Electronic Supplementary Information

Functional utilization of biochar derived from *Tenebrio molitor* feces for CO_2 capture and supercapacitor applications

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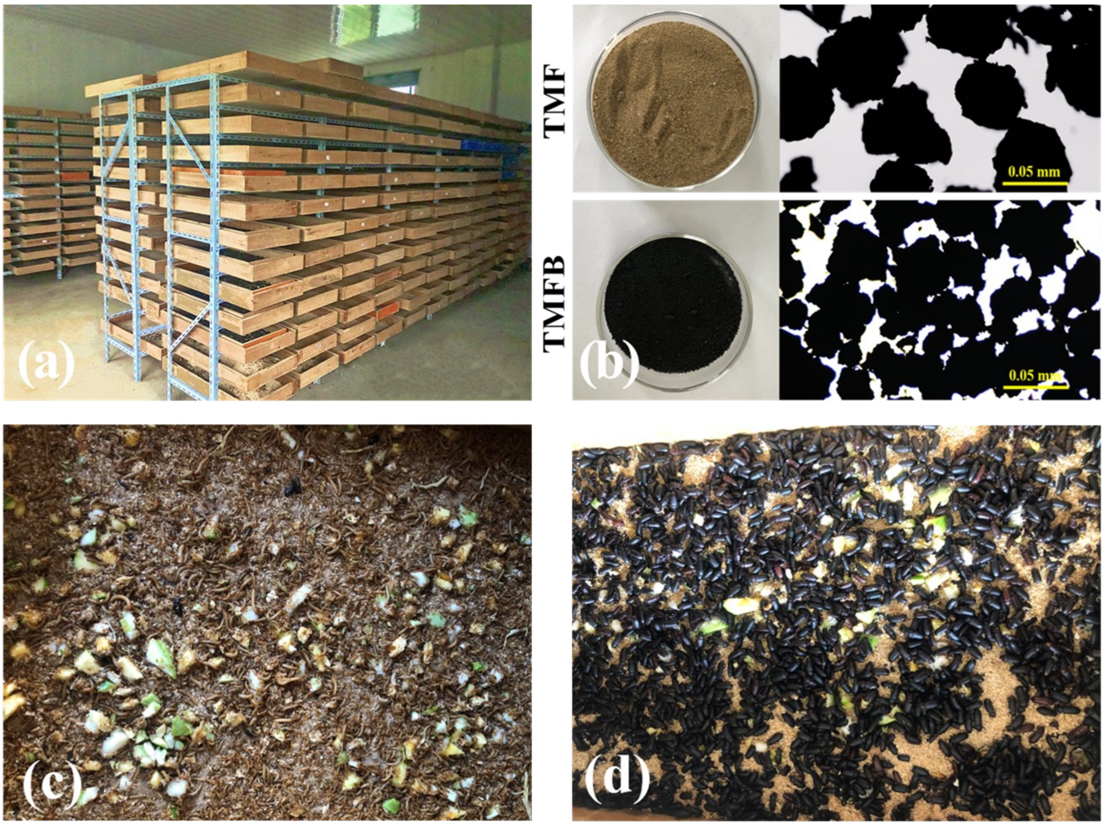

Fig. S1 (a) *Tenebrio molitor* breeding laboratory; (b) Photos of TMF and TMFB; (c) *Tenebrio molitor* larva; (d) Adult *Tenebrio molitor*.

