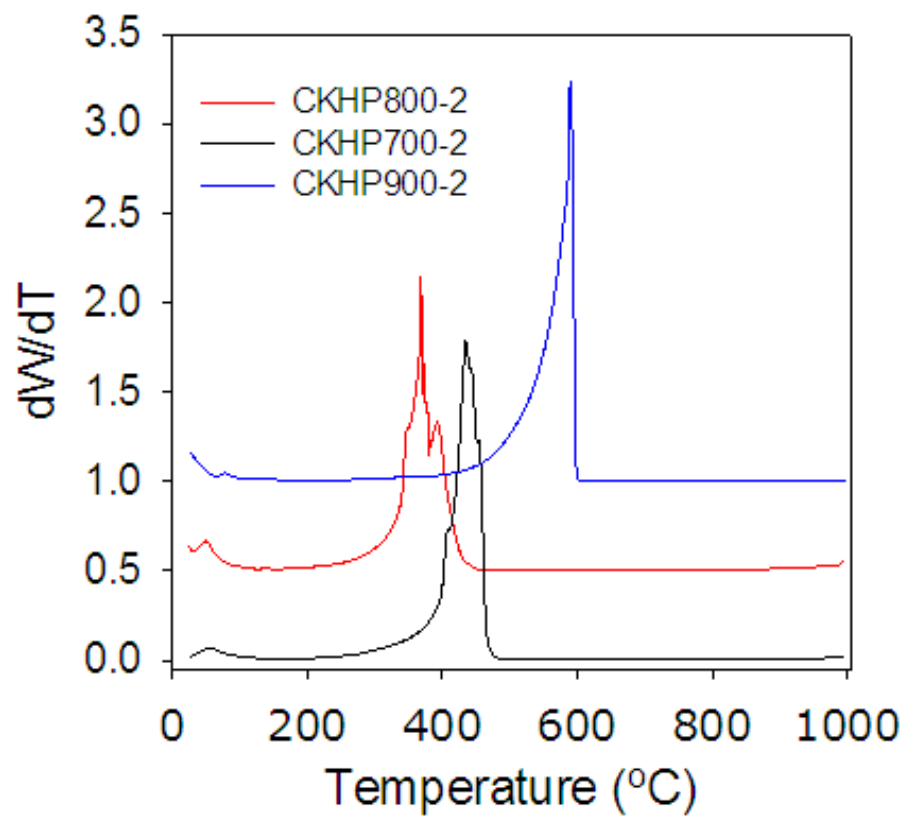
The values in the parenthesis refer to: <sup>a</sup>micropore surface area and <sup>b</sup>micropore volume. <sup>c</sup>pore size distribution maxima obtained from NLDFT analysis.



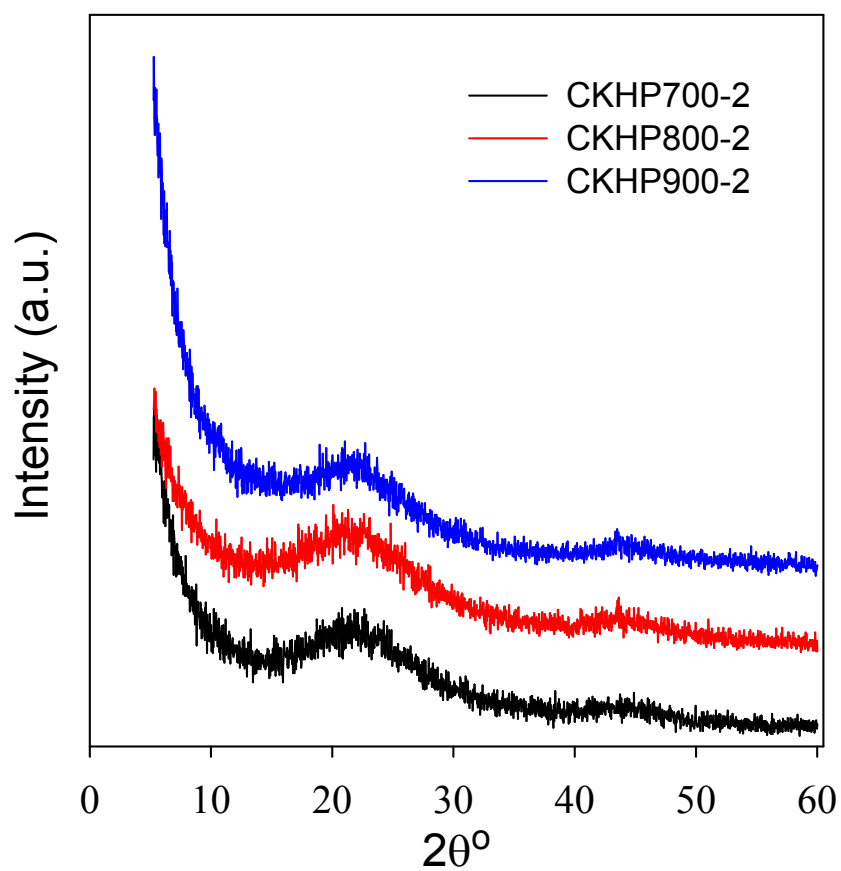
**Supporting Table S8.** Textural properties and CO<sub>2</sub> uptake of various CKHP carbons before and after compaction at a load of 5 tons (i.e. 370 MPa)

Sample	Surface area <sup>a</sup> (m <sup>2</sup> /g)	Pore volume <sup>b</sup> (cm <sup>3</sup> /g)	Pore size <sup>c</sup> (Å)	CO <sub>2</sub> uptake <sup>d</sup> (mmol/g)		
				0.15 bar	1 bar	20 bar
CKHP600-2	513 (494)	0.27 (0.24)	6.8	1.2	2.8	4.6
CKHP600-2-C5	516 (496)	0.28 (0.24)	5.8	1.4	3.3	4.9
CKHP700-1	932 (900)	0.44 (0.39)	7/8.5	1.6	4.2	7.9
CKHP700-1-C5	803 (775)	0.43 (0.37)	6/8	1.5	4.1	7.7
CKHP800-1	1255 (1200)	0.59 (0.52)	7/8.5/12	1.3	4.4	11.1
CKHP800-1-C5	1072 (1028)	0.56 (0.49)	6.5/8.5/12	1.3	4.2	10.8
CKHP900-1	1601 (1417)	0.77 (0.63)	5/6/8/12/20	1.0	3.7	13.0
CKHP900-1-C5	1508 (1403)	0.77 (0.66)	6/8/12	1.0	3.5	12.7
CKHP900-2-UW	597 (467)	0.39 (0.22)	6.4/8.5/11.5	1.2	2.9	8.6
CKHP900-2-UW-C5	789 (664)	0.48 (0.31)	6.4/8.5/11.5	1.4	3.0	7.4

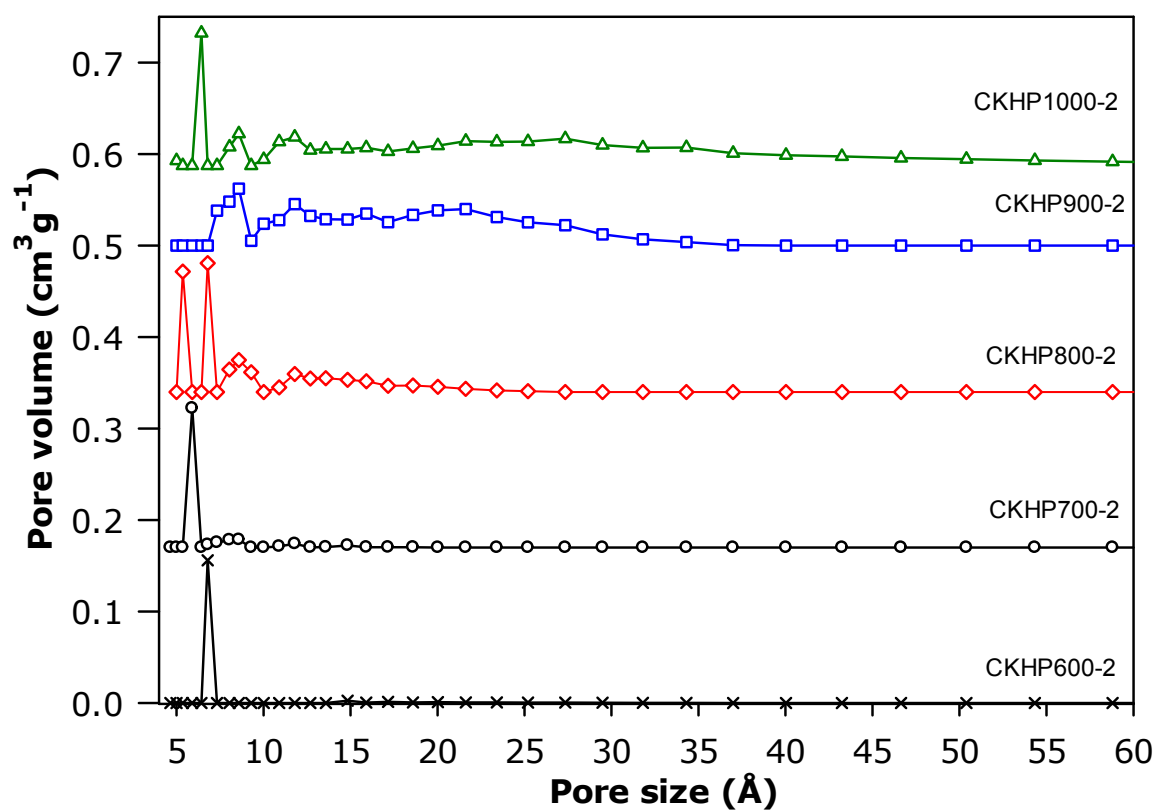
The values in the parenthesis refer to: <sup>a</sup>micropore surface area and <sup>b</sup>micropore volume. <sup>c</sup>pore size distribution maxima obtained from NLDFIT analysis. <sup>d</sup>CO<sub>2</sub> uptake at 25 °C and various pressures (i.e., 0.15 bar, 1 bar and 20 bar).



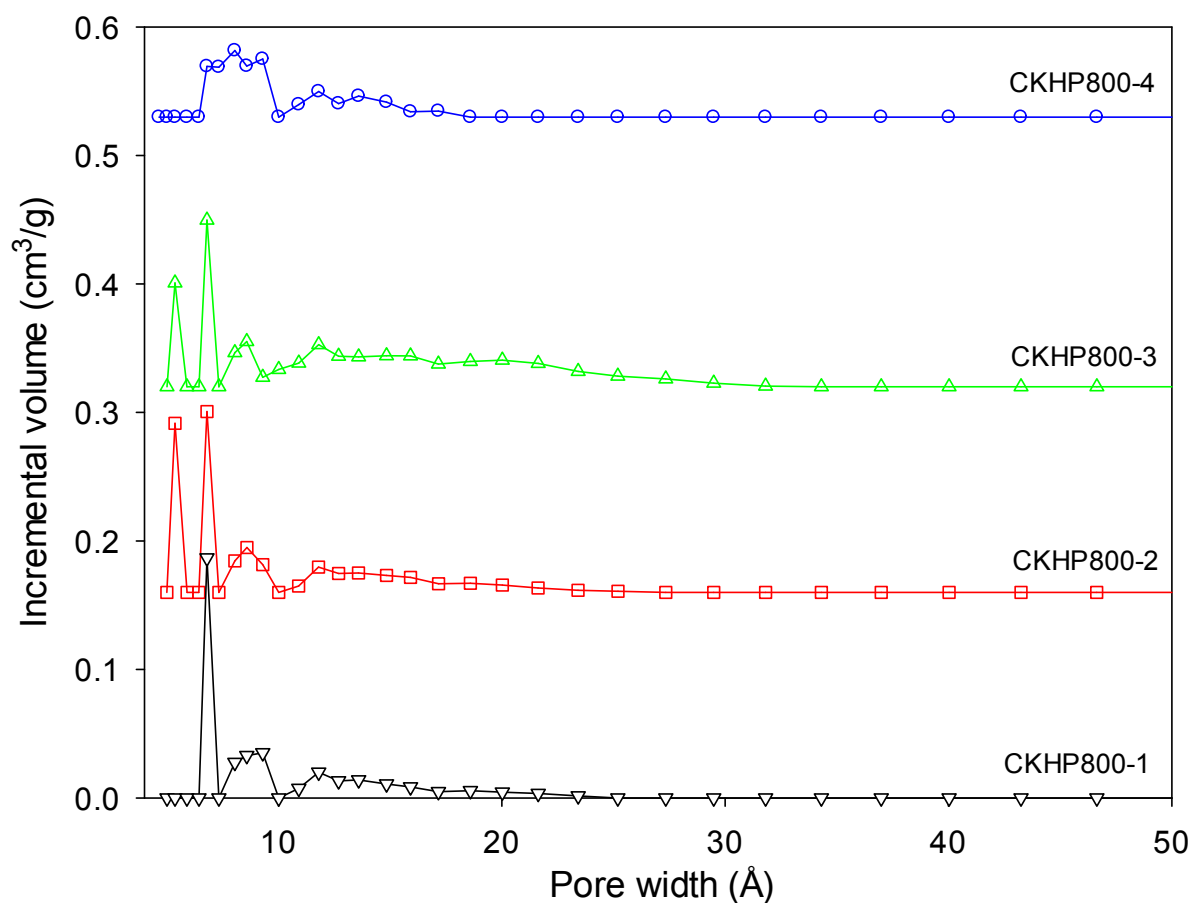
**Supporting Figure S1.** Differential thermogravimetric (DTG) profiles of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at various temperatures for 2 h.



