

Supporting Information

Enhanced piezoelectric performance of PAN nanofiber incorporated with a lead-free High entropy perovskite oxide for energy harvesting, sensing and IoT-based smart alert system for security monitoring

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Table S1: Refined parameters from XRD data of BNBSC

Sample Name	Space group	Lattice parameters	Atoms	Atomic positions (x,y,z)	Fitting factors
BNBSC	P4mm	a= 3.908316 Å b= 3.908316 Å c= 3.914477 Å Alpha= 90 Beta=90 Gamma=90 Cell Volume= 59.7920 Å ³	Ti	0.50000, 0.50000, 0.51188	R _p , R _{wp} & χ^2 46.0, 25.3, 4.23 S (goodness of fit) (R _{wp} /R _{exp}) =1.82
			Ba	0.00000, 0.00000, 0.00000	
			Na	0.00000, 0.00000, 0.00000	
			Bi	0.00000, 0.00000, 0.00000	
			Sr	0.00000, 0.00000, 0.00000	
			Ca	0.00000, 0.00000, 0.00000	
			O1	0.50000, 0.50000, 0.01600	
			O2	0.50000, 0.00000, 0.51500	

Table S2: The ionic radii of the A-site, B-site and O ions in BNBSC

Ion	Bi ³⁺	Na ⁺	Ba ²⁺	Sr ²⁺	Ca ²⁺	Ti ⁴⁺	O ²⁻
Ion radius (Å)	1.38	1.39	1.61	1.44	1.34	0.605	1.4

