Electronic Supplementary Material (ESI) for RSC Advances.

Supplementary information

Gamma-radiated biochar carbon for improved supercapacitor performance

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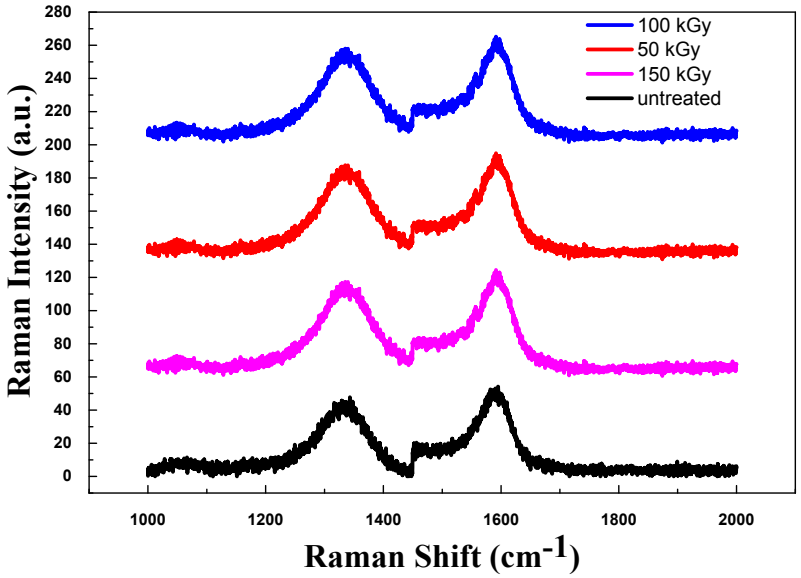

Fig. S1 Raman spectroscopy of untreated biochar, 50kGy, 100 kGy and 150 kGy of gamma radiation.

Table S1 Values of energy densities with power densities with different current densities for untreated, 50 kGy, 100 kGy, and 150 kGy gamma radiation.

	untreated		50 kGy gamma rays		100 kGy gamma rays		150 kGy gamma rays	
Current (A g^{-1})	Energy density Wh kg^{-1}	Power density (kW kg^{-1})	Energy density Wh kg^{-1}	Power density (kW kg^{-1})	Energy density Wh kg^{-1}	Power density (kW kg^{-1})	Energy density Wh kg^{-1}	Power density (kW kg^{-1})
0.05	16.01	0.12	28.3	0.101	34.2	0.1	25.7	0.1
0.1	15.5	0.26	26.4	0.204	32.7	0.202	25.1	0.207
0.2	15.4	0.6	25.6	0.422	31.8	0.411	24	0.425
0.5	14.8	2.2	24.2	1.13	30.6	1.06	22.4	1.18
1	14.2	10.2	22.9	2.57	29.7	2.3	19.2	2.6
2	13.6	16.3	21.5	7.03	28.8	5.5	17.5	8.04
5	12.8	18	17.2	51	25.9	31.08	15.8	11
10	11.1	22	13.9	60	22.5	33	13.2	13

Table S2 Comparison of our work with previous works

Precursor	Method	P (kW kg^{-1})	E (Wh kg^{-1})	References
Carbon YP-50	Gamma dose100 kGy	0.1	34.2	Present work
Active carbon	Gamma dose 5 KGy	0.236	5.45	[1]
Active carbon	Gamma dose 20 kGy	0.047– 0.101	0.3 x 10^{-3} – 0.04	[1]
Carbon nanoparticles With MnO_2	Flame synthesis	0.014	4.8	[2]
Oil Palm Kernel Shell Biomass	Annealing at 500°C/4h	0.3	7.4	[3]

Table S3 I_D/I_G ratios of untreated, 50 kGy, 100 kGy, and 150 kGy gamma radiation

Sample	I_D/I_G
untreated	0.833
50 kGy	0.839
100 kGy	0.843
150 kGy	0.839

Table S4 Specific capacitance, specific energy, and specific power with different current density for untreated, 50 kGy, 100 kGy, and 150 kGy gamma rays.

Current density (A g^{-1})	Specific Capacitance (F g^{-1})			
	untreated	50 kGy dose	100 kGy dose	150 kGy dose
0.05	115.3	203.6	246.2	185
0.1	111.8	190.3	235.5	180.9
0.2	110.8	184.1	229.3	173.2
0.5	106.5	174.5	220.2	161
1	102.4	165.3	214.2	138.0
2	98.15	154.6	207.2	126
5	92.5	123.7	186.8	114
10	80	100	162	95

Table S5 Impedance results of untreated, 50 kGy, 100 kGy, and 150 kGy gamma rays.

