**Supplementary Information**

**From waste to wealth: Coal tar residue** **derived carbon materials as low-cost anodes for** **potassium-ion batteries**

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**Fig. S1. Spectra of (002) and γ band of CTRCs.**



Fig. S2. XPS survey spectra of CTRCs.





Fig. S3. (a–c) C 1s, (d–f) O 1s, and (g–i) N 1s peak fitting results of the XPS spectra for CTRC-700H, CTRC-800H, and CTRC-1000H.



**Fig. S4. Conductivity curves of CTRCs.**



Fig. S5. Individual GITT curves.



Fig. S6. GITT curves of (a) CTRC-700H, (b) CTRC-800H, and (c) CTRC-1000H; (b) K+ apparent diffusion coefficients for the potassiation/depotassiation process of (d) CTRC-700H, (e) CTRC-800H, and (f) CTRC-1000H.

**Table S1. Structural parameters of CTRCs**

|  |  |  |  |
| --- | --- | --- | --- |
| Samples | Specific surface area, *S*BET / (m2·g−1) | Pore volume, *V*BJH / (cm3·g−1) | Average pore size, *D*BJH / nm |
| CTRC-700H | 1.864 | 0.00504 | 16.83 |
| CTRC-800H | 3.484 | 0.00897 | 9.52 |
| CTRC-900H | 3.933 | 0.00842 | 8.36 |
| CTRC-1000H | 3.163 | 0.00688 | 11.07 |

Table S2. Contents of the C 1s, O 1s, and N 1s peaks in deconvoluted CTRCs samples

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Peak | CTRC-700 | CTRC-800 | CTRC-900 | CTRC-1000 |
| C 1s | 86.9 | 88.1 | 89.8 | 90.8 |
| O 1s | 10.3 | 9.0 | 7.5 | 7.2 |
| N 1s | 1.1 | 0.9 | 1.3 | 1.0 |
| Others | 1.7 | 2.0 | 1.4 | 1.0 |
| C 1s element composition / at% |
| C–C/C=C | 73.8 | 84.5 | 86.0 | 84.5 |
| C–O | 19.4 | 11.1 | 10.9 | 11.6 |
| O–C=O | 6.8 | 4.4 | 3.1 | 3.9 |
| O 1s element composition / at% |
| C=O | 6.0 | 9.0 | 24.1 | 18.7 |
| C–OH/C–O–C | 57.9 | 61.7 | 62.2 | 53.2 |
| –COOH | 36.1 | 29.3 | 13.7 | 28.1 |
| N 1s element composition / at% |
| Graphitic nitrogen (N-Q) | 11.6 | 14.9 | 19.7 | 21.2 |
| Pyrrolic (N-5) | 62.5 | 57.7 | 55.7 | 56.2 |
| Pyridinic (N-6) | 25.9 | 27.4 | 24.6 | 22.6 |

Table S3. Electrochemical performances of coal/ pitch/solid waste-derived carbon as anode materials for potassium ion batteries.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| No. | Sample | Precursor | Synthesis method | Initial reversible capacity / (mAh·g−1) | Current density / (mA·g−1) | Rate performance / (mAh·g−1) | Cycling performance / (mAh·g−1) | Ref. |
| 1 | HC1200 | Coal tar pitch | Carbonization | **296** | 0.1 C | **115.2** (5 C) | 93.1% (1000 cycles, 1 C) | [1] |
| 2 | NPPC-2-700 | Coal tar pitch | N P doping + template + carbonization | **240** | 50 | **133** (5 A·g−1) | **121** (400 cycles, 1 A·g−1) | [2] |
| 3 | SC-800 | Polyvinyl chloride | Carbonization | **280** | 50 | **127** (1 A·g−1) | **106** (150 cycles, 0.1 A·g−1) | [3] |
| 4 | PET | Polyethylene terephthalate  | Solvent thermal method | **225** | 50 | **75** (0.5 A·g−1) | **158.7** (800 cycles, 0.1 A·g−1) | [4] |
| 5 | rGOCOF | Coffee waste + graphene oxide | Carbonization | **175** | 0.1 C | **50** (2 C) | 80% (300 cycles, 1 C) | [5] |
| 6 | NOS-HC900 | Waste tires containing N, O, S | Carbonization | **323.1** | 100 | **231.7** (2 A·g−1) | **322.7** (1000 cycles, 0.1 A·g−1) | [6] |
| 7 | M700 | Lignin | Carbonization | **304** | 50 | **171** (0.2 A·g−1) | 79% (100 cycles, 0.05 A·g−1) | [7] |
| 8 | CSHP2 | Camellia shell | Carbonization | **264.5** | 100 | **164** (0.5 A·g−1) | **237.6** (100 cycles, 0.1 A·g−1) | [8] |
| 9 | A-900 | Anthracite | Carbonization | **213** | 100 | **118.6** (0.5 A·g−1) | **138.7** (100 cycles, 0.1 A·g−1) | [9] |
| 10 | CTRC-800 | Coal tar residue | Carbonization | **265.6** | 50 | **171.8** (0.5 A·g−1) | **249.2** (93.8%; 0.05 A·g−1) | This work |

**References**[1] Y. Liu, Y.X. Lu, Y.S. Xu, *et al.*, Pitch-derived soft carbon as stable anode material for potassium ion batteries, *Adv*. *Mater*., 32(2020), No. 17, art. No. 2000505.[2] X.Q. Ma, N. Xiao, J. Xiao, *et al.*, Nitrogen and phosphorus dual-doped porous carbons for high-rate potassium ion batteries, *Carbon*, 179(2021), p. 33.[3] X. He, L. Zhong, X.Q. Qiu, *et al.*, Sustainable polyvinyl chloride-derived soft carbon anodes for potassium-ion storage: Electrochemical behaviors and mechanism, *ChemSusChem*, 16(2023), No. 19, art. No. e202300646.[4] Z.H. Kang, K.X. Sun, C.F. Sun, and Q. Liu, A plastics-derived organic anode material for practical and sustainable potassium-ion batteries, *Int*. *J*. *Electrochem*. *Sci*., 18(2023), No. 9, art. No. 100222.[5] J.L. Gómez-Urbano, C. Leibing, M. Jauregui, *et al.*, Unravelling charge storage mechanisms of lithium, sodium and potassium into graphene-coffee waste derived hard carbon composites, *Batter*. *Supercaps*, 6(2023), No. 3, art. No. e202200508.[6] Q. Zhao, Q.T. Zheng, S.H. Li, *et al.*, Nitrogen/oxygen/sulfur tri-doped hard carbon nanospheres derived from waste tires with high sodium and potassium anodic performances, *Inorg*. *Chem*. *Front*., 10(2023), No. 9, p. 2574.[7] Z.R. Wu, J. Zou, Y. Zhang, *et al.*, Lignin-derived hard carbon anode for potassium-ion batteries: Interplay among lignin molecular weight, material structures, and storage mechanisms, *Chem*. *Eng*. *J*., 427(2022), art. No. 131547.[8] S.J. Chen, K.J. Tang, F. Song, *et al.*, Porous hard carbon spheres derived from biomass for high-performance sodium/potassium-ion batteries, *Nanotechnology*, 33(2022), No. 5, art. No. 055401.[9] X.Y. Liu, H.C. Tao, C.Y. Tang, and X.L. Yang, Anthracite-derived carbon as superior anode for lithium/potassium-ion batteries, *Chem*. *Eng*. *Sci*., 248(2022), art. No. 117200.