Electronic supplementary information (ESI)

Morphology tailoring and improved electrochemical performance of hexagonal boron nitride (h-BN) for symmetric supercapacitor applications

Madhav Dobhal[a], Aditya Sharma*[a], Bhavi Agrawal[a], Mayora Varshney[b], Hyun-Joon Shin[c#], Ranjeet Kumar Brajpuriya[a], and Shalendra Kumar[a]

[a]Department of Physics, SOAE, University of Petroleum and Energy Studies (UPES), Dehradun, Uttarakhand, 248007, India.
[b]Department of Applied and Life Sciences, & Division of Research & Innovation, Uttaranchal University, Dehradun, Uttarakhand 248007, India.
[c]Department of Physics, Chungbuk National University, Cheongju-28644, South Korea.
*adityaiuac@gmail.com, #shin@chungbuk.ac.kr

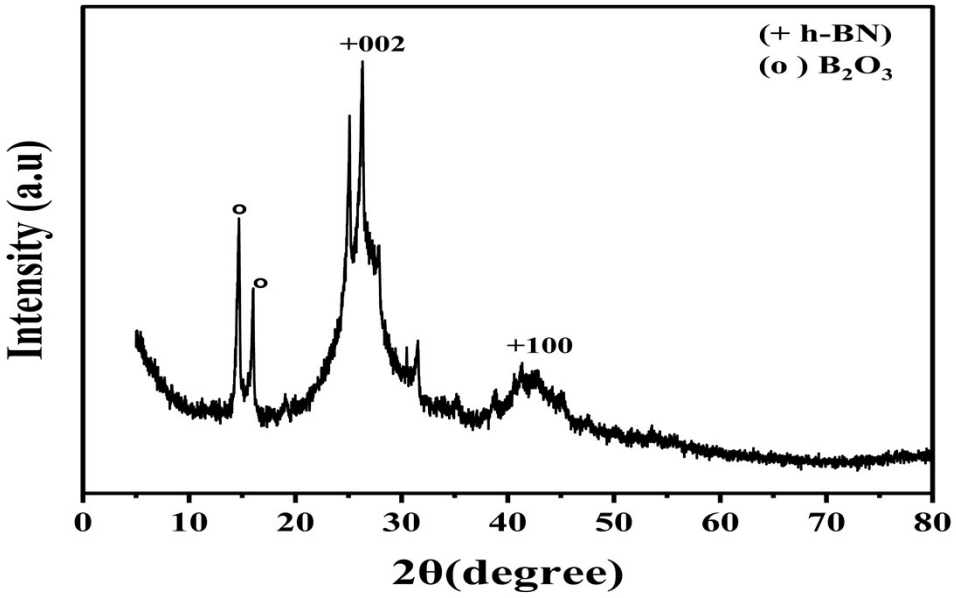

Figure S1. XRD pattern showing mixed-phase formation, where reflections of h-BN are accompanied by a distinct peak near ~15°, corresponding to the B_2O_3 phase.