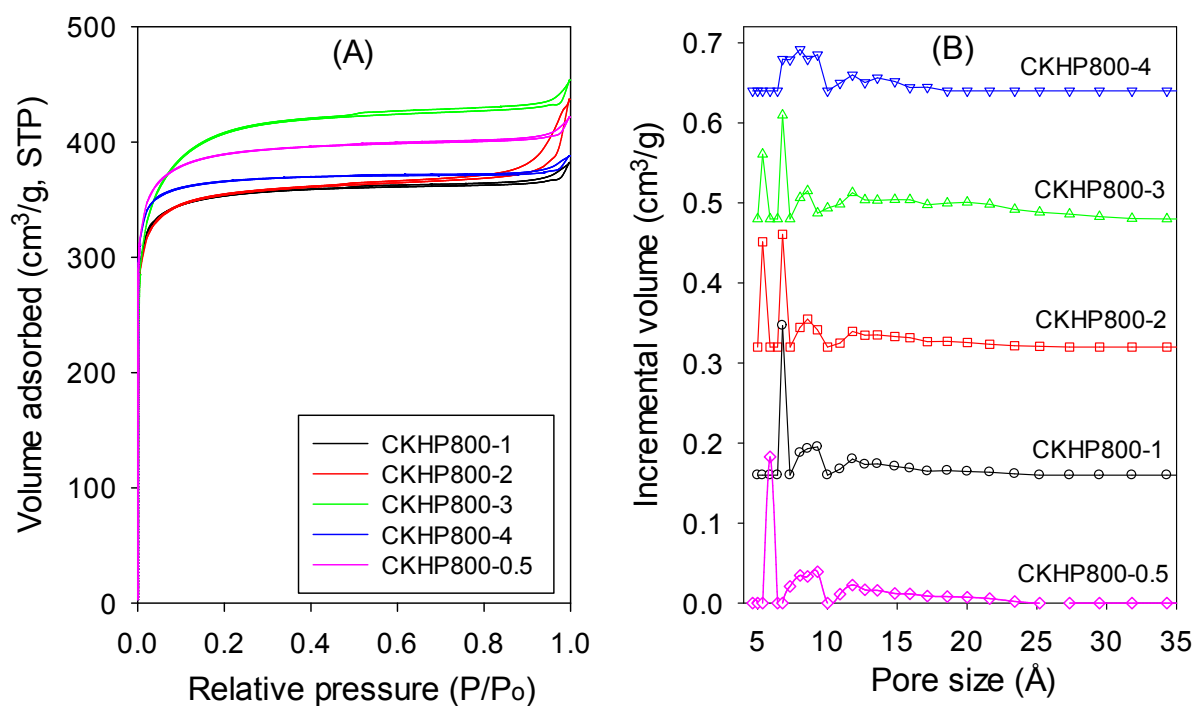
**Supporting Figure S2.** Powder XRD patterns of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at various temperatures for 2 h.



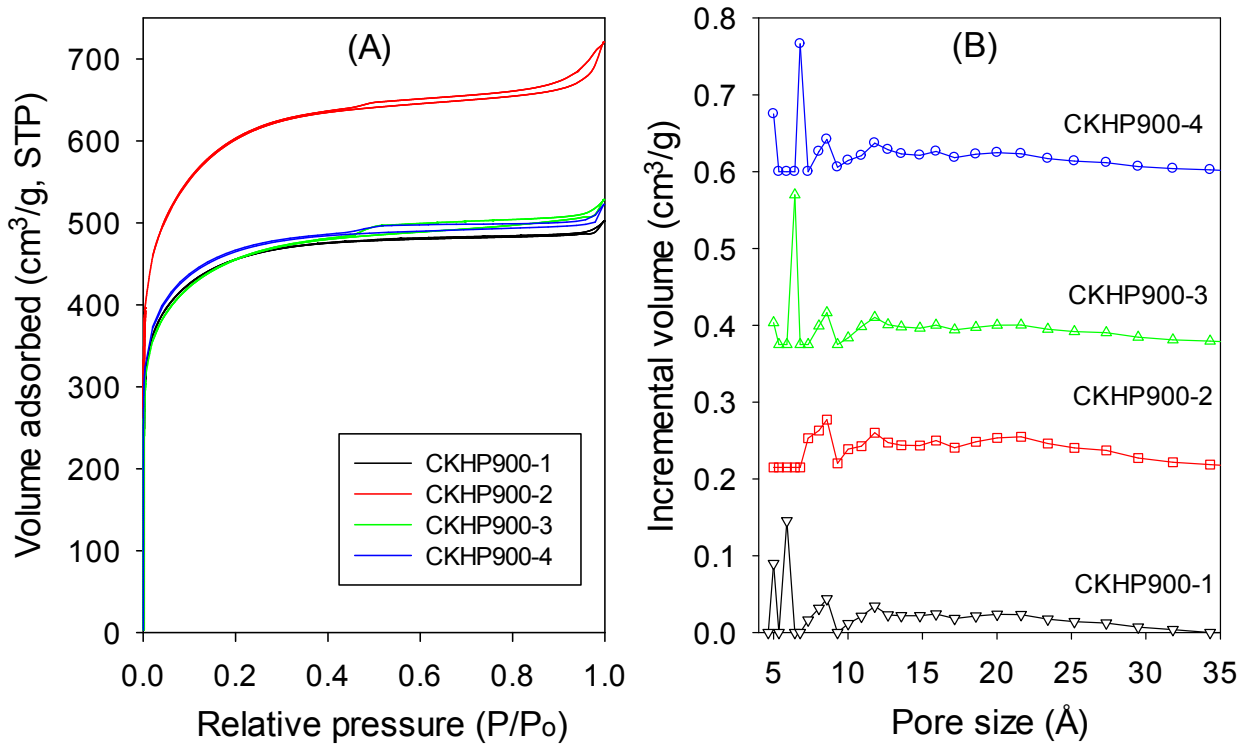
**Supporting Figure S3.** Pore size distribution curves of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at various temperatures for 2 h. Samples CKHP600-2, CKHP700-2 and CKHP800-2 have no pores larger than 15 Å. Largest pores for CKHP900-2 and CKHP1000-2 are up to 30 Å and 40 Å, respectively, although even for these samples, only a small proportion of pores are larger than 15 Å.



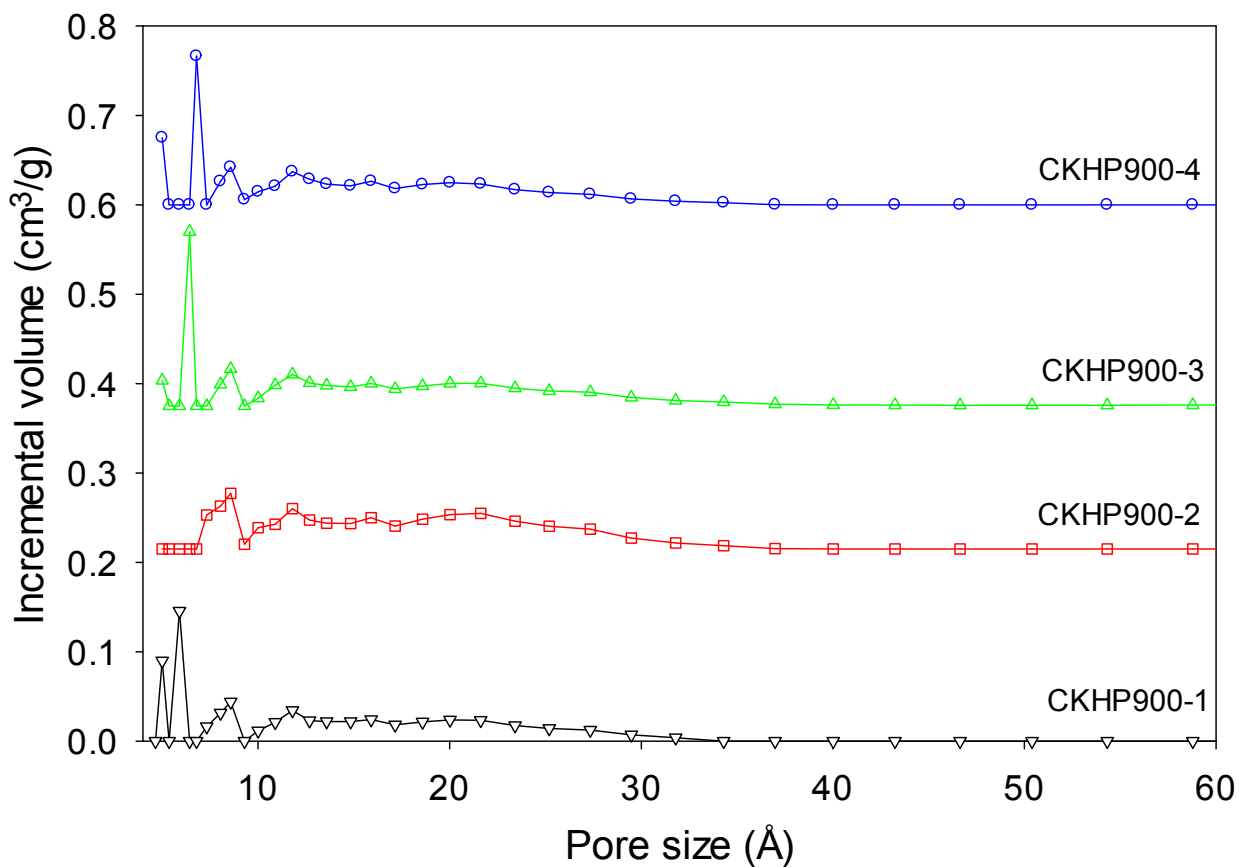
**Supporting Figure S4.** Pore size distribution curves of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 800 °C for between 1 and 4 h. Samples CKHP800-1, CKHP800-2 and CKHP800-4 have no pores larger than ca. 15 Å. For sample CKHP800-3 the largest pores are up to 30 Å, though only a small proportion of pores are larger than 15 Å.



**Supporting Figure S5.** Nitrogen sorption isotherms (A) and corresponding pore size distribution curves (B) of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 800 °C for various periods of time, from as low as 0.5 h to 4 h. The isotherm and pore size distribution of the sample carbonised for 0.5 h is largely similar to the other CKHP800-y samples. The pore size distribution of CKHP800-0.5 exhibits maxima at 6 and 8.5 Å, which is very similar to sample CKHP800-1.

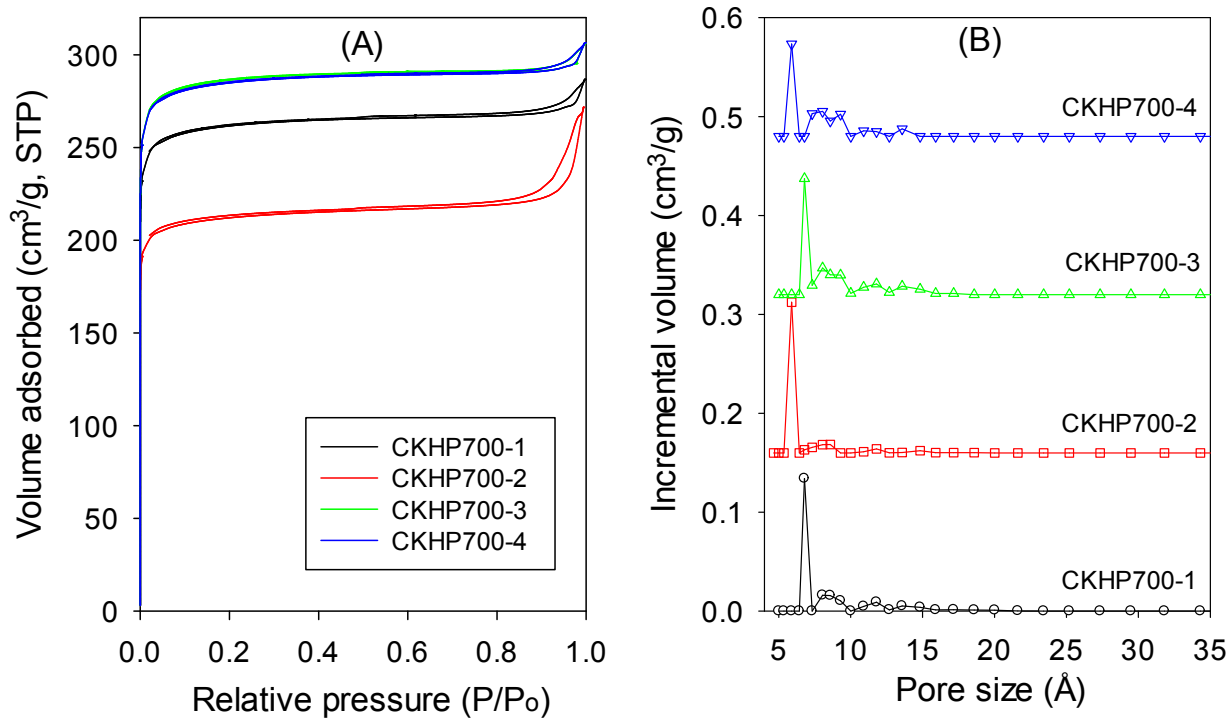


**Supporting Figure S6.** Nitrogen sorption isotherms (A) and corresponding pore size distribution curves (B) of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 900 °C for various periods of time.

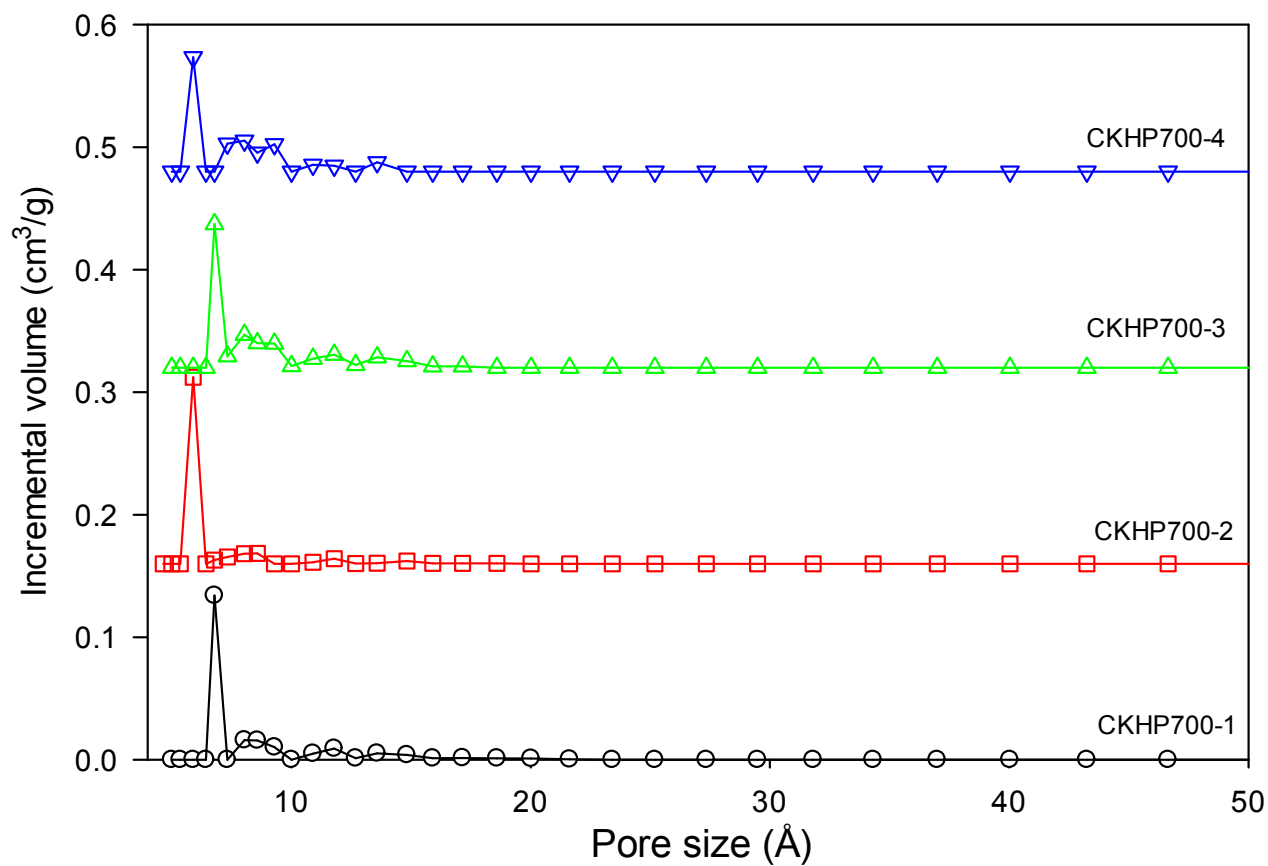


**Supporting Figure S7.** Pore size distribution curves of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 900 °C for between 1 and 4 h. The largest pores in all samples are up to 35 Å, and a significant proportion of pores are larger than 15 Å.