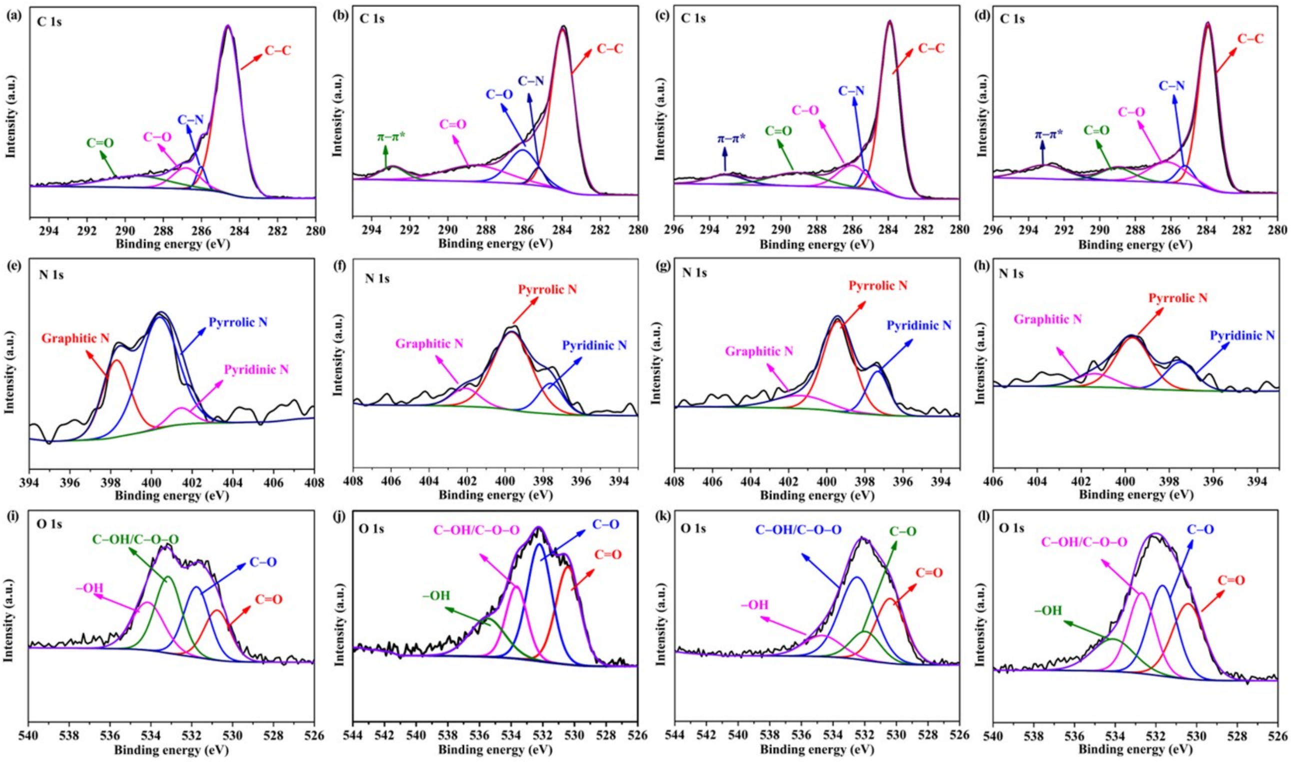

Fig. S2 (a), (b), (c), and (d) C 1s XPS of TMFB, TMFB-600A, TMFB-700A and TMFB-800A; (e), (f), (g) and (h) N 1s XPS of TMFB, TMFB-600A, TMFB-700A and TMFB-800A; (i), (j), (k) and (l) O 1s XPS of TMFB, TMFB-600A, TMFB-700A and TMFB-800A.