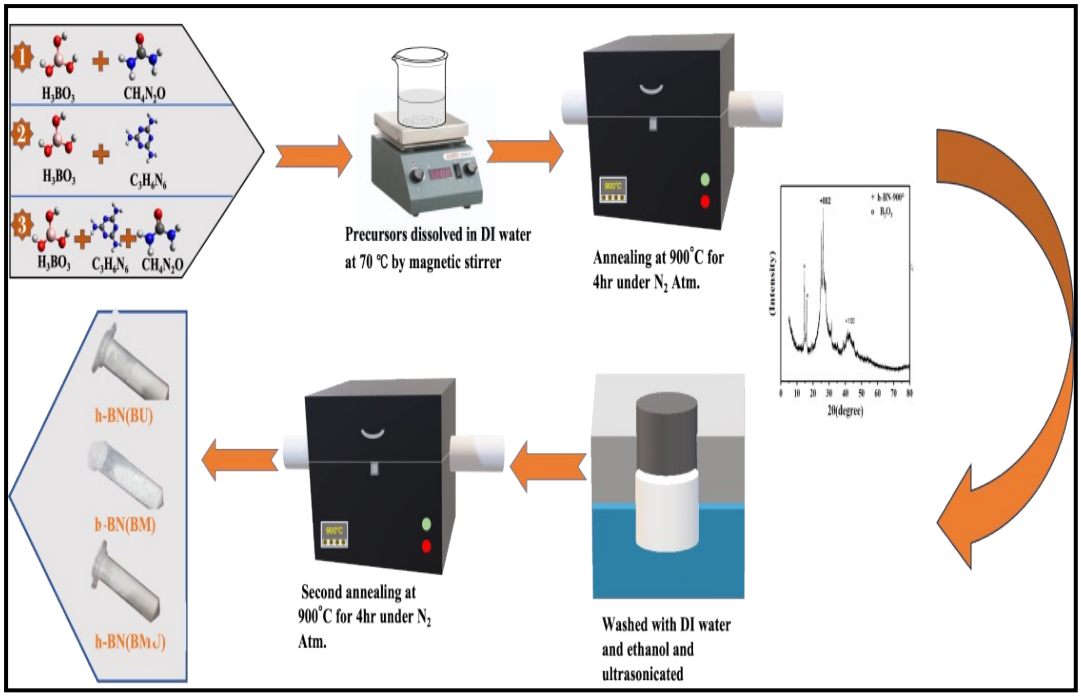

Figure S2. Synthesis process of h-BN using different precursor combinations: boric acid-urea (h-BN(BU)), boric acid- melamine (h-BN(BM)), boric acid-urea-melamine (h-BN(BMU)).

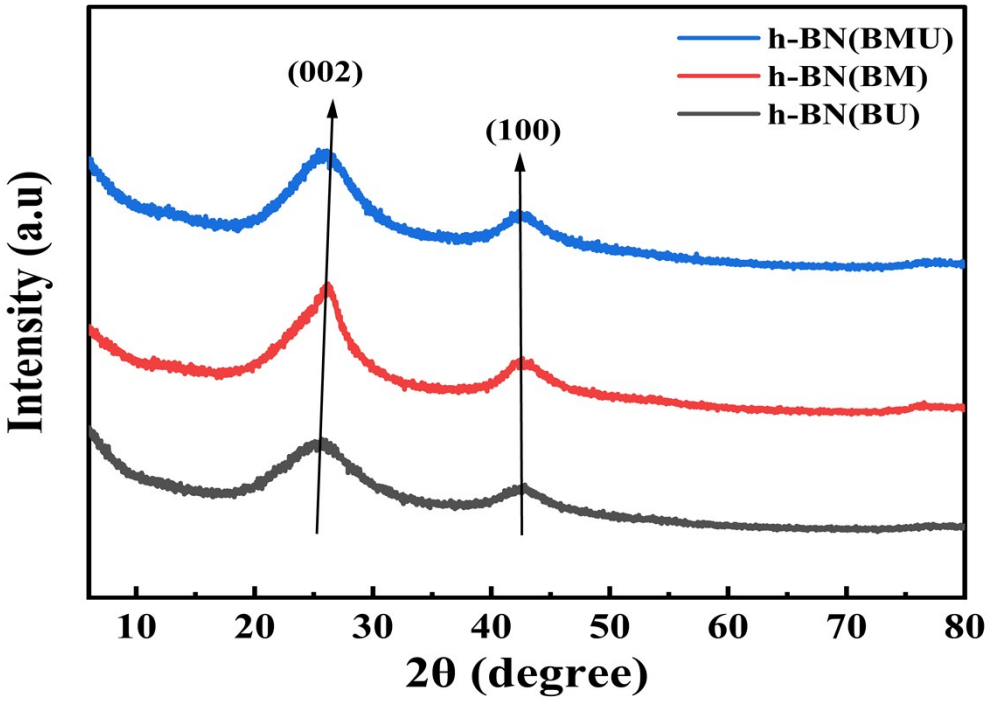

Figure S3. XRD patterns of h-BN(BU), h-BN(BM), and h-BN(BMU) samples prepared via different precursor routes, showing the characteristic (002) and (100) reflections of hexagonal boron nitride.