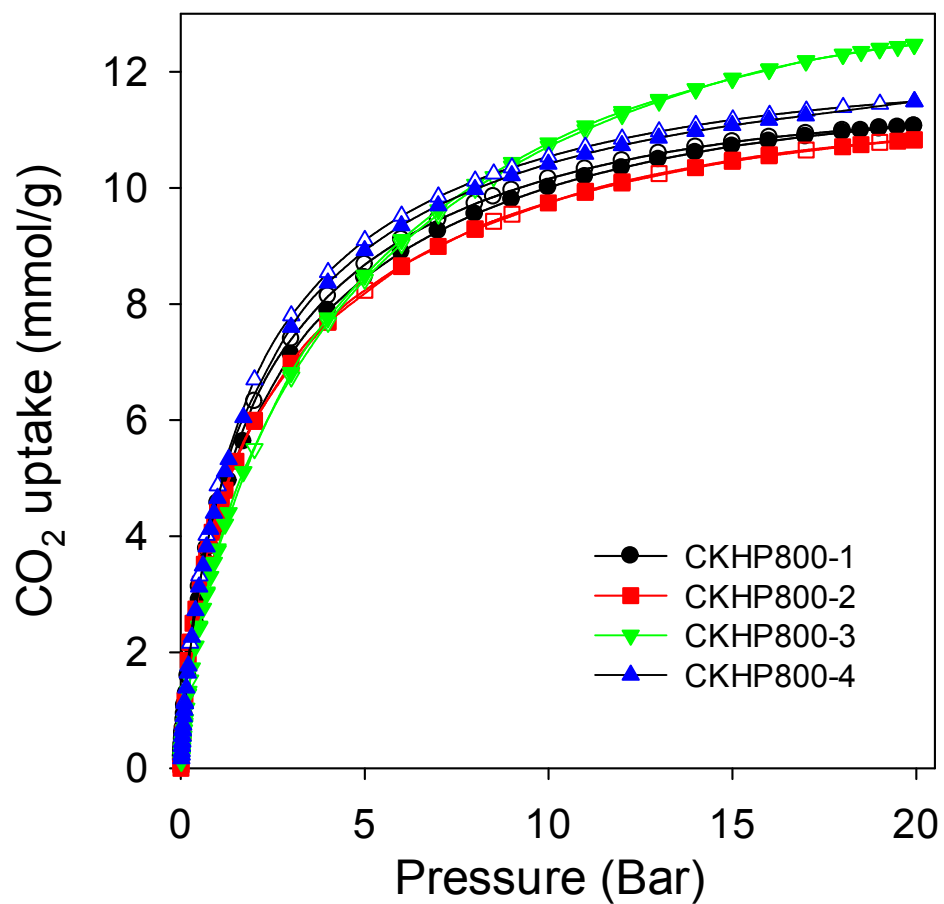




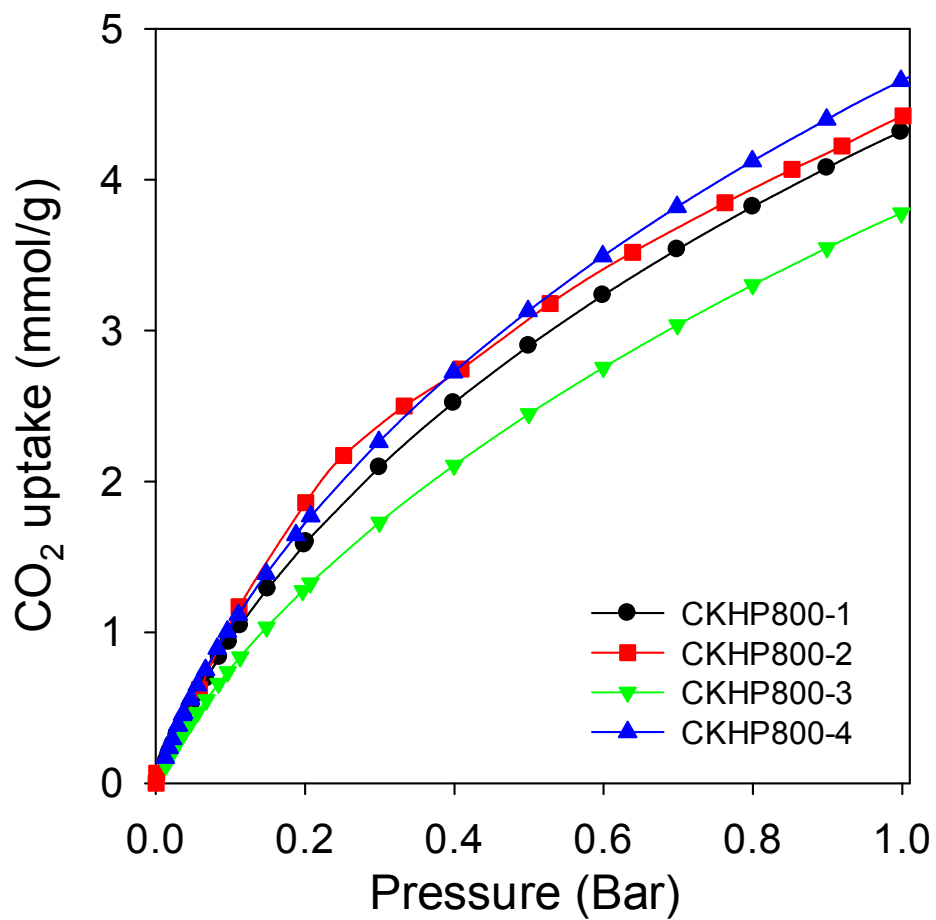
**Supporting Figure S8.** Nitrogen sorption isotherms (A) and corresponding pore size distribution curves (B) of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 700 °C for various periods of time.



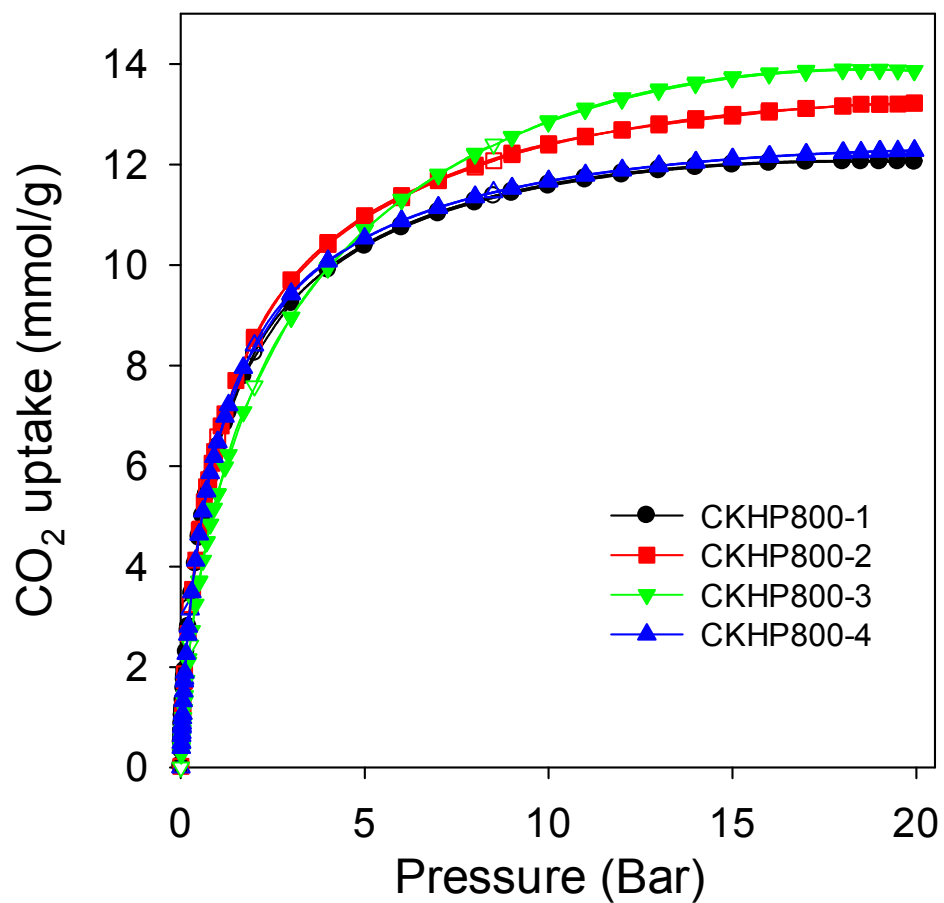
**Supporting Figure S9.** Pore size distribution curves of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 700 °C for between 1 and 4 h. The CKHP700-x samples have virtually no pores larger than 10 Å.



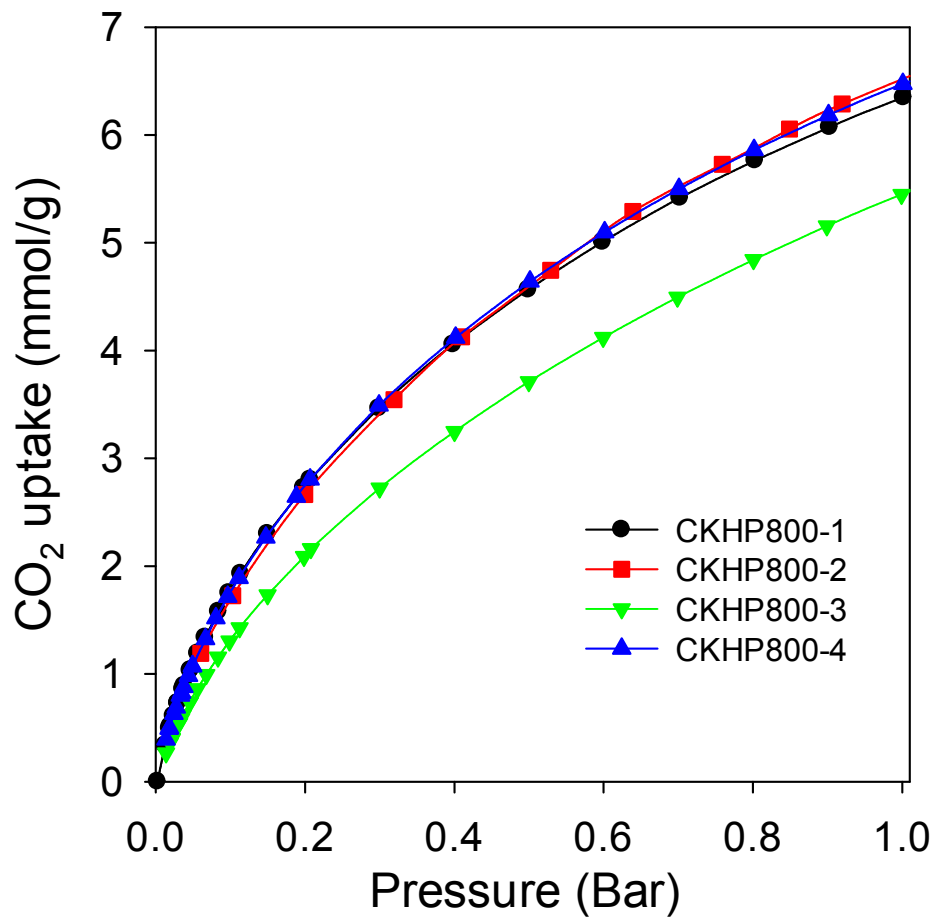
**Supporting Figure S10.** CO<sub>2</sub> uptake isotherms at 25 °C and 0 – 20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 800 °C for 1 to 4 h.



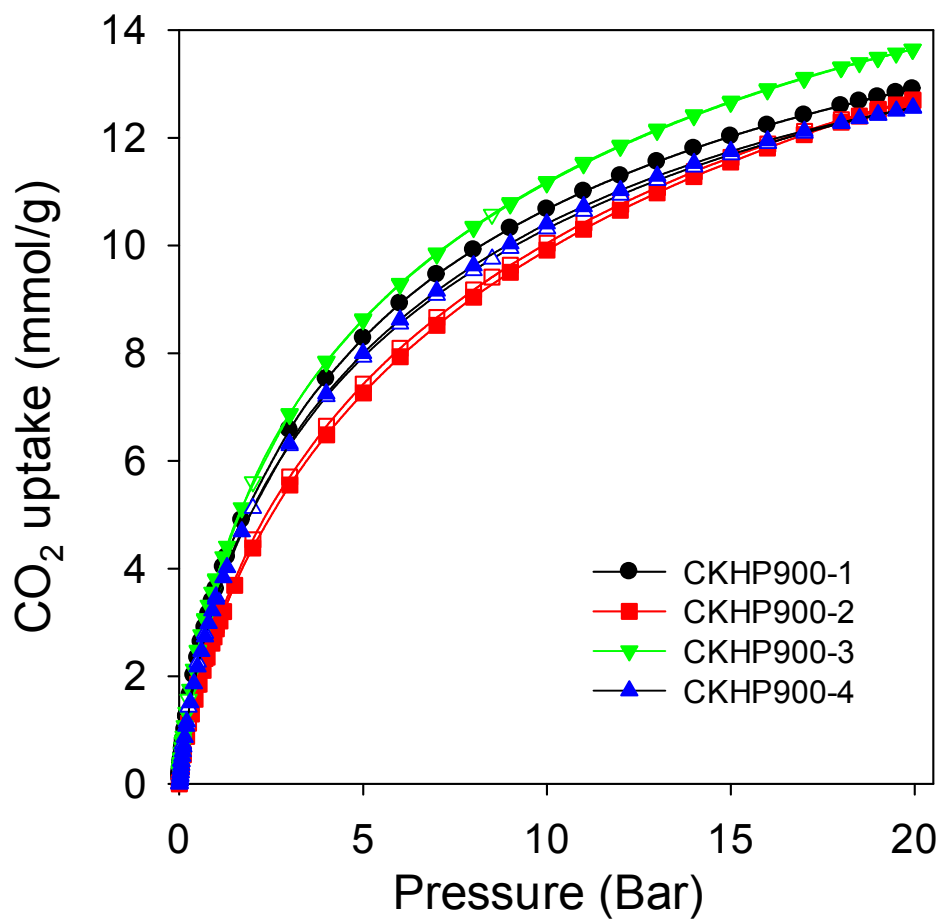
**Supporting Figure S11.** Low pressure CO<sub>2</sub> uptake isotherms at 25 °C for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 800 °C for 1 to 4 h.