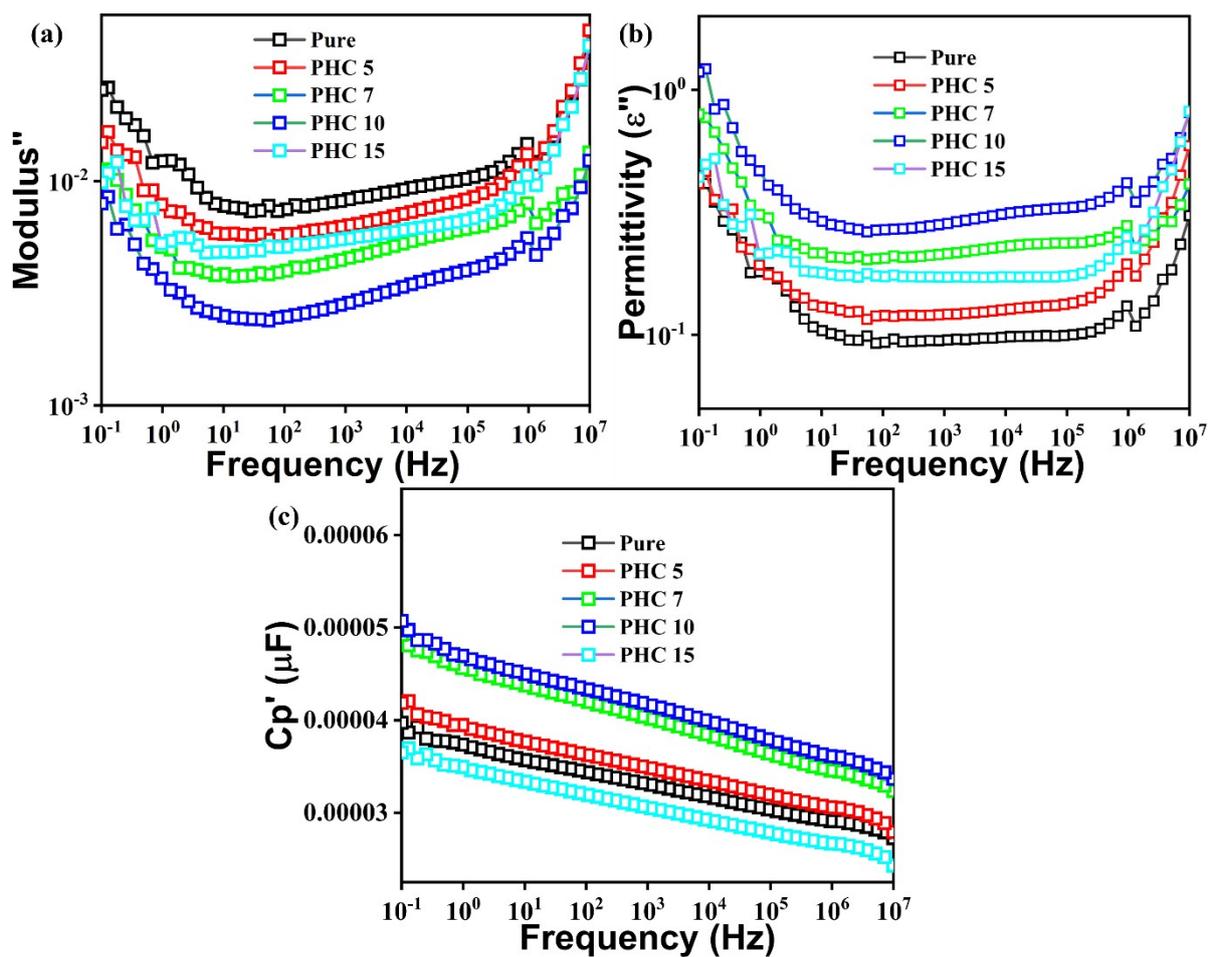


Figure S1: (a) Frequency Vs Imaginary modulus for Pure PAN and different PHC composites, (b) Variance of imaginary permittivity of Pure PAN and composites, (c) Variance of real capacitance for pure PAN and different composites.