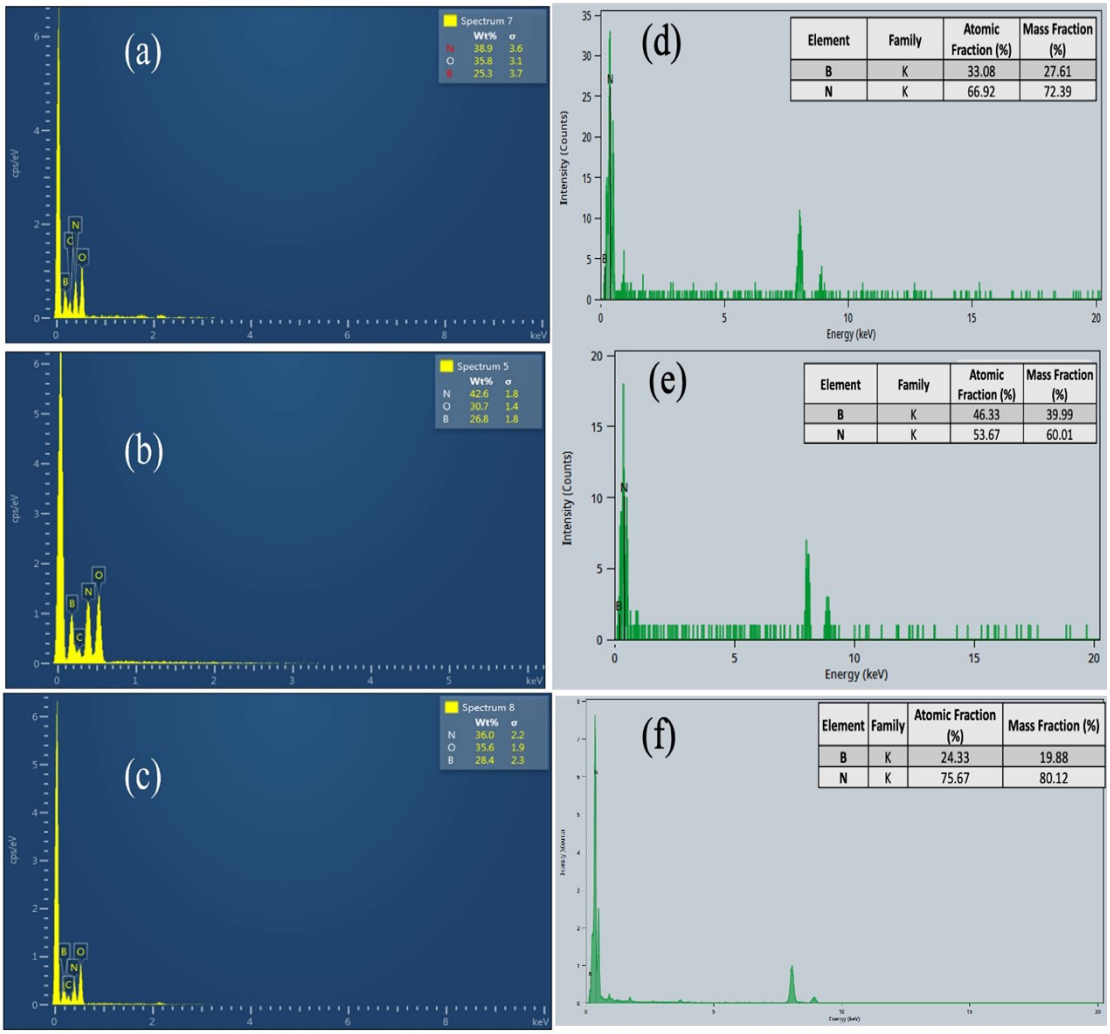

Figure S4. EDS from FE-SEM of (a) h-BN(BU), (b) h-BN(BM), (c) h-BN(BMU). And from TEM (d) h-BN(BU), (e) h-BN(BM), (f) h-BN(BMU).