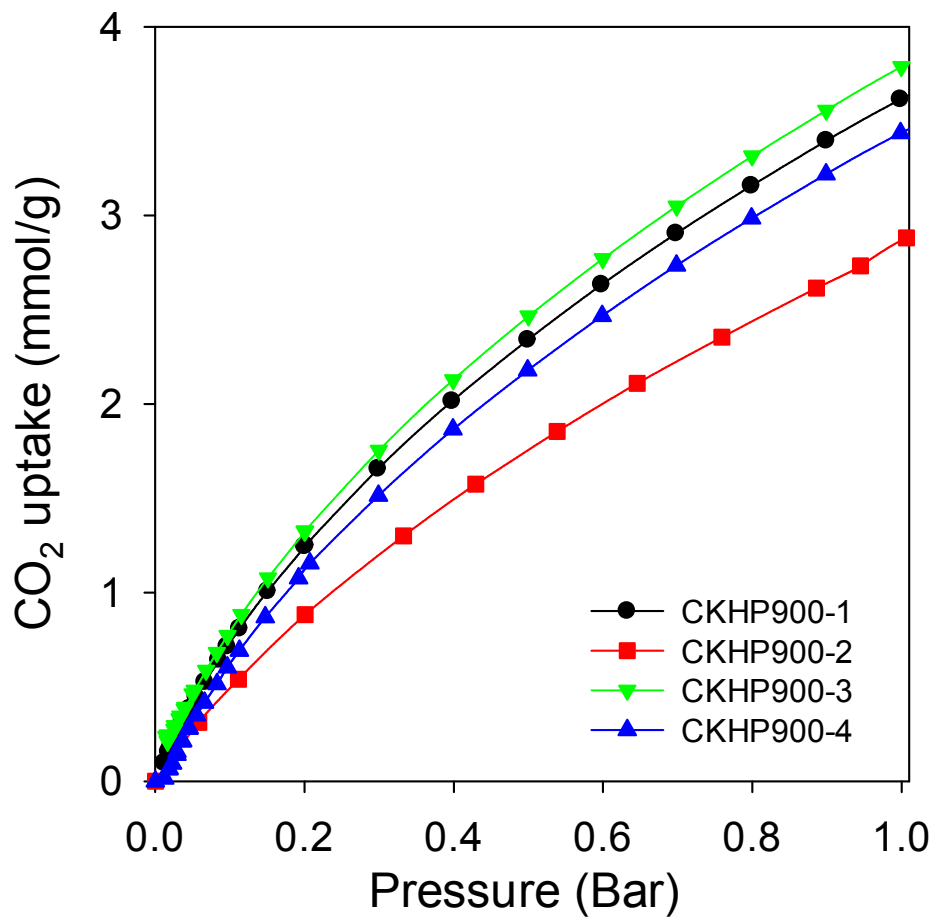
**Supporting Figure S12.** CO<sub>2</sub> uptake isotherms at 0 °C and 0 – 20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 800 °C for 1 to 4 h.



**Supporting Figure S13.** Low pressure CO<sub>2</sub> uptake isotherms at 0 °C for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 800 °C for 1 to 4 h.

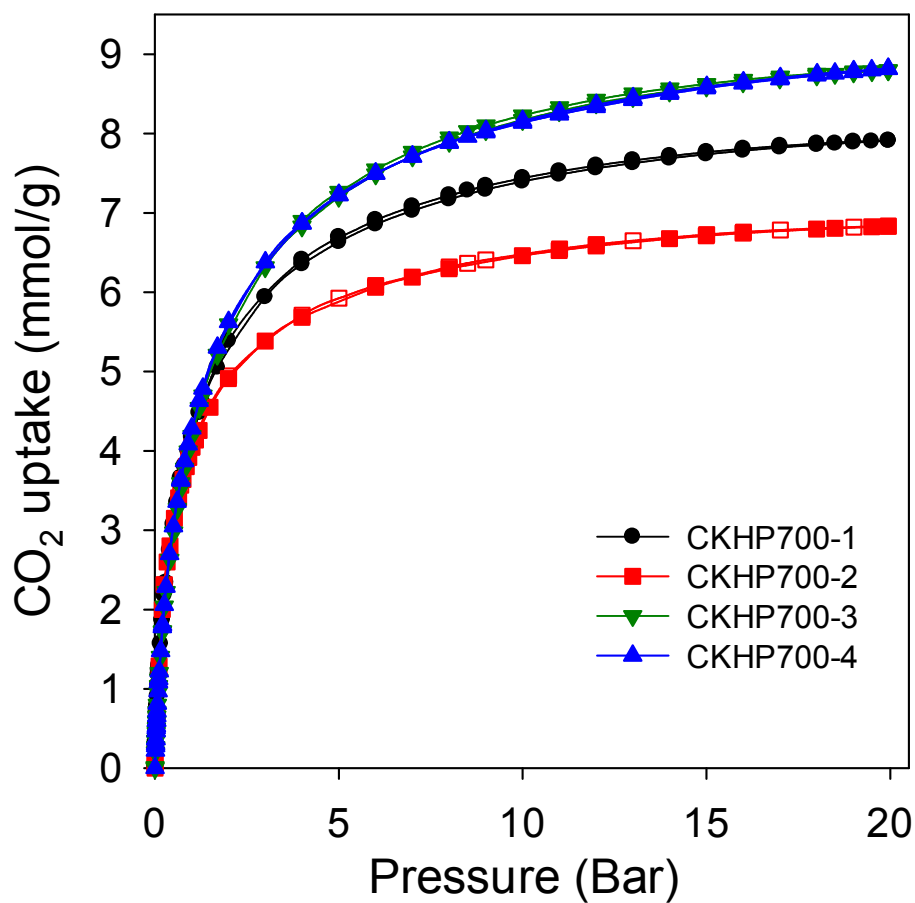


**Supporting Figure S14.** CO<sub>2</sub> uptake isotherms at 25 °C and 0-20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 900 °C for 1 to 4 h.

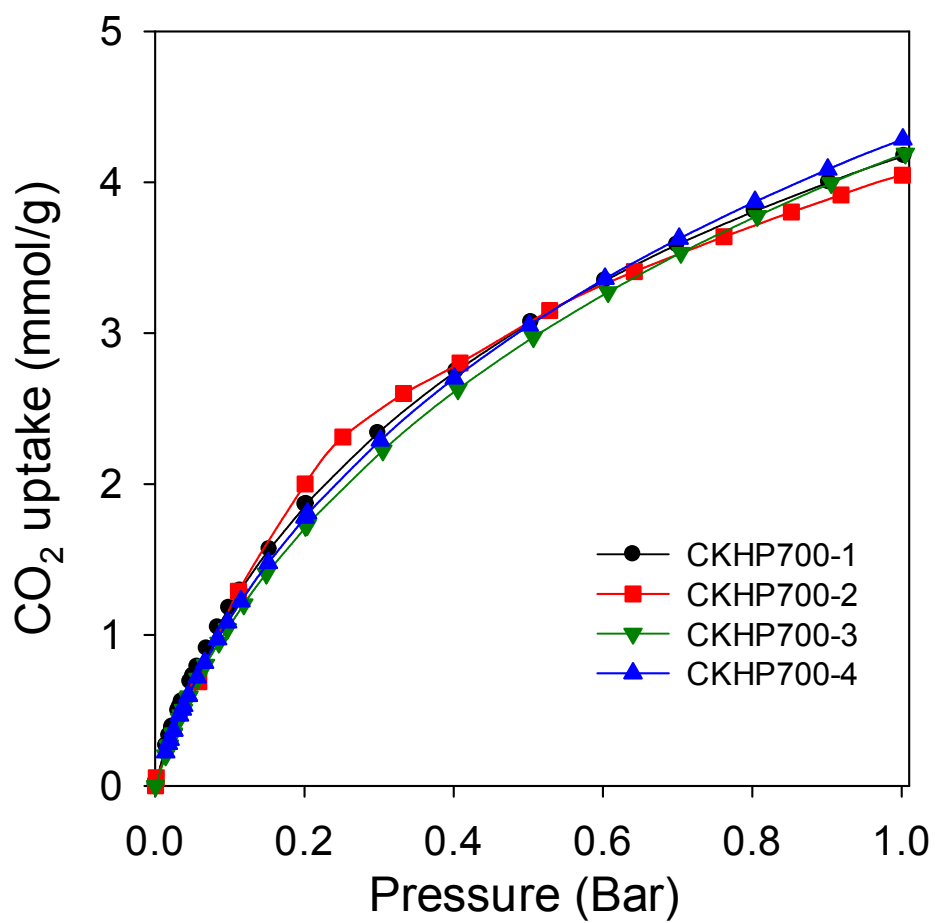


**Supporting Figure S15.** Low pressure CO<sub>2</sub> uptake isotherms at 25 °C for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 900 °C for 1 to 4 h.

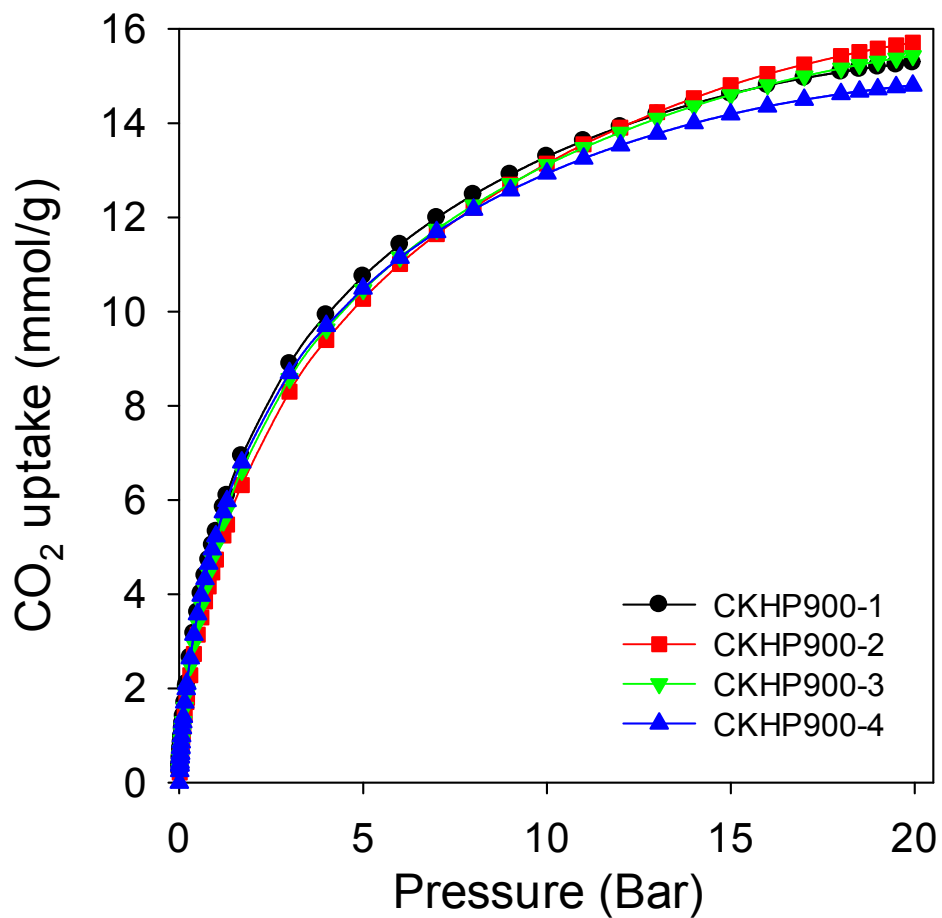




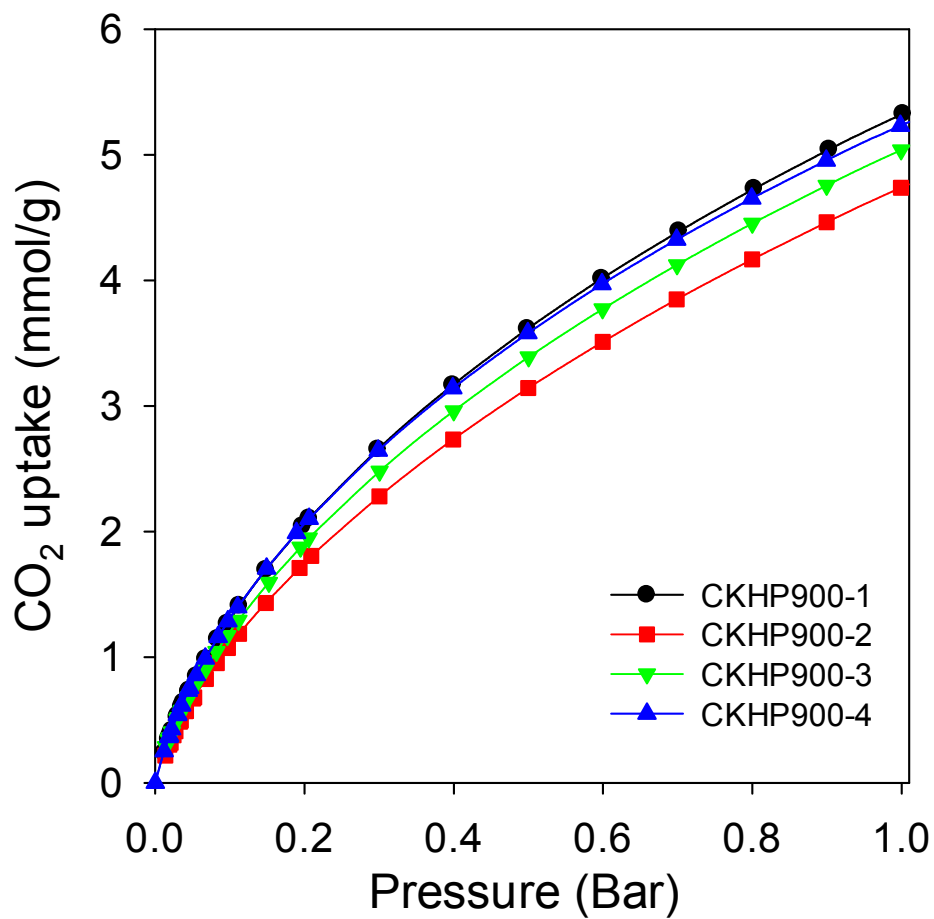
**Supporting Figure S16.** CO<sub>2</sub> uptake isotherms at 25 °C and 0 – 20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 700 °C for 1 to 4 h.