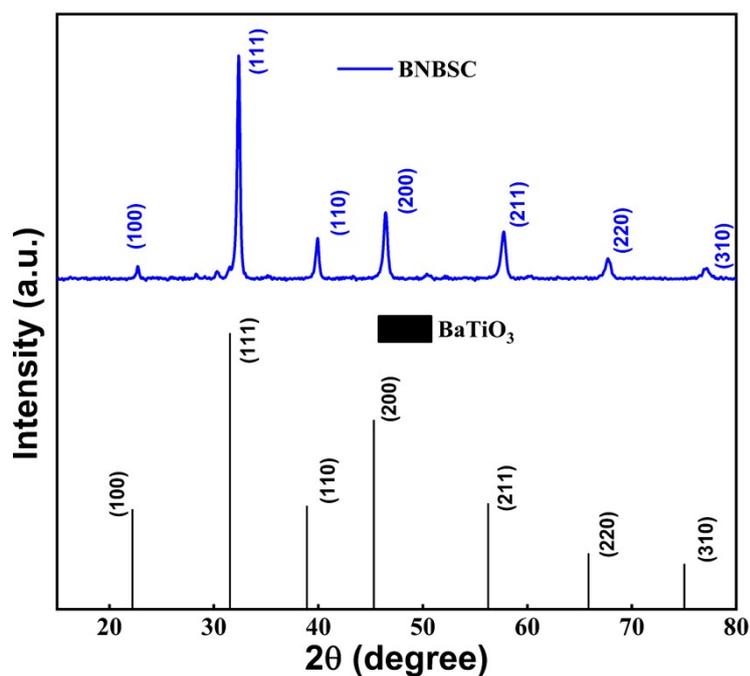


Figure S2: Comparison of the BNBSX XRD pattern with the XRD pattern of BaTiO₃.¹

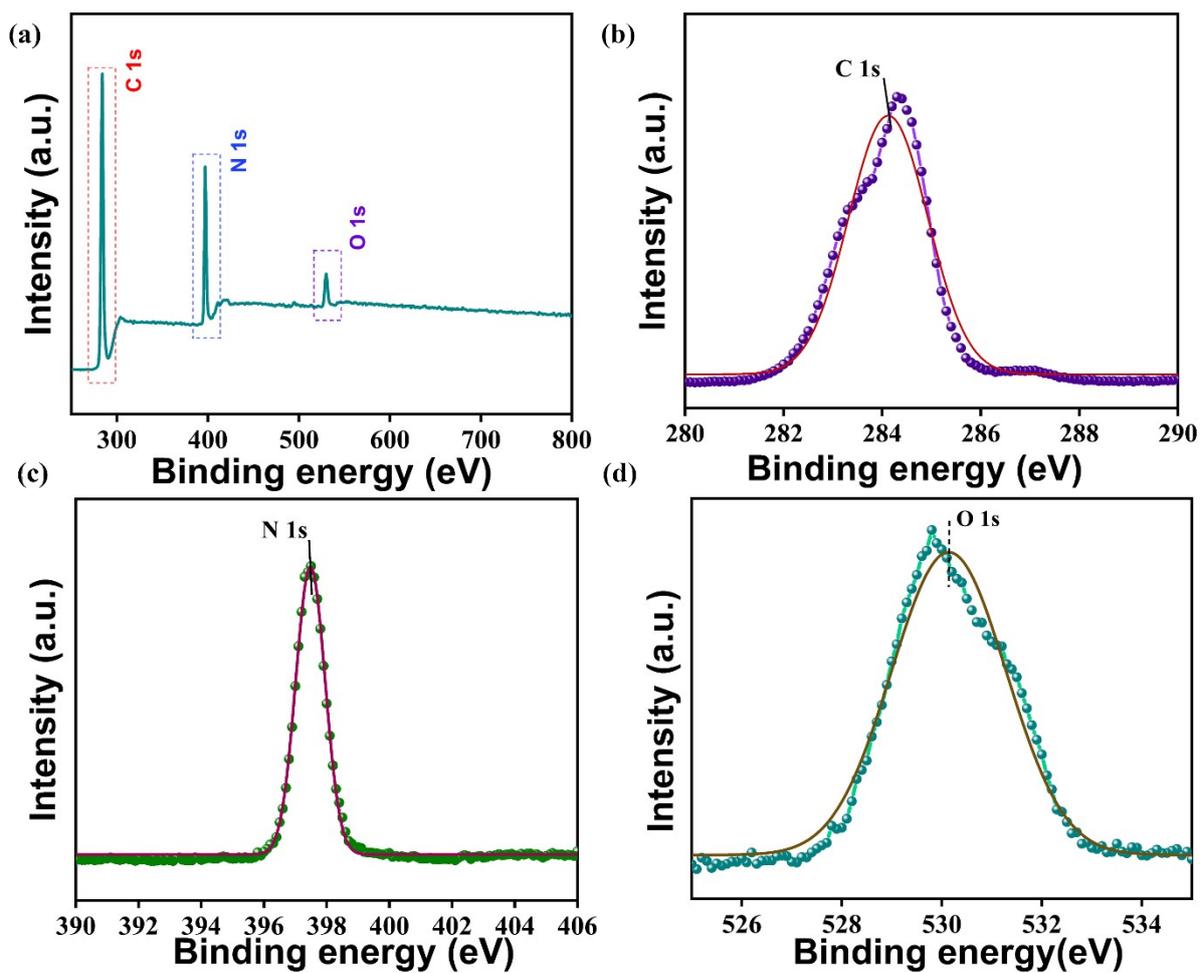


Figure S3: XPS analysis of Pure PAN film, (a) Survey scan spectra, (b) high resolution XPS elemental analysis of Carbon, (c) elemental analysis for Nitrogen, (d) elemental analysis for oxygen.