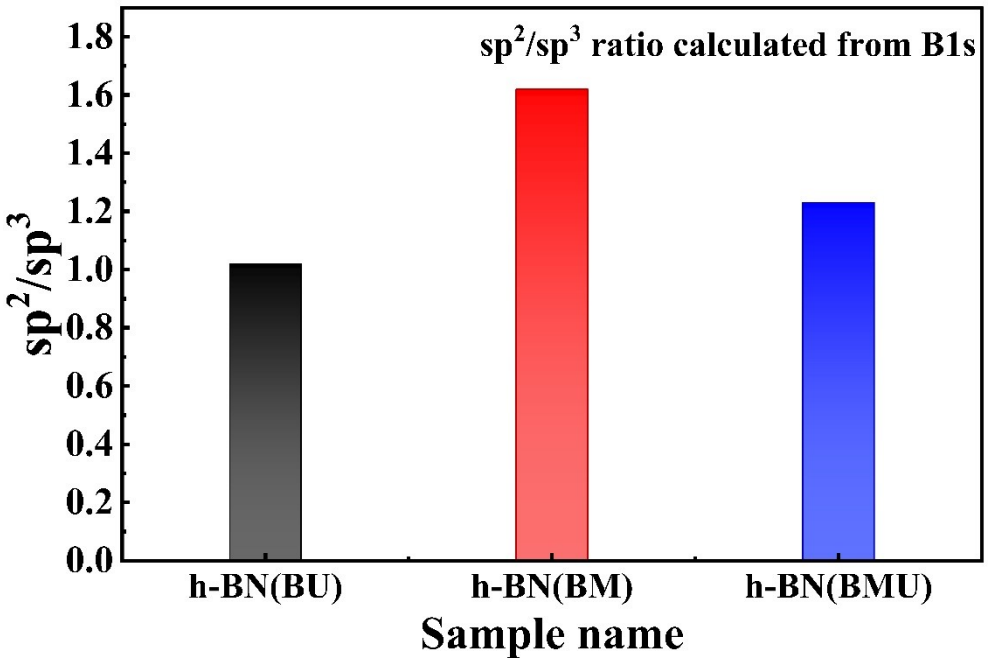

Figure S5. sp^2/sp^3 ratios of *h*-BN(BU), *h*-BN(BM), and *h*-BN(BMU), evaluated from B1s XPS spectra.