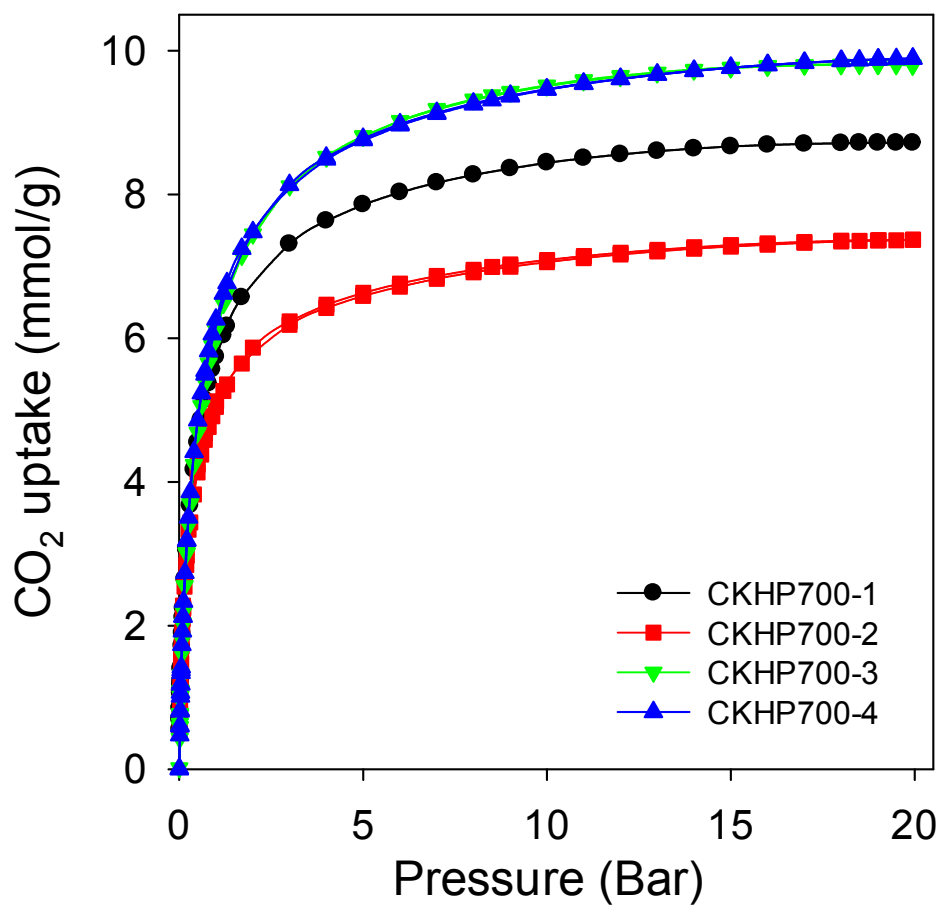
**Supporting Figure S17.** Low pressure CO<sub>2</sub> uptake isotherms at 25 °C for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 700 °C for 1 to 4 h.



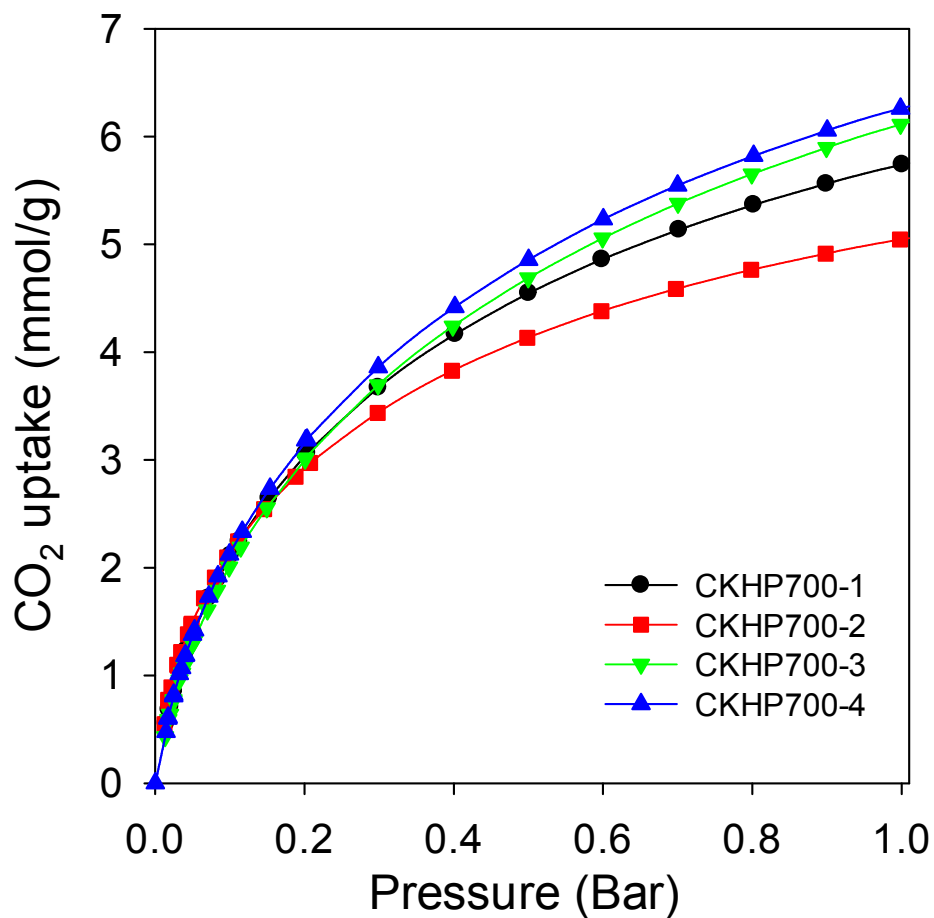
**Supporting Figure S18.** CO<sub>2</sub> uptake isotherms at 0 °C and 0 – 20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 900 °C for 1 to 4 h.



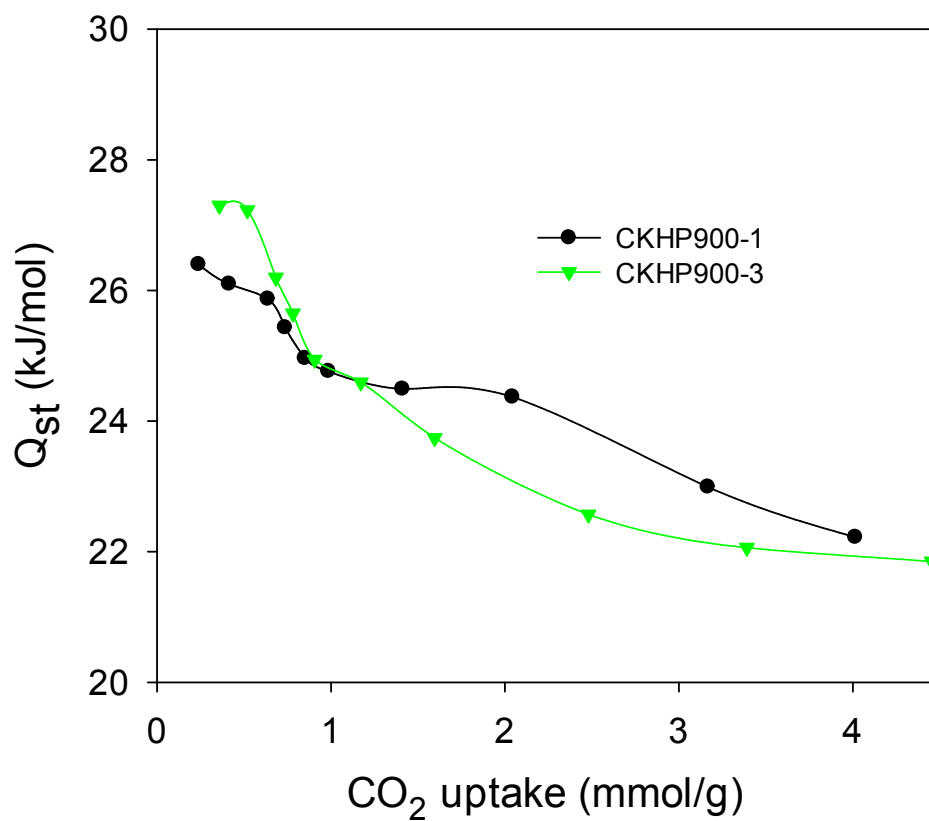
**Supporting Figure S19.** Low pressure CO<sub>2</sub> uptake isotherms at 0 °C and 0-20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 900 °C for 1 to 4 h.



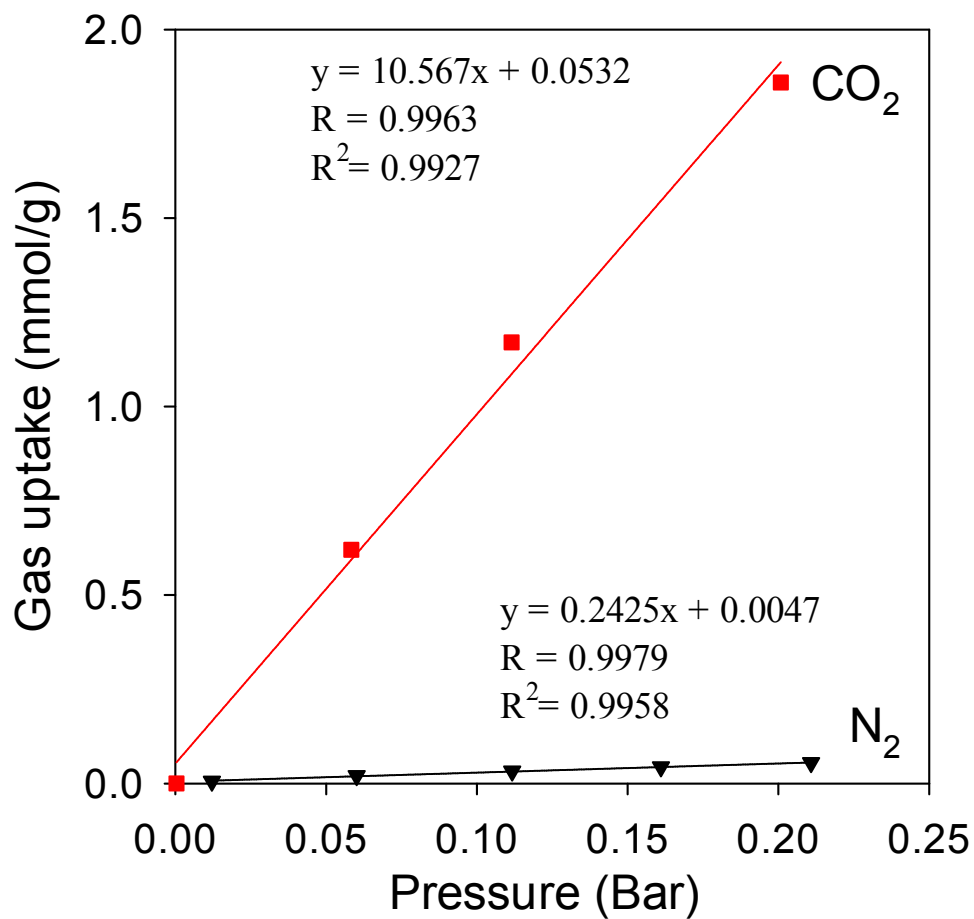
**Supporting Figure S20.** CO<sub>2</sub> uptake isotherms at 0 °C and 0 – 20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 700 °C for 1 to 4 h.



**Supporting Figure S21.** Low pressure CO<sub>2</sub> uptake isotherms at 0 °C and 0-20 bar for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 700 °C for 1 to 4 h.

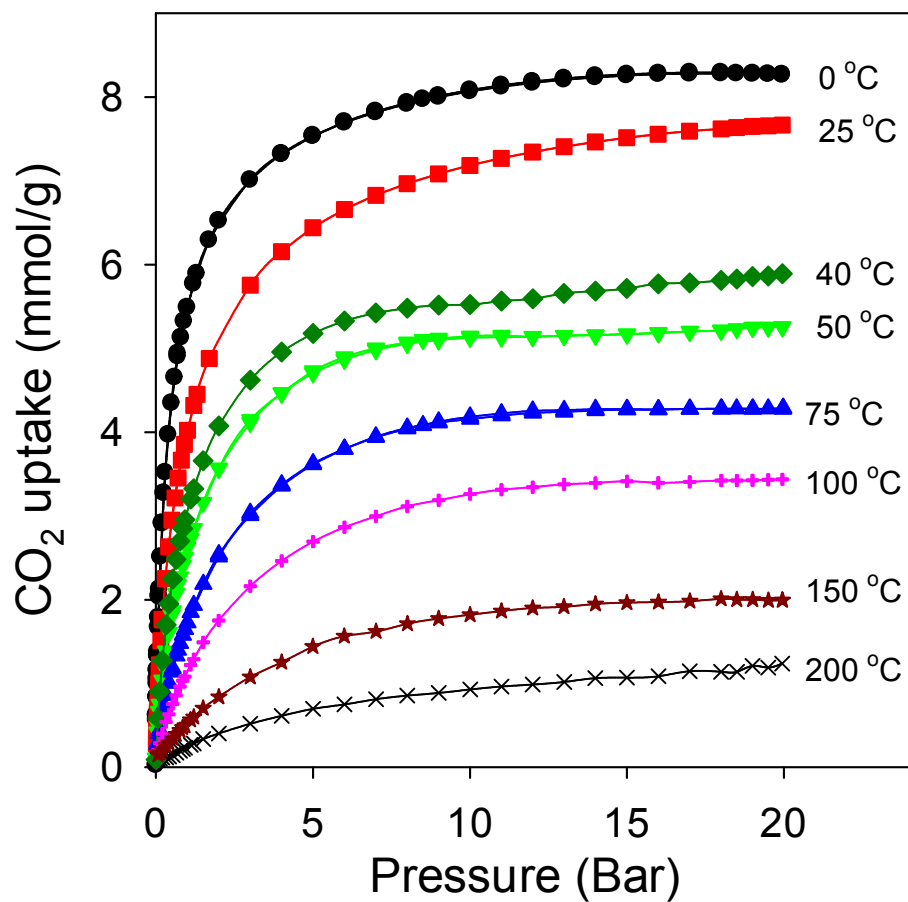


**Supporting Figure S22.** Isosteric heat of CO<sub>2</sub> adsorption ( $Q_{st}$ ) as a function of CO<sub>2</sub> uptake for CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at 900 °C for 1 or 3 h.