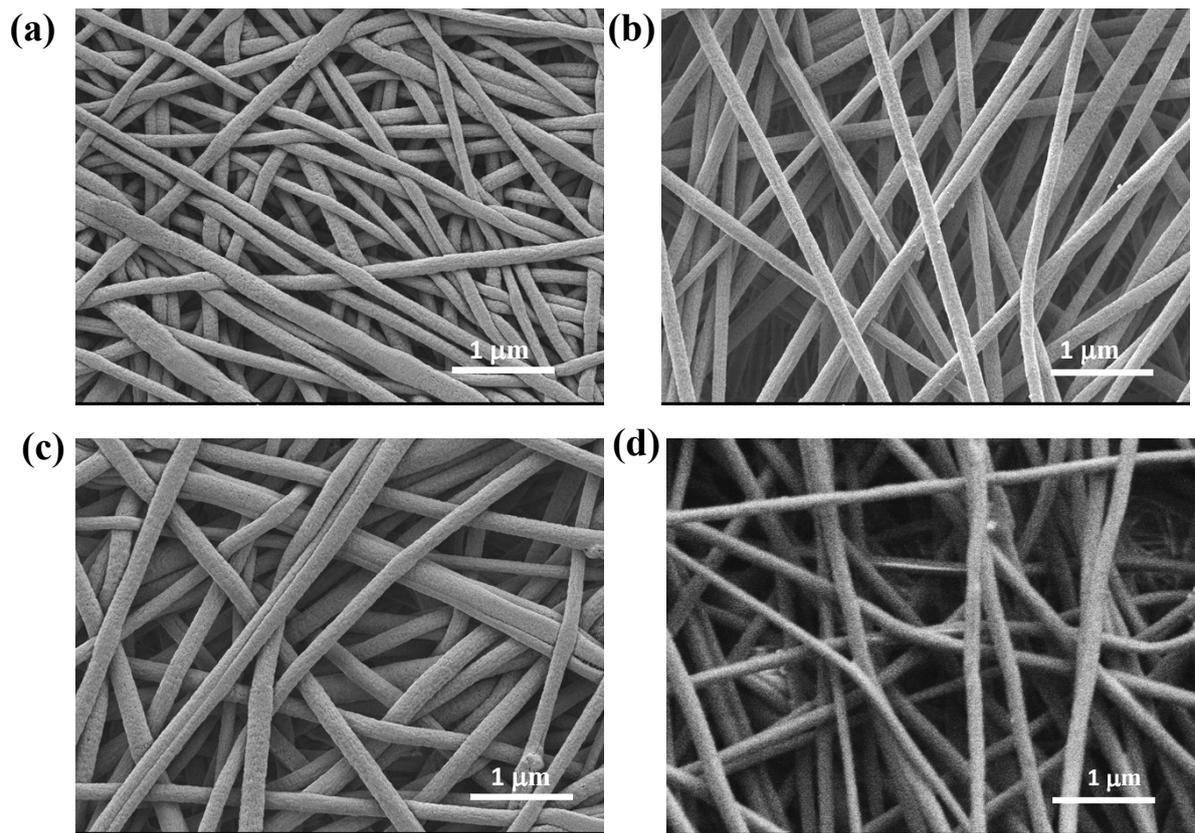


Figure S4: Scanning electron microscopic images (a) PHC 5 composite, (b) PHC 7 composite, (c) PHC 15 composite, (d) morphological observation of the PHC 10 composite after 10,000 cycles.

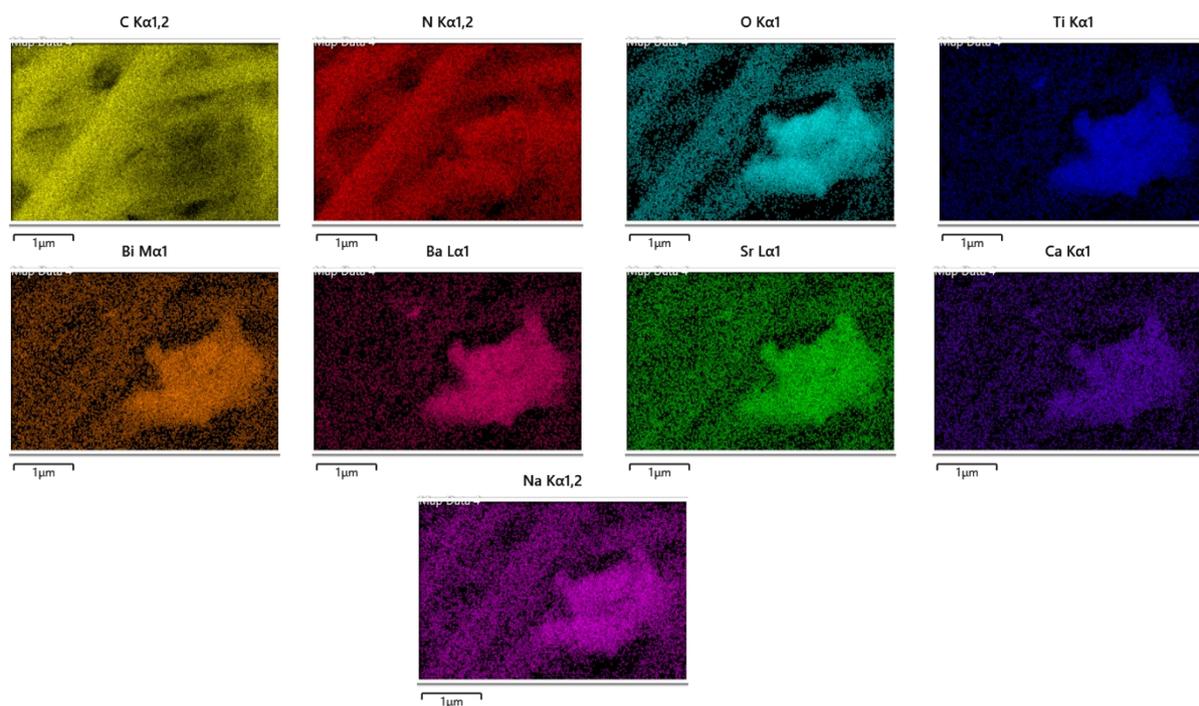


Figure S5: Representation of different elements present in PAN/HEPO composite from EDS elemental mapping.