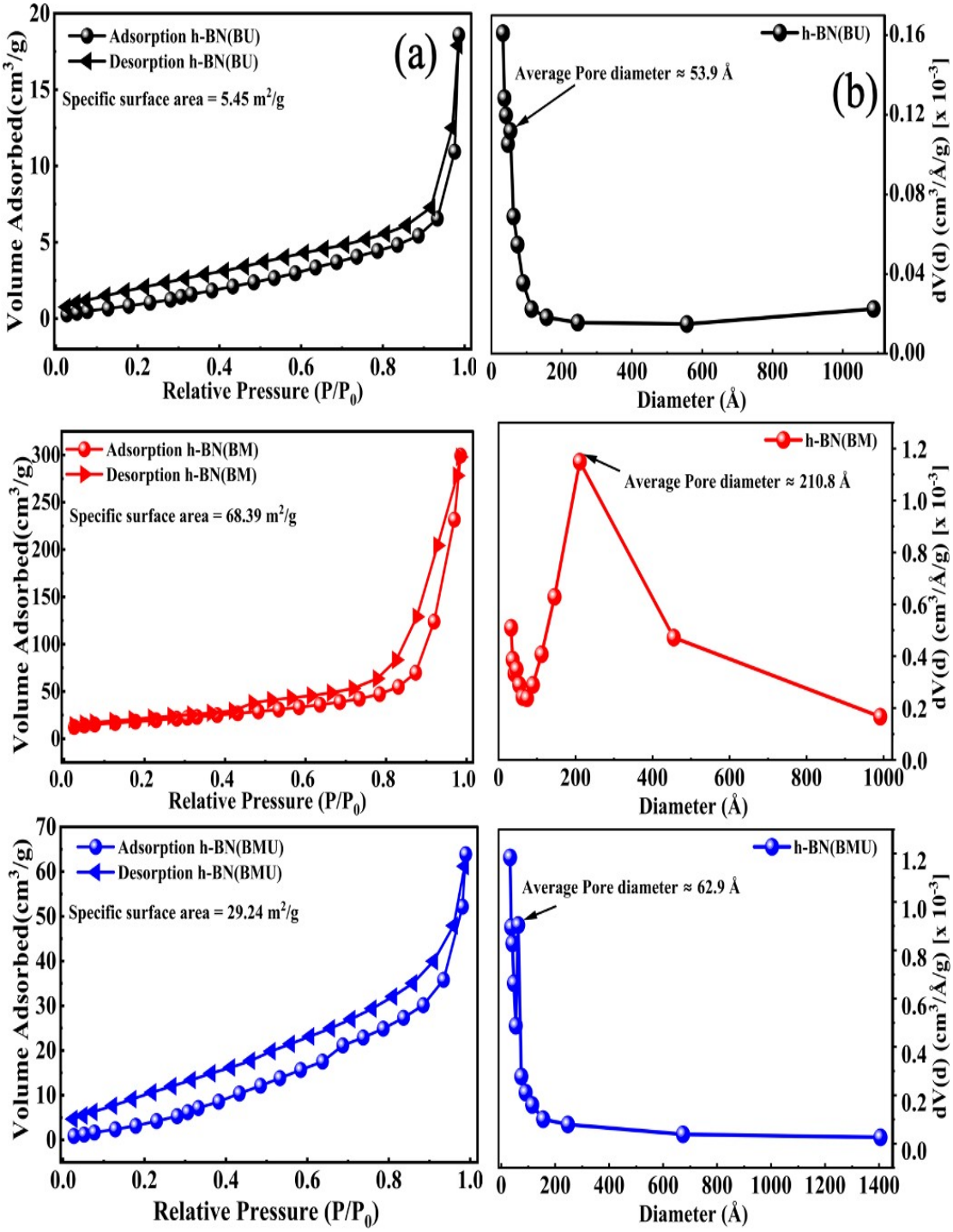

Figure S6. BET analysis of nitrogen adsorption-desorption isotherms and pore size distribution curves of *h*-BN(BU), *h*-BN(BM), and *h*-BN (BMU) samples.