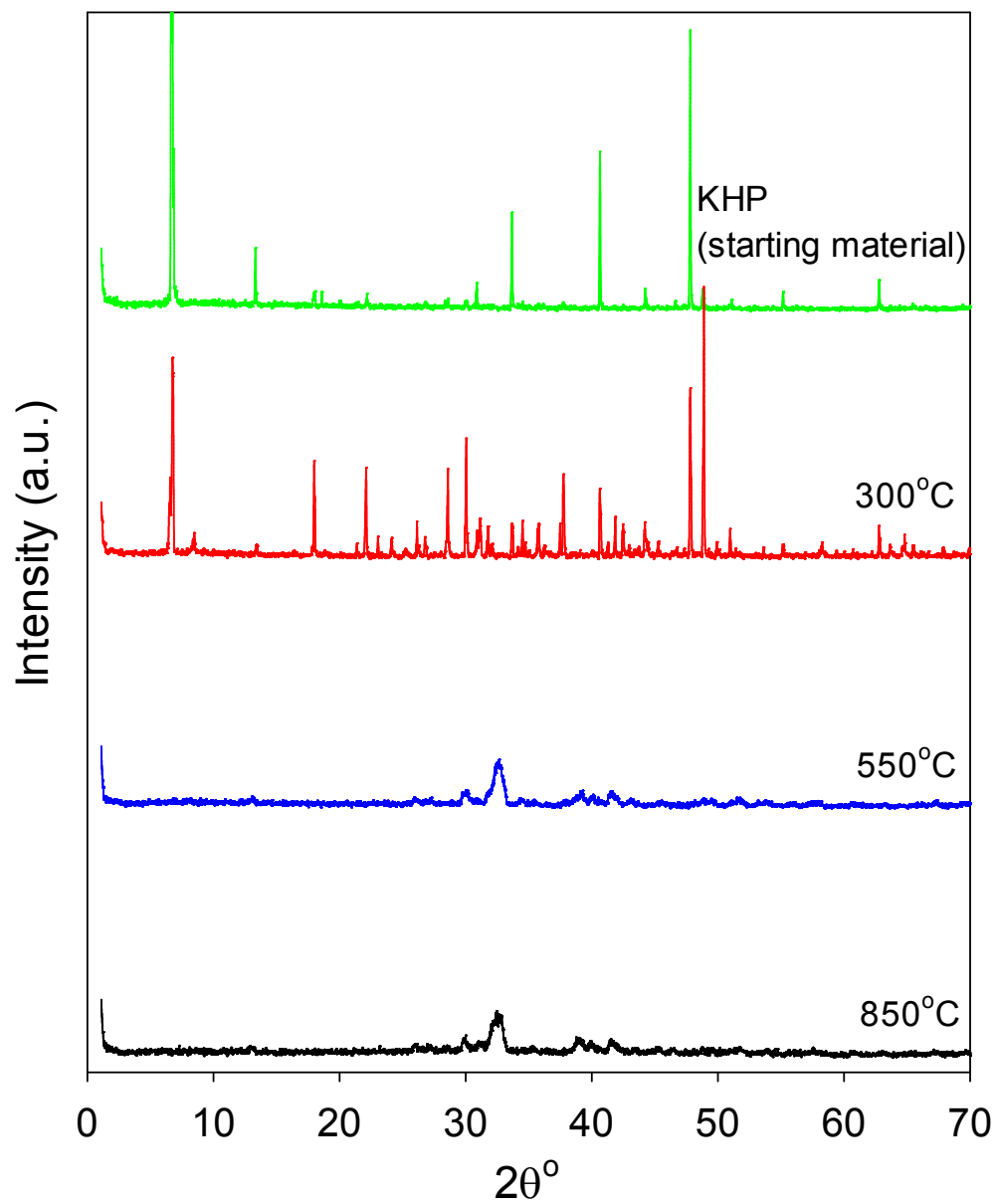


**Supporting Figure S23.** Comparison of initial rates of CO<sub>2</sub> and N<sub>2</sub> uptake at room temperature for sample CKHP800-2. The comparison gives a CO<sub>2</sub>/N<sub>2</sub> selectivity of 43.

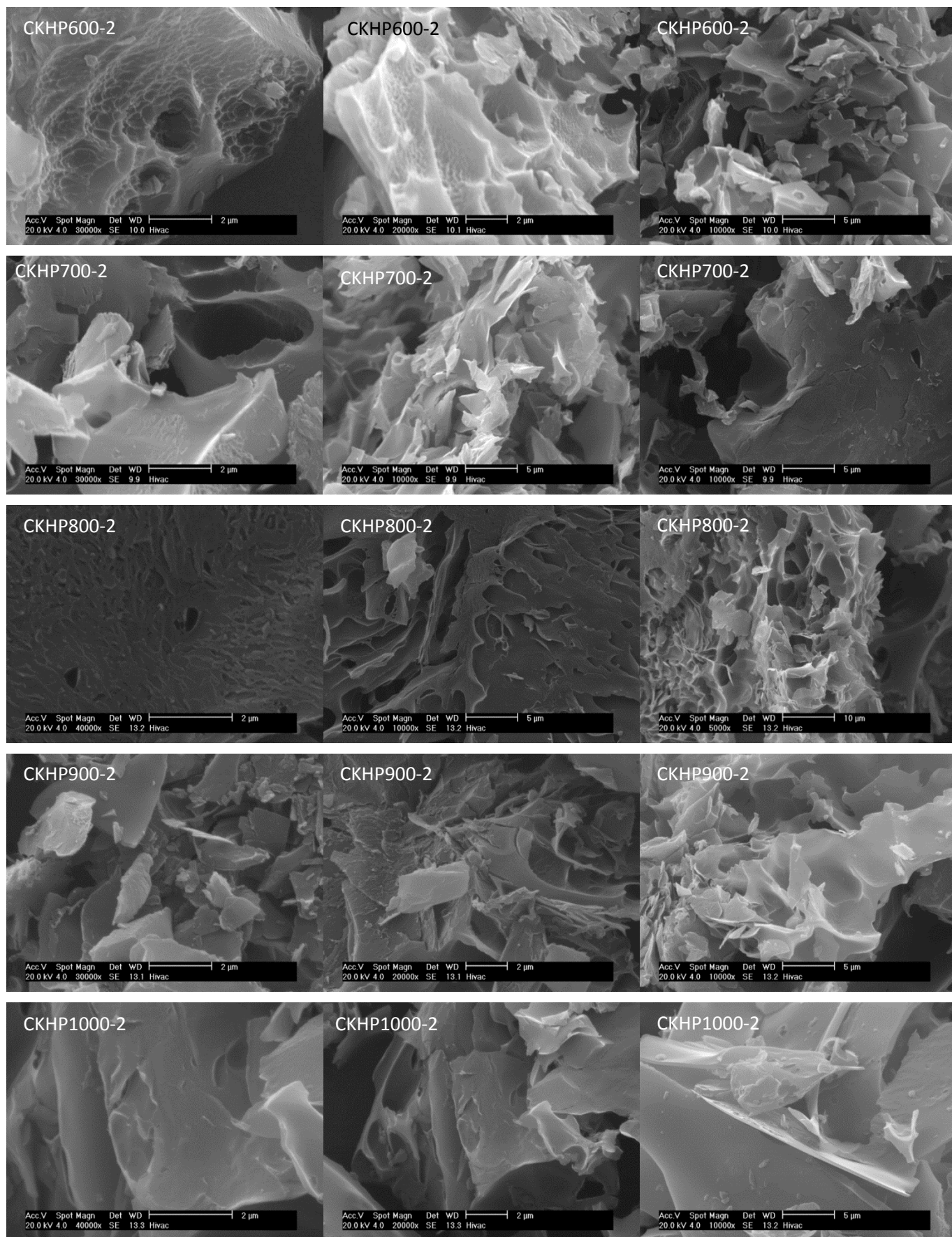




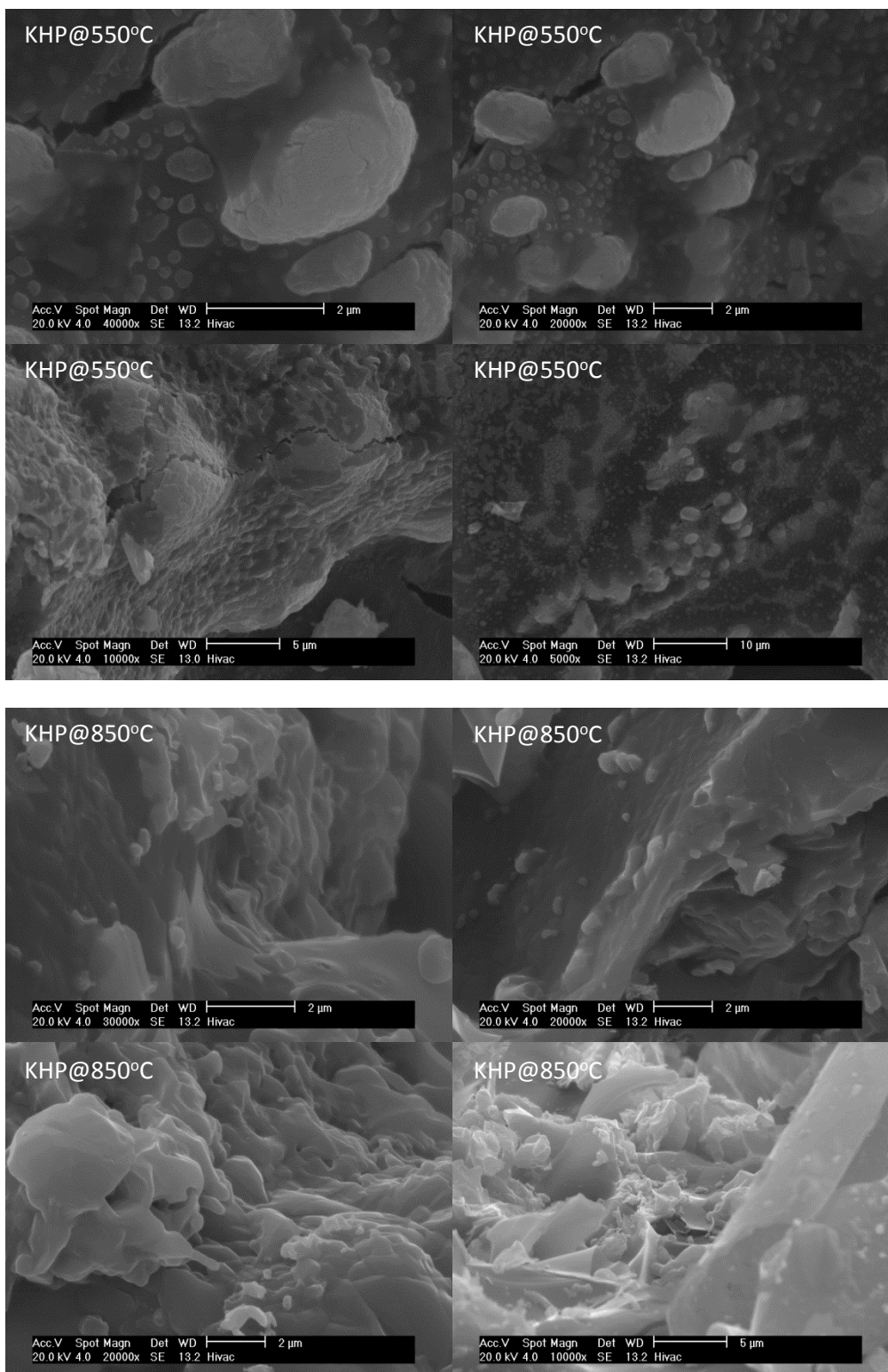
**Supporting Figure S24.** CO<sub>2</sub> uptake isotherms at various temperatures and 0 – 20 bar for sample CKHP700-1-C5.



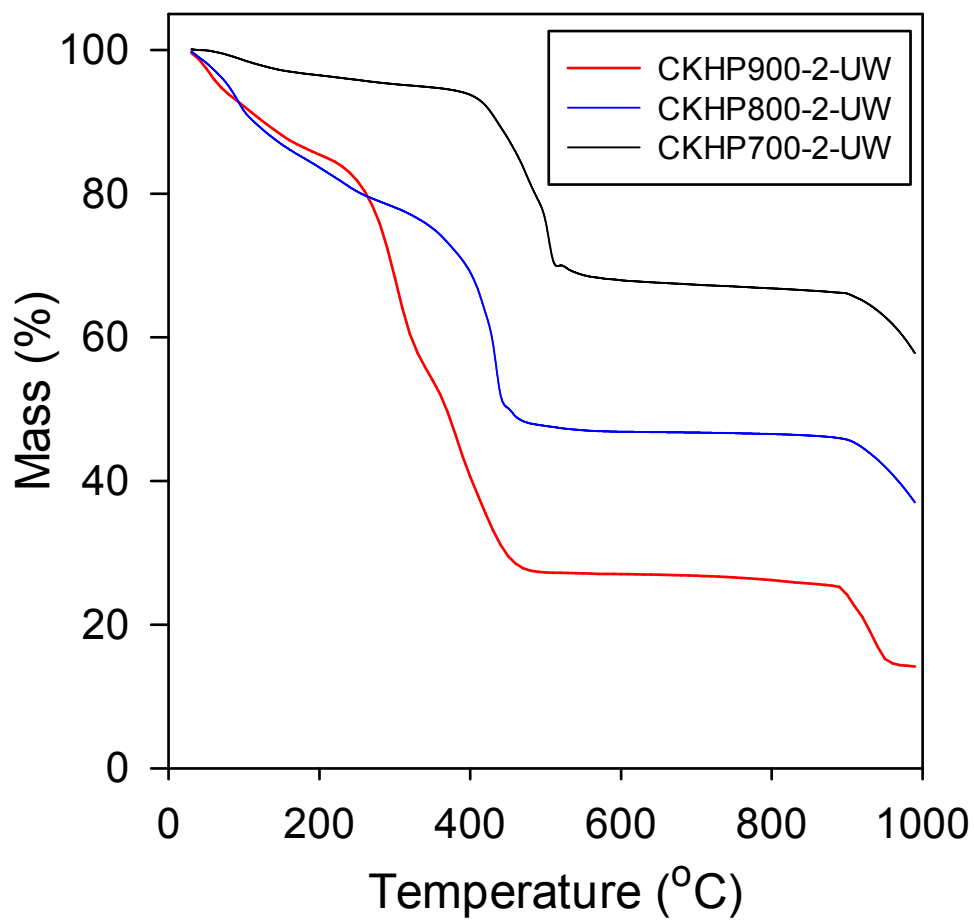
**Supporting Figure S25.** Powder XRD patterns of potassium hydrogen phthalate (KHP) salt and carbonisation products under nitrogen at various temperatures.