Resistance	untreated	50 kGy	100 kGy	150 kGy
R_{CT}	21.7 Ω	13.6 Ω	7.4 Ω	16.7 Ω
R_S	0.33 Ω	0.31 Ω	0.30 Ω	0.32 Ω

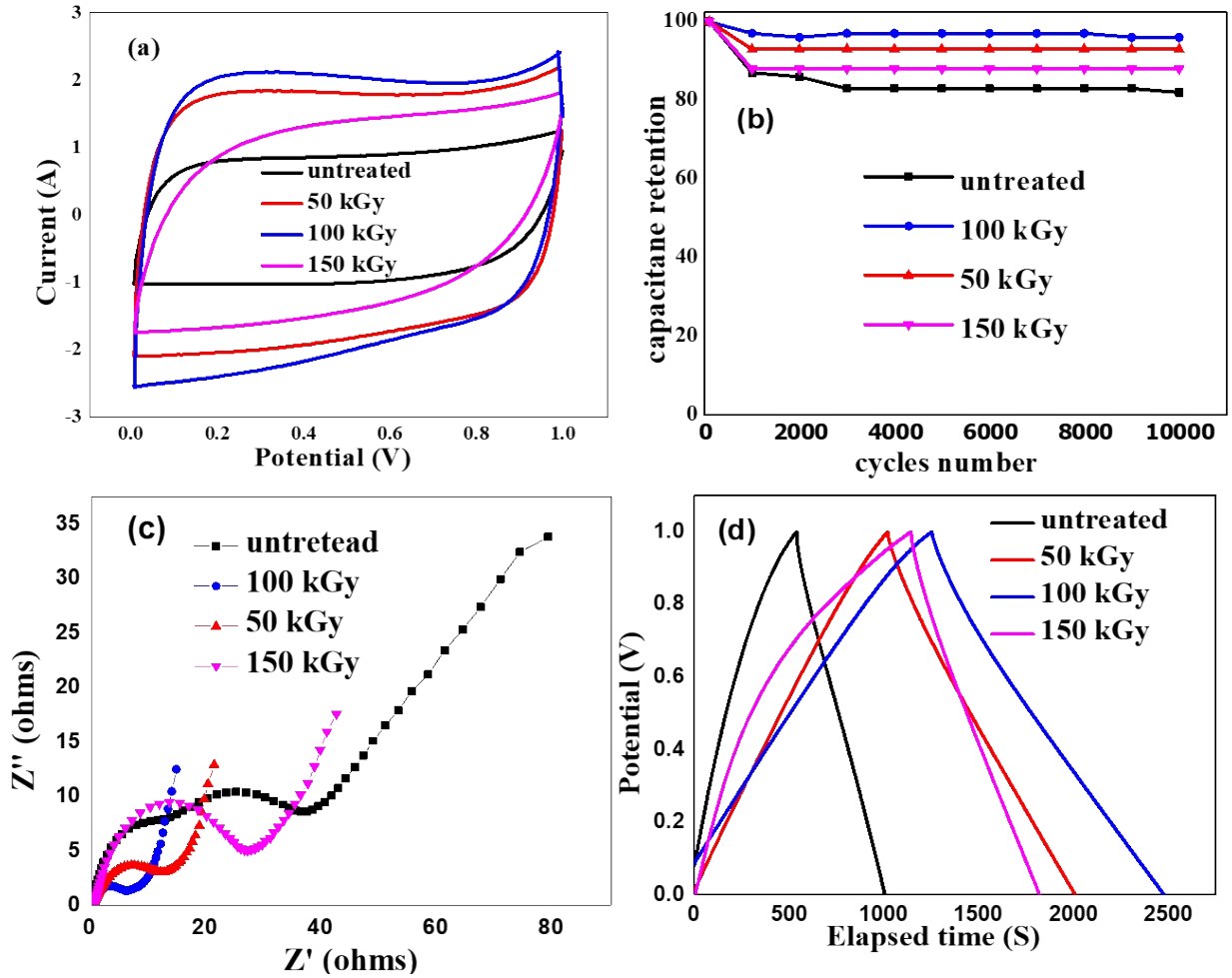

Fig. S2. The electrochemical properties of different carbon sample after 10,000 cycles. (a) CV curves of untreated and treated samples with gamma radiation, (b) capacitance retention versus cycles number at a current density of 2 A g^{-1}, (c) EIS curves of untreated and treated samples with gamma radiation (d) Galvanostatic charge-discharge curve of untreated and treated samples.

References

1. Nor, N.S.M., et al., *Influence of gamma irradiation exposure on the performance of supercapacitor electrodes made from oil palm empty fruit bunches.* Energy, 2015. **79**: p. 183-194.
2. Yuan, L., et al., *Flexible solid-state supercapacitors based on carbon nanoparticles/MnO2 nanorods hybrid structure.* ACS nano, 2012. **6**(1): p. 656-661.
3. Misnon, I.I., N.K.M. Zain, and R. Jose, *Conversion of oil palm kernel shell biomass to activated carbon for supercapacitor electrode application.* Waste and Biomass Valorization, 2019. **10**(6): p. 1731-1740.