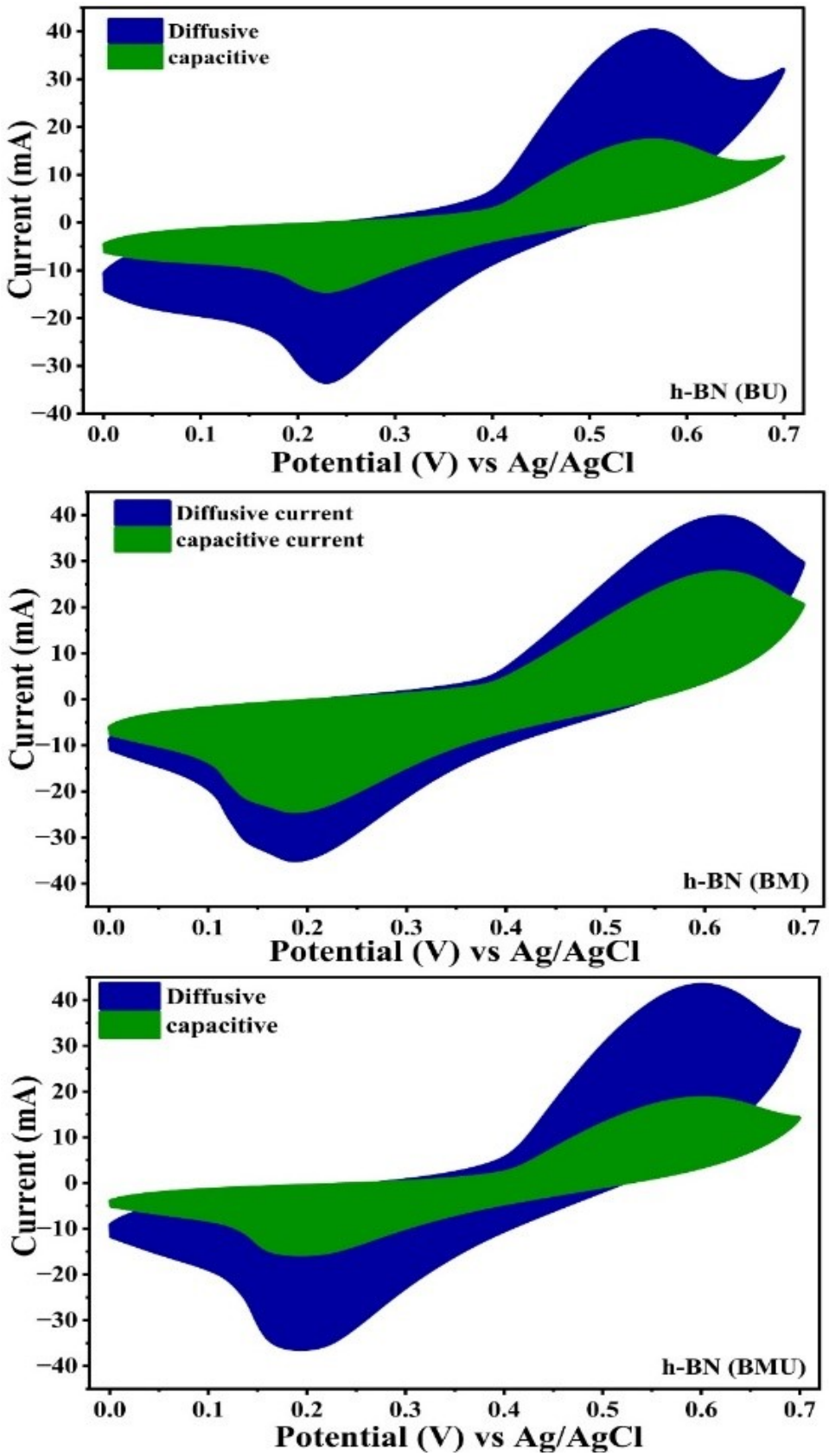

Figure S7. Comparison of capacitive and diffusive contributions in CV data (taken at a scan rate of 100 mV/s) of *h-BN*(BU), *h*-BN(BM), and *h*-BN(BMU) samples.

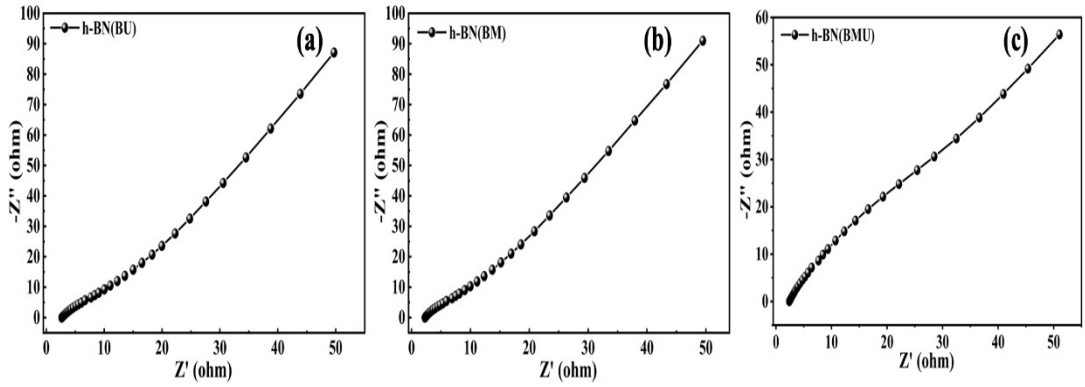

Figure S8. Nyquist plots of (a) h-BN(BU), (b) h-BN(BM), (c) h-BN(BMU).