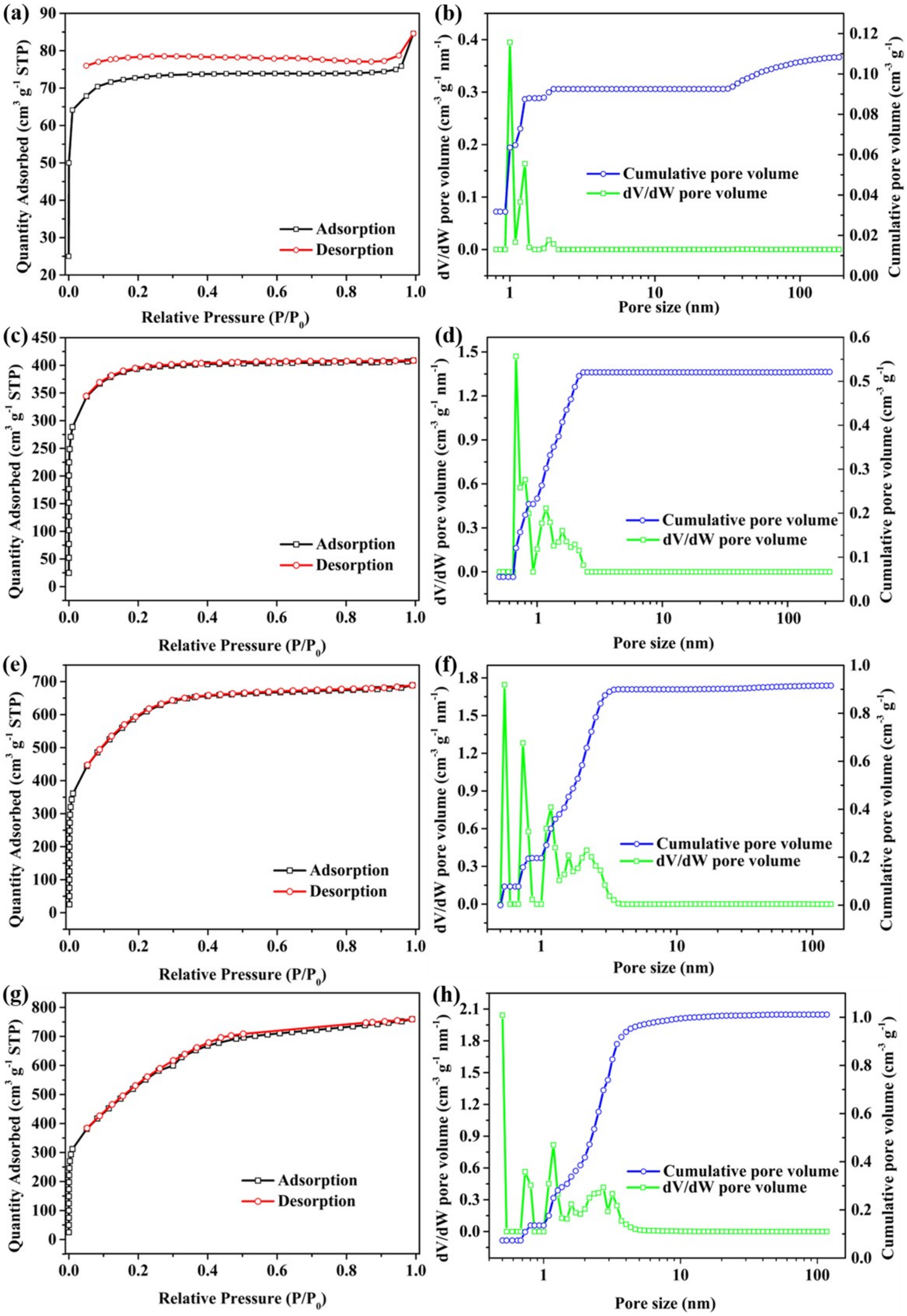

Fig. S3 Adsorption-desorption isotherm and pore size distribution graph. (a, b) TMFB; (c, d) TMFB-600A; (e, f) TMFB-700A; (g, h) TMFB-800A.

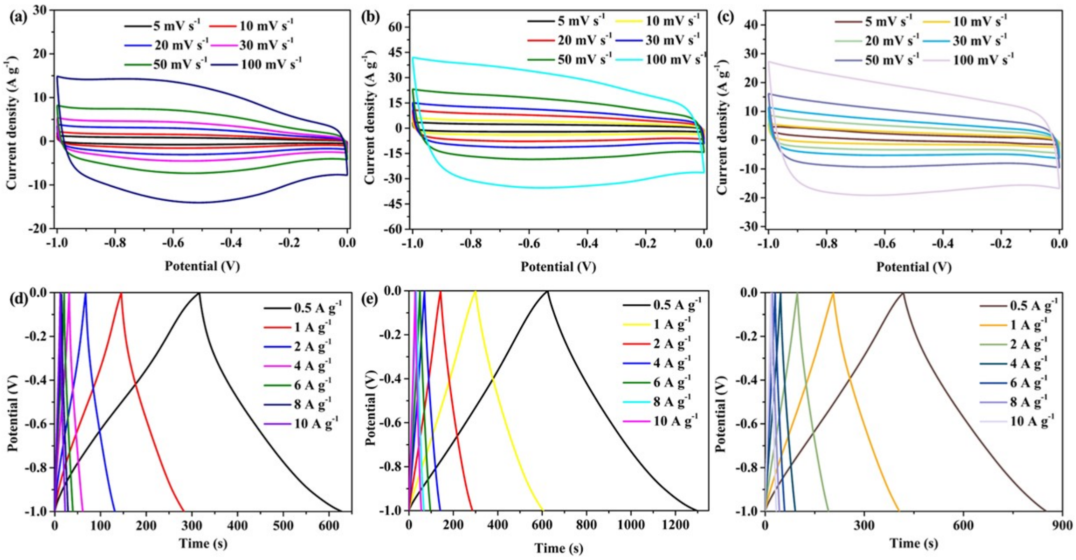

Fig. S4 CV curves. (a), (b) and (c) TMFB-600A, TMFB-700A and TMFB-800A; GCD curves. (d), (e) and (f) TMFB-600A, TMFB-700A and TMFB-800A.