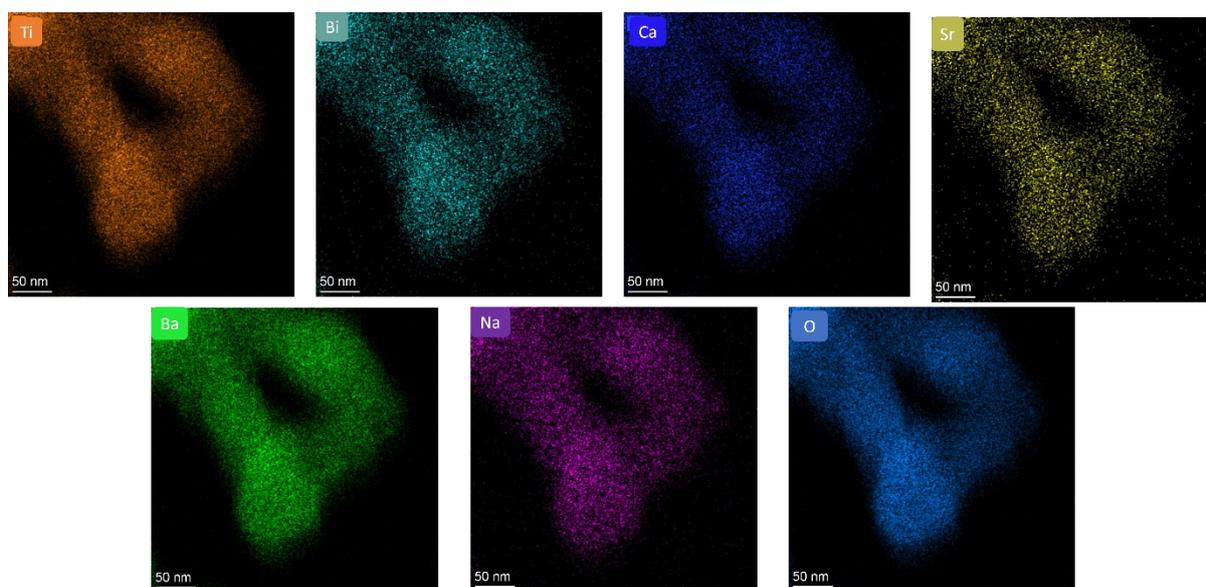


Figure S6: Compositional elemental mapping of the HEPO nanoparticle from a bright-field transmission electron microscopy (TEM).

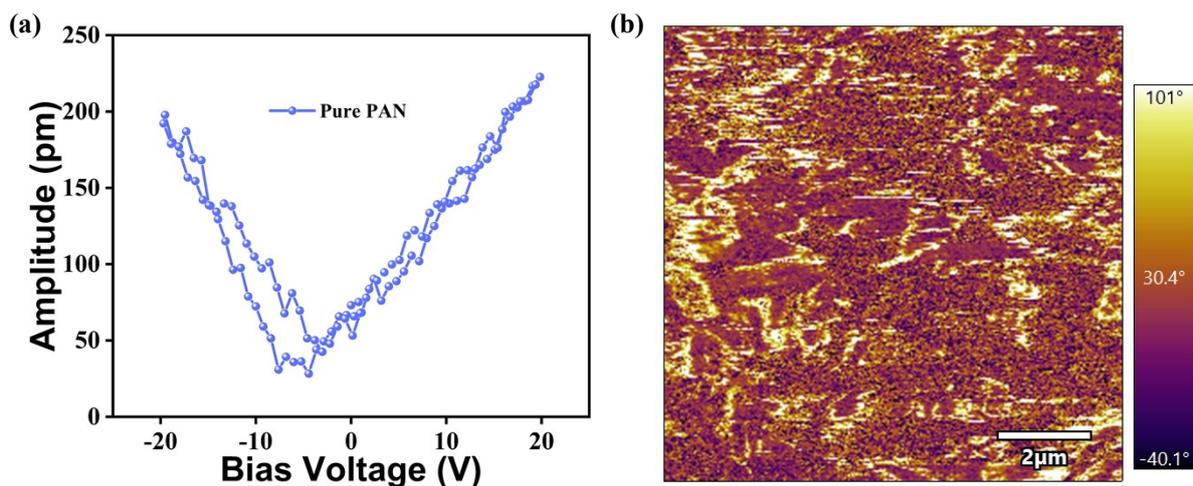


Figure S7: (a) PFM amplitude vs bias voltage for Pure PAN, (b) AFM topographic image of Pure PAN