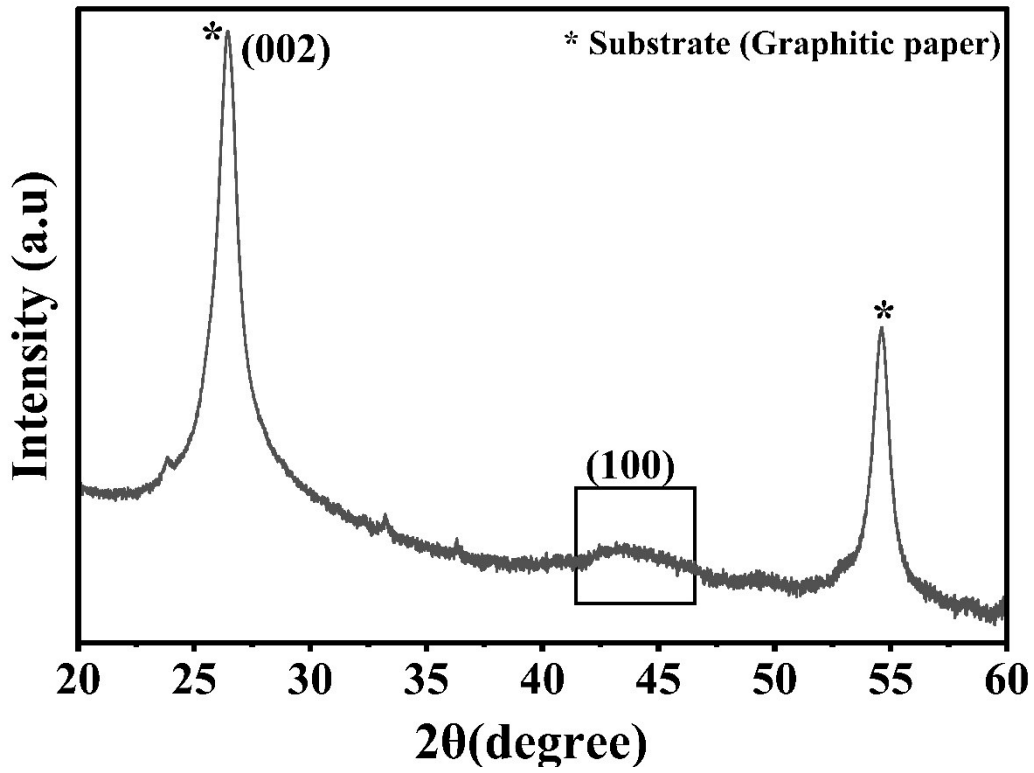

Figure S9 *XRD patterns collected after*10,000 charging-discharging cycles, of the h-BN (BM) electrodes prepared on Graphitic paper.