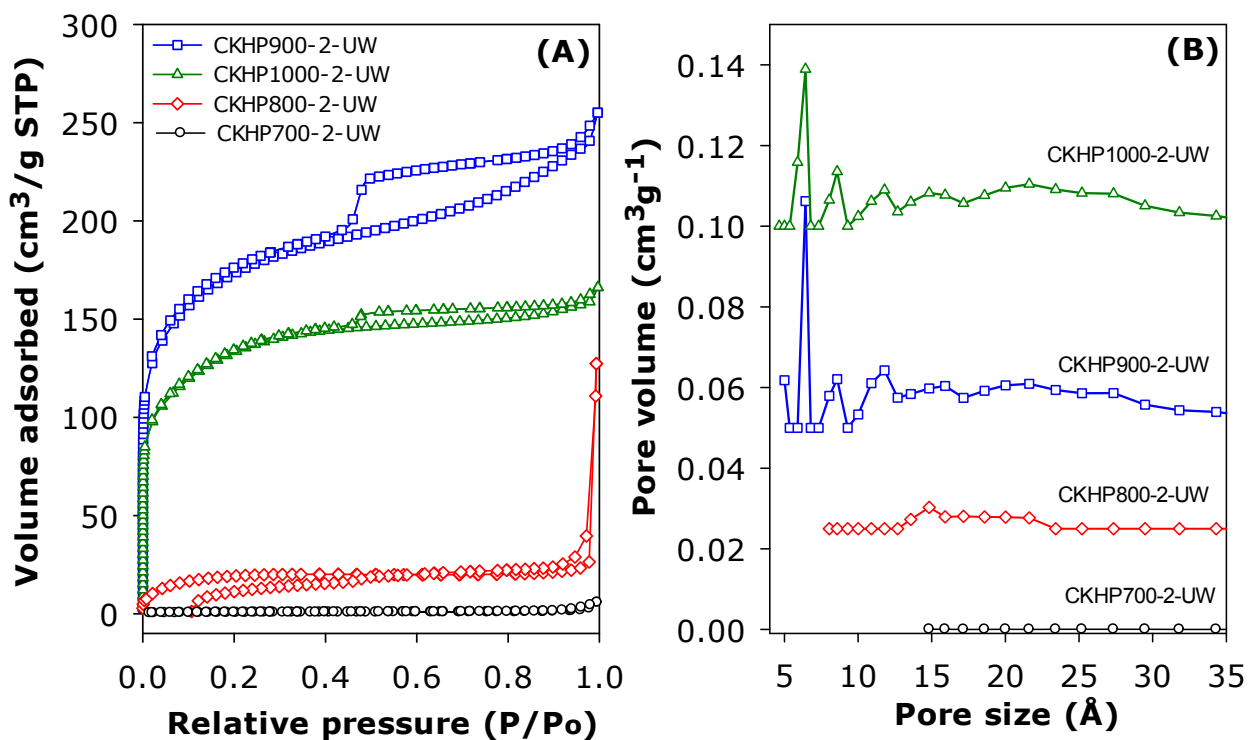
**Supporting Figure S26.** SEM images of CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at various temperatures for 2 h.



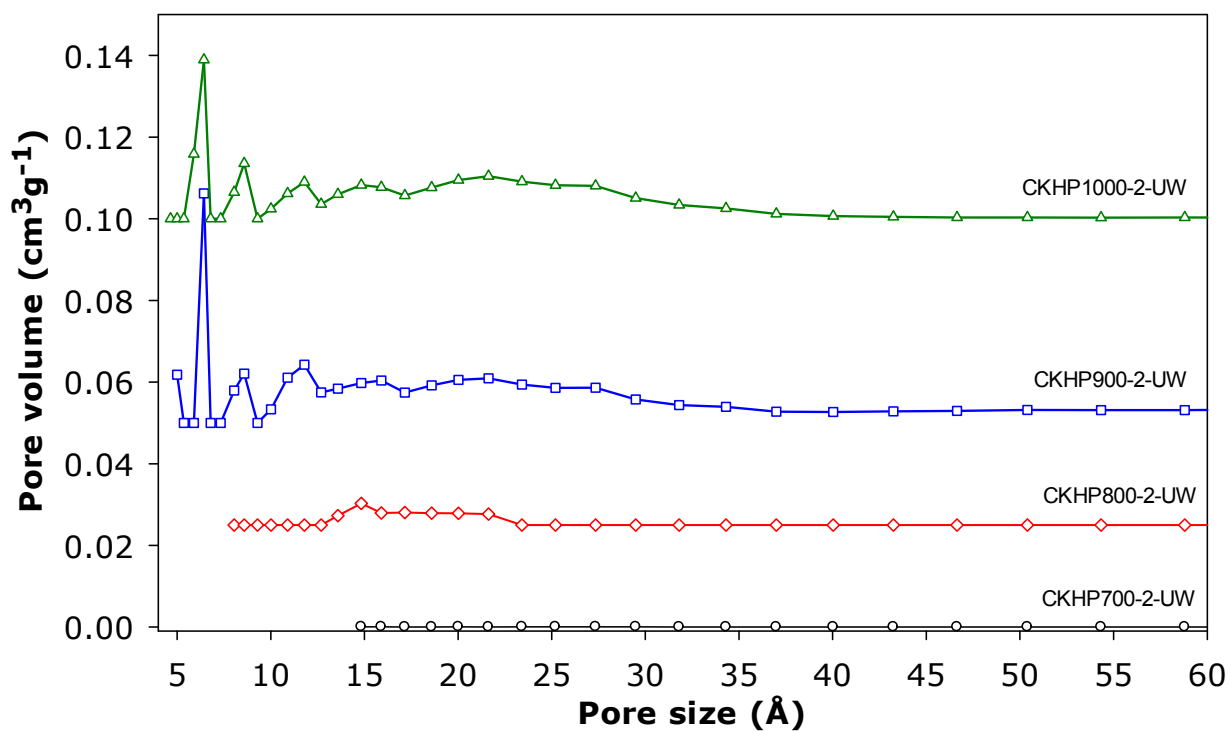
**Supporting Figure S27.** SEM images of carbonisation products of potassium hydrogen phthalate (KHP) salt under nitrogen at various temperatures. The carbonisation products are not washed.



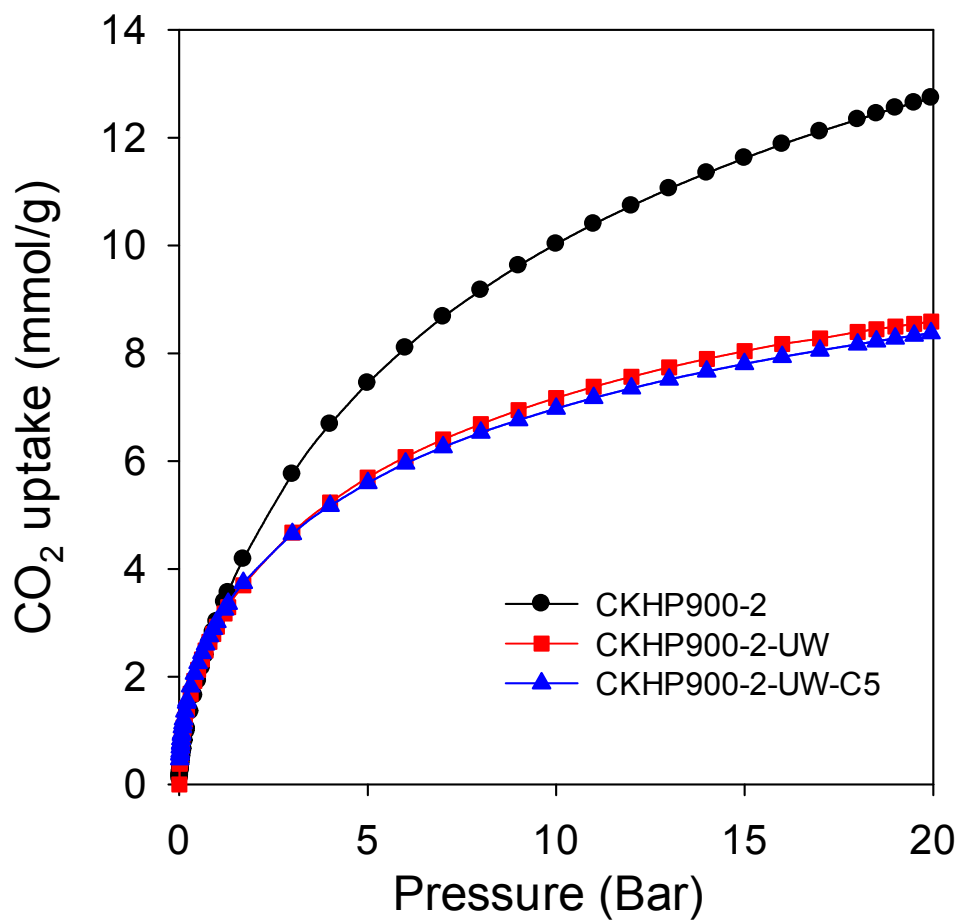
**Supporting Figure S28.** Thermogravimetric analysis (TGA) curves of unwashed CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at various temperatures for 2 h.



**Supporting Figure S29.** Nitrogen sorption isotherms (A) and corresponding pore size distribution curves (B) of unwashed CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at various temperatures for 2 h.

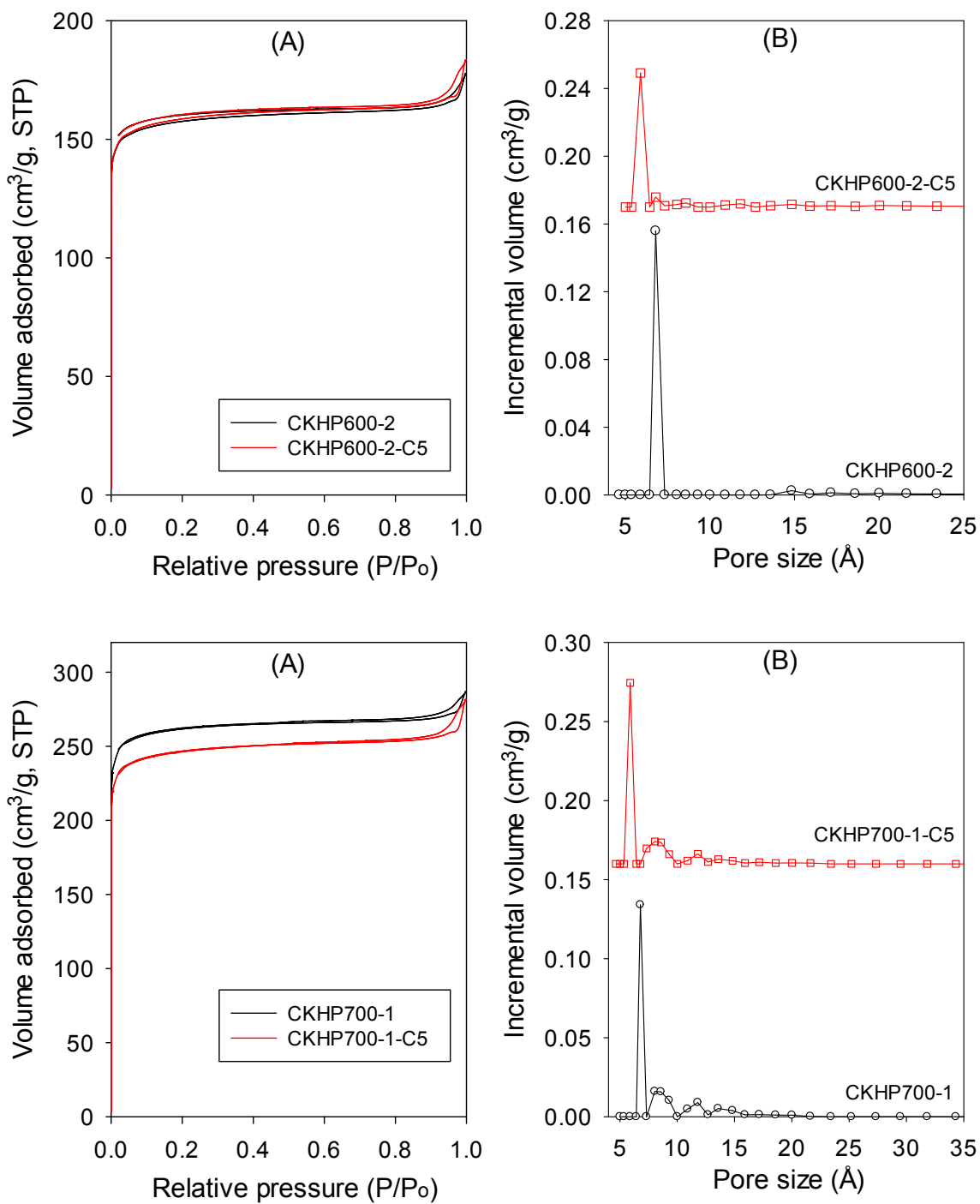


**Supporting Figure S30.** Pore size distribution curves of unwashed CKHP carbons derived from potassium hydrogen phthalate (KHP) via carbonisation at various temperatures for 2 h. Samples CKHP700-2-UW is non-porous, CKHP800-UW has hardly any pores, while the largest pores in samples CKHP900-2-UW and CKHP1000-UW are up to 35 Å.