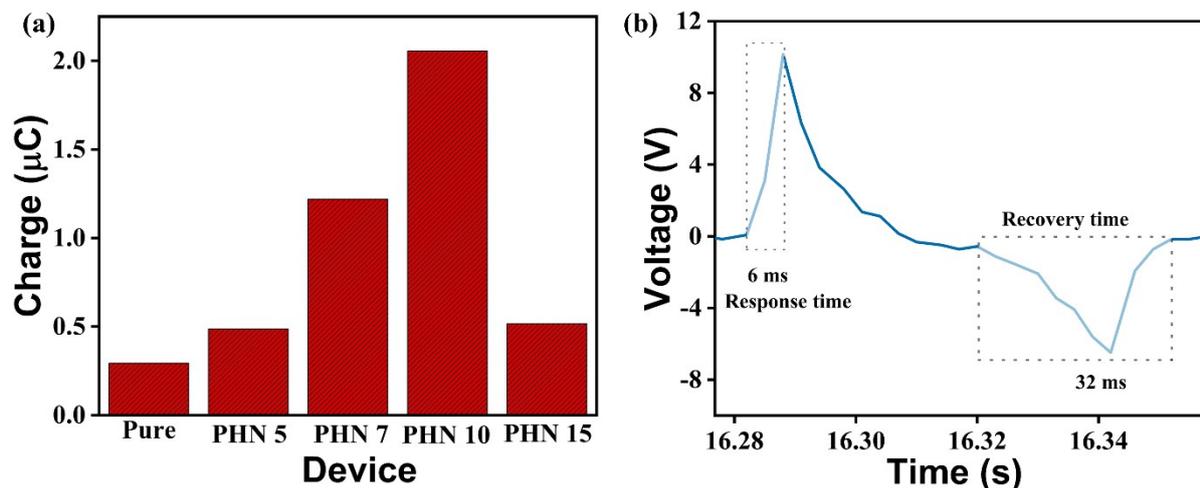


Figure S8: (a) Charge generated by different devices under hand tapping, (b) response and recovery time of the optimized device.

Table S3: Dielectric properties of pure PAN and other PHC composites

Sample	Dielectric constant (ϵ_r), at 0.1 Hz	Dielectric loss ($\tan \delta$), 0.1 Hz	AC Conductivity (μCm^{-1}), 10^7 Hz	Modulus'' at 0.1 Hz
Pure PAN	4.07	0.10512	10.1419	0.02549
PHC 5	5.25	0.07877	14.3024	0.0149
PHC 7	6.66	0.09441	25.3138	0.01111
PHC 10	12.14	0.09741	39.5343	0.00795
PHC 15	8.42	0.06603	19.6532	0.00987

Table S4: Voltage, Current, current density, power and power density of PHN 10 device across various load resistors.

Output Voltage, Current and Power response at different resistance:

Resistance Ω	Voltage V	Current μA	Power μW	Current Density ($\mu\text{A}/\text{cm}^2$)	Power Density ($\mu\text{W}/\text{cm}^2$)
100000	4.1	41	168.1	6.56	26.896
150000	5	33.33	166.66	5.33	26.666
330000	8.5	25.75	218.93	4.12	35.028
470000	11.5	24.46	281.38	3.91	45.021
560000	13.2	23.57	311.14	3.77	49.782
680000	15.7	23.08	362.48	3.69	57.997
800000	18.1	22.62	409.51	3.62	65.52
1000000	21.8	21.8	475.24	3.48	76.04
2200000	53.2	24.18	1286.47	3.87	205.84
3200000	65	20.31	1320.31	3.25	211.25
4400000	76	17.27	1312.72	2.76	210.04
6600000	81	12.27	994.09	1.96	159.05
1E7	96	9.6	921.6	1.54	147.46
2E7	98	4.9	480.2	0.784	76.83
3E7	99.5	3.31	330.01	0.53	52.80

S9. Supporting videos:

S10. References:

- (1) Al-Shakarchi, E. K.; Mahmood, N. B. Three Techniques Used to Produce BaTiO₃ Fine Powder. *Journal of Modern Physics* **2011**, 2 (11), 1420–1428.
<https://doi.org/10.4236/jmp.2011.211175>.