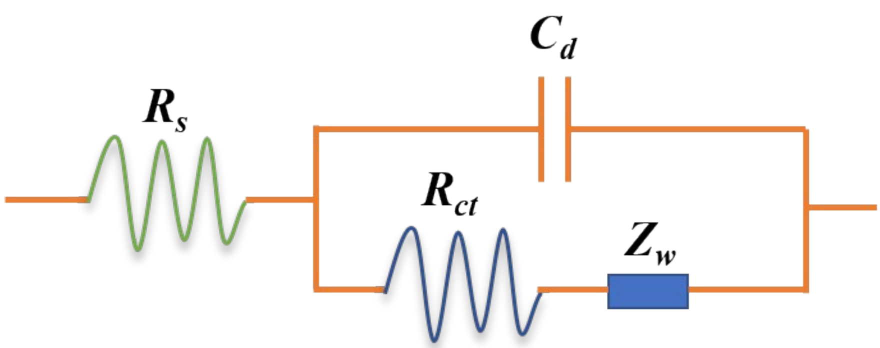

Fig. S5 Equivalent circuit diagram of biochar materials.

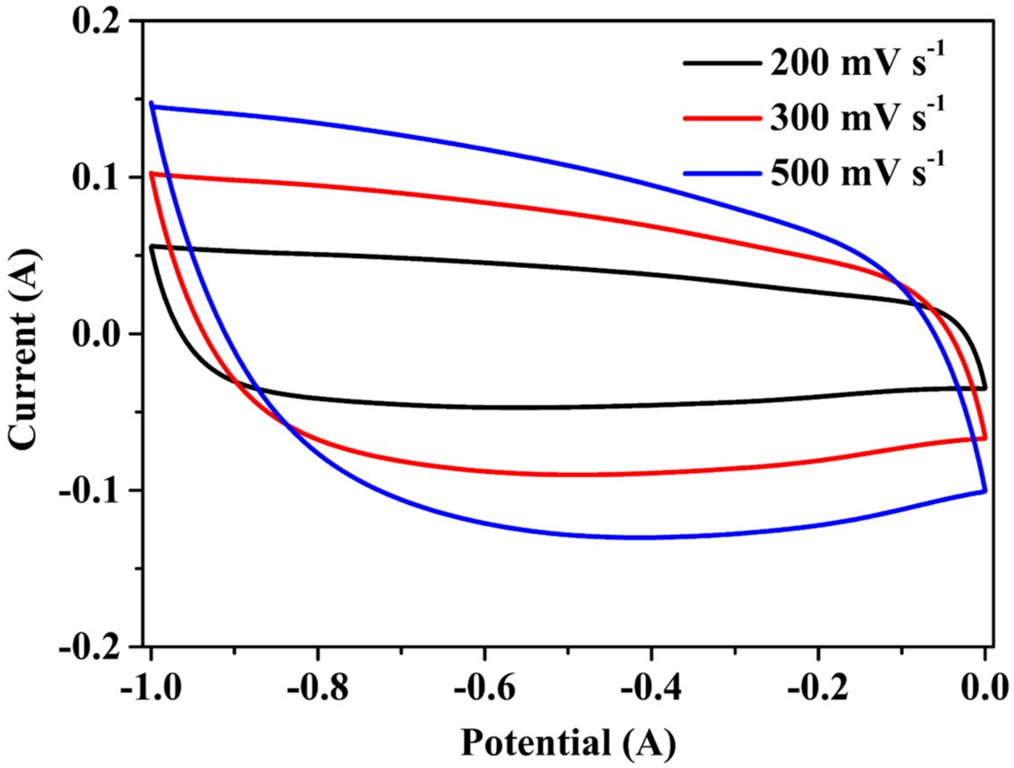

Fig. S6 CV curves of TMFB-700A//TMFB-700A at high scan rate.

Table S1 Comparison of characteristics with TMF and other animal manure

Sample	TMF	cow dung	pig manure	chicken manure
pH	6.86±0.03	10.55±0.01	10.05±0.02	10.34±0.04
Moisture content (%)	8.2±0.59	11.64±0.41	12.93±0.13	8.30±0.11
VS (%)	84.45±1.16	78.83±2.00	69.82±0.61	40.66±1.01
Density (g cm^{-3})	0.36	0.418	0.757	0.776

Table S2 Comparison of BET with other animal manure-based biochar and activated animal manure-based biochar.