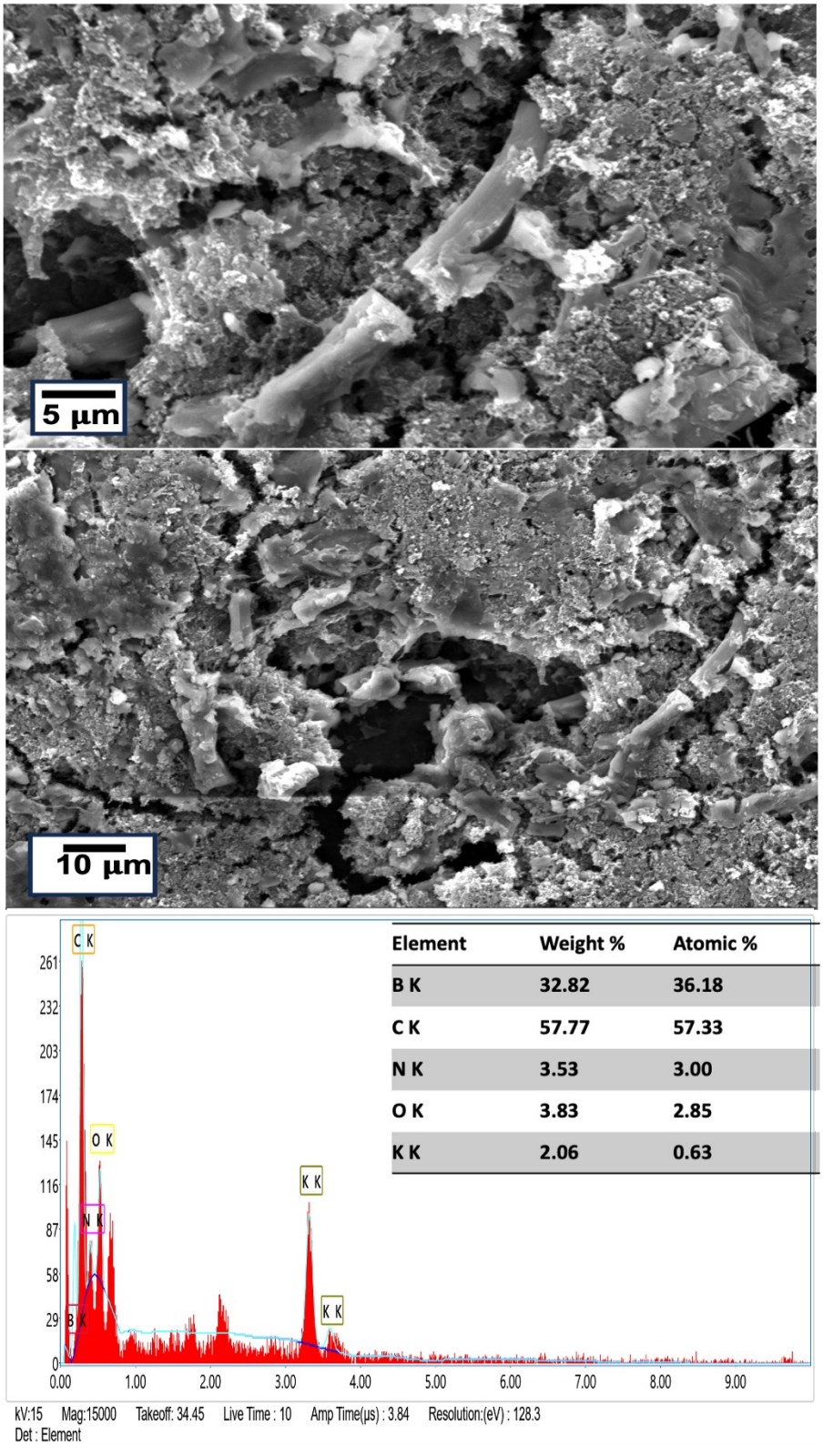

Figure.S10 SEM images and EDS, collected after 10,000 charging-discharging cycles of the h-BN (BM) electrode prepared on Graphitic paper. Higher magnification SEM images show the existence of rod-like morphology. The EDS shows K-related peaks due to the residual KOH present in the electrode.

Table S1. Structural parameters of h-BN samples synthesized via different precursor combinations, including lattice constants, interplanar spacing (d_{002}), average crystalline size (D), cell volume and χ^2 values derived from XRD.

Sample name	Lattice constant a=b (Å)	Lattice constant c (Å)	Interplanar spacing $d_{(002)}$ (Å)	Crystallite size D (nm)	Cell volume Å^3	χ^2	Rp	Rwp	Rexp
h-BN(BU)	2.556	7.032	3.51	1.3	39.77	2.27	4.23	5.57	3.70
h-BN(BM)	2.455	6.810	3.40	1.4	35.56	2.90	5.16	6.38	3.74
h-BN(BMU)	2.541	6.920	3.46	1.5	38.72	2.06	4.25	5.42	3.77

Table S2. XPS deconvolution results of the B 1s and N 1s core-level spectra for h-BN(BU), h-BN(BM), and h-BN(BMU) samples, showing binding energies and relative percentage contributions of B–N, B–O, N–B, and N–H bonding states.

Sample Name	Region	Labelling	Binding Energy (eV)	% contribution	(sp^2/sp^3) ratio
h-BN(BU)	B1s	B-N	190.83	50.40 %	1.01
		B-O	192.42	49.60%	
	N1s	N-B	398.47	81.04%	
		N-H	400.30	18.96%	
h-BN(BM)	B1s	B-N	190.65	61.90%	1.62
		B-O	192.32	38.10%	
	N1s	N-B	398.30	87.93%	
		N-H	400.20	12.14%	
h-BN(BMU)	B1s	B-N	190.58	55.32%	1.23
		B-O	192.43	44.68%	
	N1s	N-B	398.04	86.30%	
		N-H	400.02	13.70%	

Table S3. Specific capacitance of h-BN(BU), h-BN(BM) and h-BN(BMU) calculated from CV at different scan rates in 1 M KOH electrolyte.

Scan Rate (mV/s)	C_{sp} h-BN(BU) (F/g)	C_{sp} h-BN(BM) (F/g)	C_{sp} h-BN(BMU) (F/g)
2	455.0	516.8	493.3
5	415.3	461.9	445.2
10	369.9	415.5	390.5
25	282.8	335.4	303.2
50	212.5	264.2	232.4
75	174.2	224.7	195.0
100	152.4	196.2	168.9

Table S4. Specific capacitance of h-BN(BU), h-BN(BM) and h-BN(BMU) calculated from GCD at different current densities in 1 M KOH electrolyte.

Current Density (A/g)	C_{sp} h-BN(BU) (F/g)	C_{sp} h-BN(BM) (F/g)	C_{sp} h-BN(BMU) (F/g)
1	429.5	479.2	431.3
2	390.3	449.6	384.6
3	359.1	424.3	353.8
4	332.9	402.4	326.4
5	309.7	382.3	301.7
10	227.8	306.8	218.8