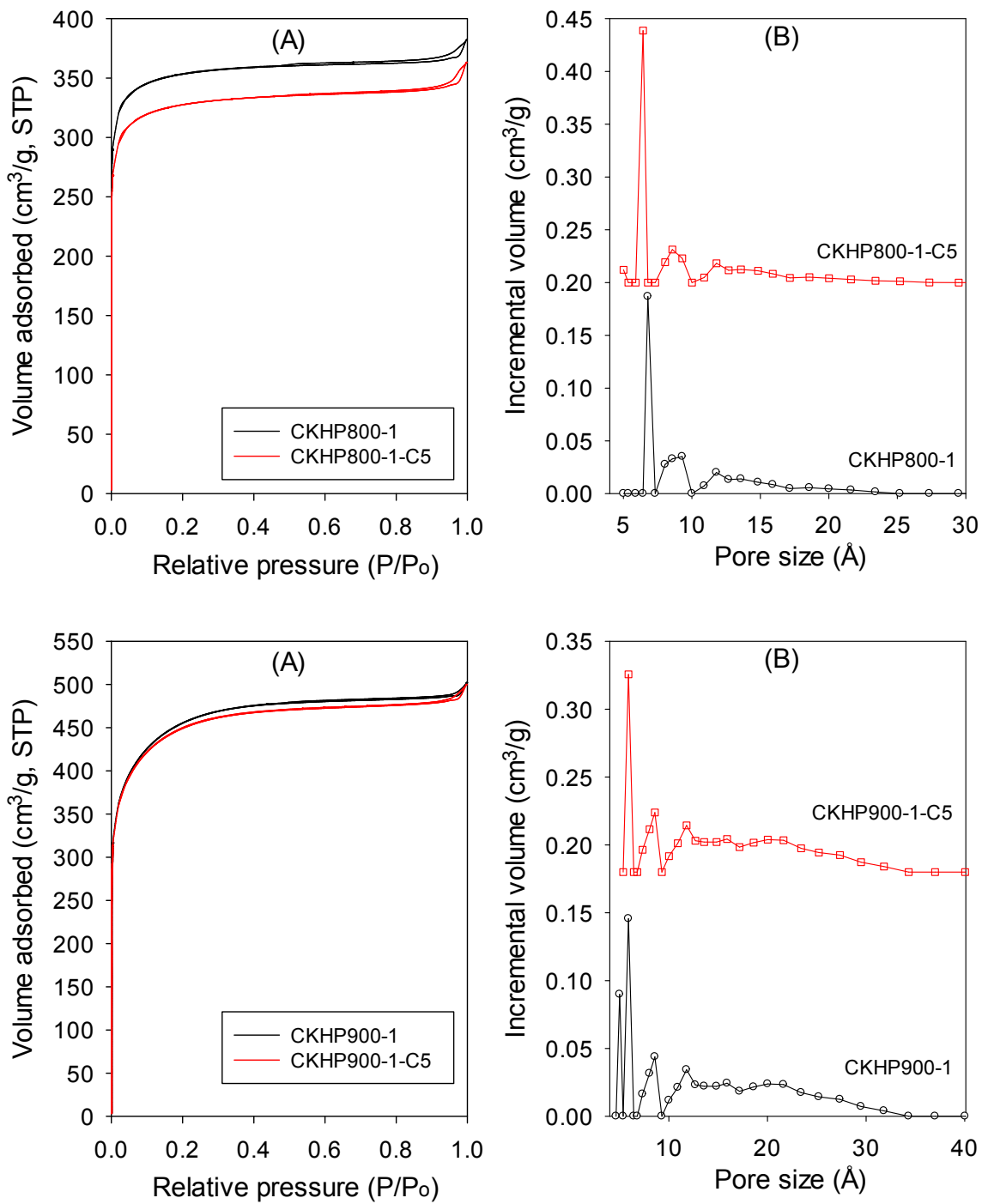


**Supporting Figure S31.** CO<sub>2</sub> uptake isotherms at 25 °C and 0 – 20 bar for washed (CKHP900-2), unwashed (CKHP900-2-UW) and unwashed compacted (CKHP900-2-UW-C5) samples carbonised at 900 °C for 2 h.

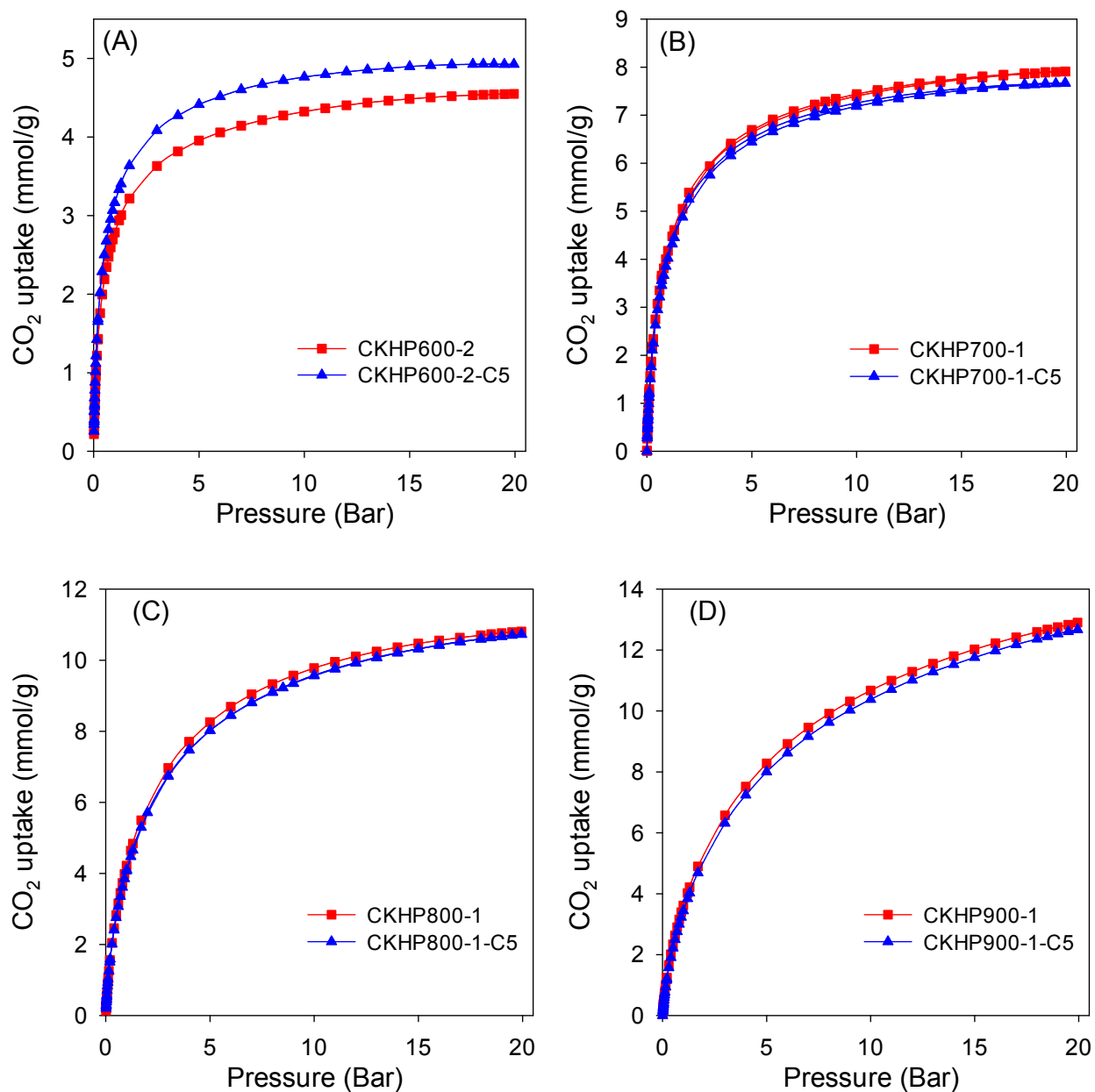




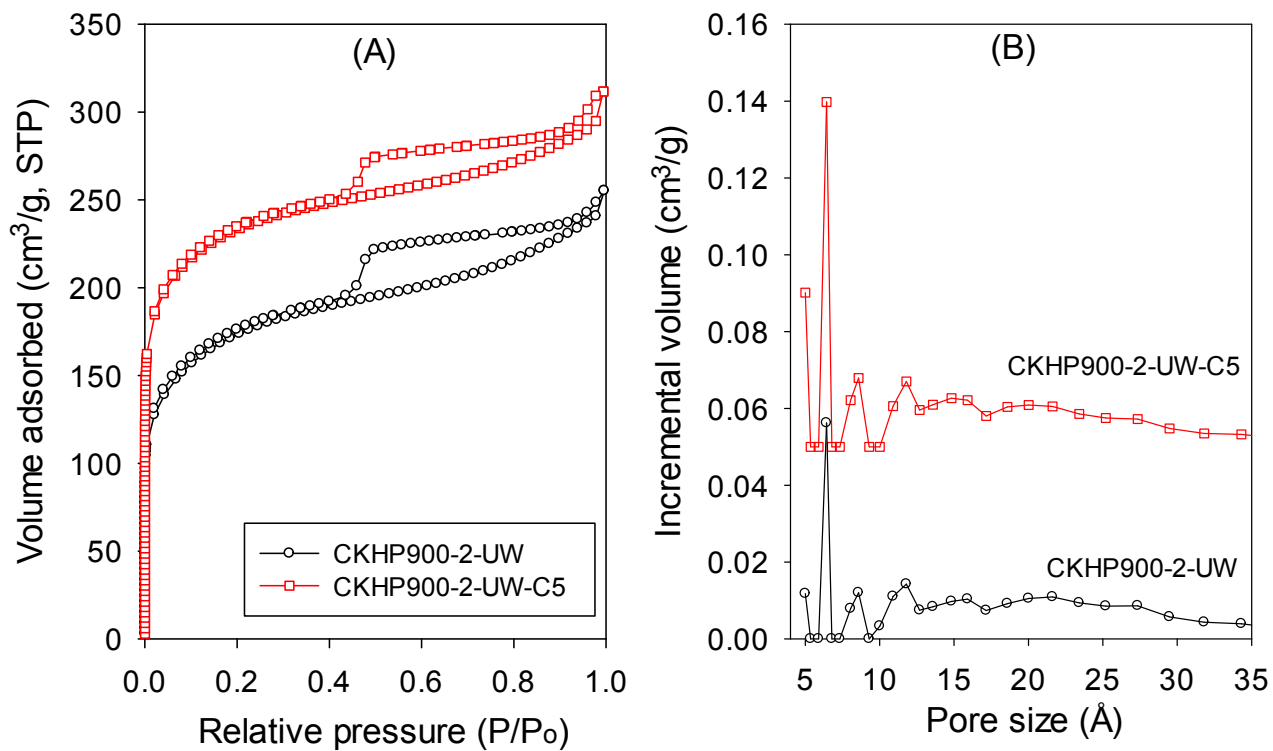
**Supporting Figure S32.** Nitrogen sorption isotherms (A) and pore size distribution curves (B) of CKHP carbons prepared at 600 °C (top) or 700 °C (bottom), before (CKHP600-2 and CKHP700-1) and after (CKHP600-2-C5 and CKHP700-1-C5) compaction at a load of 5 tons (i.e. 370 MPa).



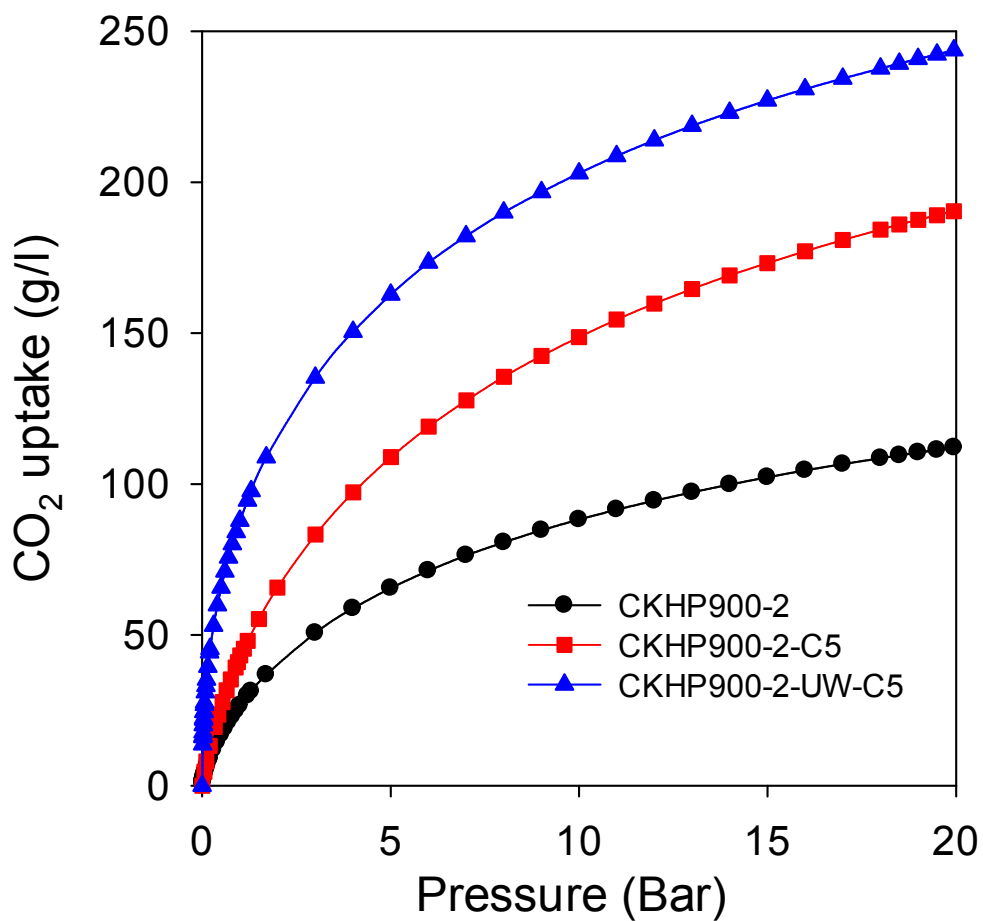
**Supporting Figure S33.** Nitrogen sorption isotherms (A) and pore size distribution curves (B) of CKHP carbons prepared at 800 °C (top) or 900 °C (bottom), before (CKHP800-1 and CKHP900-1) and after (CKHP800-1-C5 and CKHP900-1-C5) compaction at a load of 5 tons (i.e. 370 MPa).



**Supporting Figure S34.** CO<sub>2</sub> uptake isotherms at 25 °C and 0 – 20 bar for various CKHP carbons (A) CKHP600-2, (B) CKHP700-1, (C) CKHP800-1 and (D) CKHP900-1, before and after compaction at a load of 5 tons (i.e. 370 MPa).



**Supporting Figure S35.** Nitrogen sorption isotherms (A) and pore size distribution curves (B) of unwashed CKHP carbon, before (CKHP900-2-UW) and after (CKHP900-2-UW-C5) compaction at a load of 5 tons (i.e. 370 MPa).



**Supporting Figure S36.** Volumetric CO<sub>2</sub> uptake of washed (CKHP900-2), unwashed (CKHP900-2-UW) and unwashed compacted (CKHP900-2-UW-C5) samples carbonised at 900 °C for 2 h.