Sample	Biomass precursor	Pyrolysis temperature	Activation method	Activation temperature	BET (m^2/g)	V_{total} (cm^3/g)	Reference
TMFB	*Tenebrio molitor feces*	*500*			*232.1*	*0.13*	*This work*
TMFB–700A	*Tenebrio molitor feces*	*500*	*KOH*	*700*	*2081.8*	*1.07*	*This work*
SB	Swine manure	500			8.7	0.021	[1]
MB	Pig manure	500	Alkali-fused fly ash	500	7.6	0.014	[1]
CD–500P –650A	Cow dung	500	CO_2	650	130.80		[2]
PM –500P–750A	Pig manure	500	CO_2	750	125.80		[2]
CM–500P–650A	Chicken manure	500	CO_2	650	23.55		[2]
Swine-Manure-Derived Biochar	Swine manure	750			37.59	0.0438	[3]
UBC	Earthworm manure	700			38.28		[4]
WBC	Earthworm manure	700	HCl washing		80.85		[4]
Fe/CM–biochar	cattle manure	500	$FeCl_3$	500	11.1	0.027	[5]

nZVZ-CMC-PMBC	Panda manure	600	nano-zero valent zinc	/	72.96	0.049	6
GMC-900	goat manure	900			341.6	0.313	7
C-700	Cow manure	700			121.10		8
BC700	Pig manure	700			32.6	0.035	9
DABC700	Pig manure	700	HCl washing		218.1	0.315	9

Table S3 Langmuir and Freundlich adsorption equation parameters.

Sample	Langmuir			Freundlich		
	q_s (mmol g^{-1})	K_L (MPa^{-1})	R^2	K_F (mmol g^{-1} $MPa^{-1/n}$)	n	R^2
TMFB	2.159	28.103	0.9962	5.079	2.080	0.9933
TMFB-600A	3.428	13.835	0.9843	7.992	1.691	0.9985
TMFB-700A	4.771	15.911	0.9816	11.370	1.743	0.9998
TMFB-800A	4.473	12.363	0.9909	10.306	1.642	0.9966

Table S4 Comparison of CO_2 capture capacity with other biochar.

Sample	**Biomass precursor**	**Pyrolysis temperature**	**Activation method**	**Activation temperature**	**CO_2 adsorption capacity (mol kg^{-1})**	**Reference**
TMF–700A	*Tenebrio molitor feces*	*500*	*KOH*	*700*	*3.05*	*This work*
WFW40-K	60% wood waste + 40% food waste	850	KOH	550	1.30	10
SCK-800-1	sargassum	800	KOH	800	1.05	11
ECK-800-1	enteromorpha	800	KOH	800	0.52	11
KMHC	coffee grounds	600	KOH+ nitrogen-doped	600	2.67	12
NC-700-1	sawdust	700	urea phosphate	700	1.34	13
WCMK	70% wood chips and 30% chicken manure	850	KOH+CO_2	850	2.92	14
SNK-2	spirulina	800	KOH+ nitrogen-doped	800	3.09	15
WS900	walnut shell	900	Mg doped	/	1.86	16

Table S5 Comparison of the electrochemical parameters of biochar material-based capacitor devices

Capacitor	Biomass precursor	Electrolyte	Power density (W kg^{-1})	Energy density (Wh kg^{-1})	Capacitance retention	Reference
TMFB–700A//TMFB-700A	*Tenebrio molitor* feces	6M KOH	250	33.39	90.47% after 10000 cycles	This work
AC-700//AC-700	Nut inner shell biochar	1 M Na_2SO_4	700	19.9	97% after 5000 cycles	17
MnO_2/NBC/PEDOT	Rice straw	PVA/H_2SO_4	706.3	7.8	83% after 1000 cycles	18
WBMs-800//WBMs-800	wood	2M KOH	227	9.4	111% after 10000 cycles	19
TBC-$K_{3.6}$//TBC-$K_{3.6}$	pine tannin	1 M H_2SO_4	110	6.7	92% after 10000 cycles	20
HBFC-1//HBFC-1	Hibiscus sabdariffa fruits	0.5 M Na_2SO_4	225	13.1	96% after 5000 cycles	21
NFAC-c//NFAC-c	Nostoc flagelliform e algae	1 M Na_2SO_4	80	22	101.7% after 10000 cycles	22
FBC//FCBC	Cladophora Glomerata ($FeSO_4$ modificatio n)	3M KCl	900	41.5	93.1% after 10000 cycles	23
FBC//MBC	Cladophora Glomerata ($FeCl_3$ modificatio n)	3M KCl	900	30.8	99.5% after 10000 cycles	23
$BMIMBF_4$/AN	parasol fluf (Co^{2+} modificatio n)	2M H_2SO_4	300	46.38	92.2% after 10000 cycles	24
$Ni(OH)_2$-MnO_2-RGO//NBKBC	Bamboo (boron and nitrogen co-doping)	1M KOH	264	39.5	72% after 2000 cycles	25

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