Almond Shell-Derived Carbonaceous Materials as Anodes for Sodium-Ion Batteries

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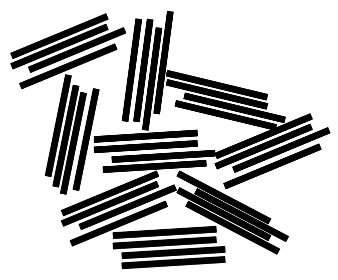
Objective

- To synthesize disordered carbon from biowaste materials
- To optimize synthesis procedure by varying the type of gas [Ar, N_2, Ar + 5% H_2 (AW5)] during synthesis
- To investigate their electrochemical performance as anode in Na-ion battery

Synthesis

Washing with 10% (v/v) H_2SO_4 → Washing with distilled water until neutral, then drying at 80°c → Ball milling, then carbonization at 1000°c under different atmospheres →

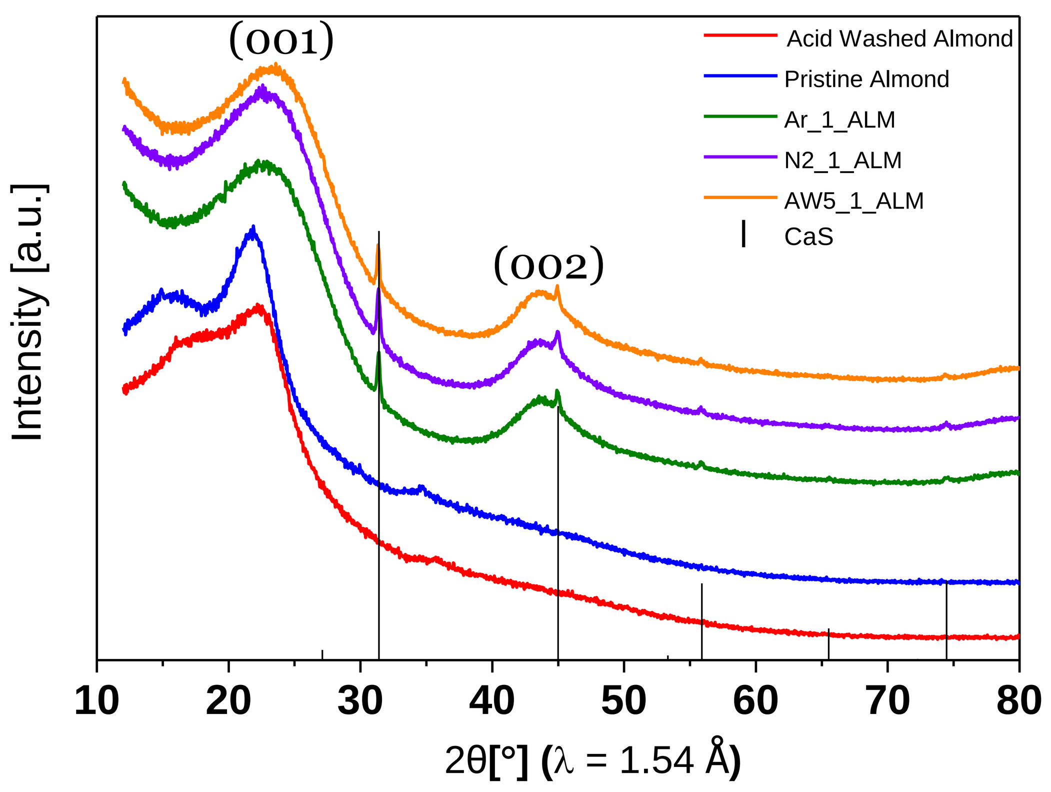


Disordered carbon[1]

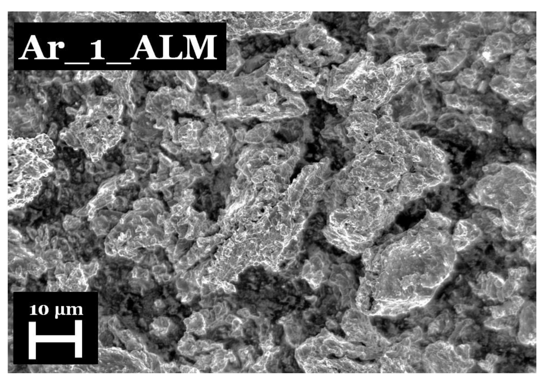
[1]D. A. Stevens and J. R. Dahn, *Journal of the Electrochemical Society*, 2000.

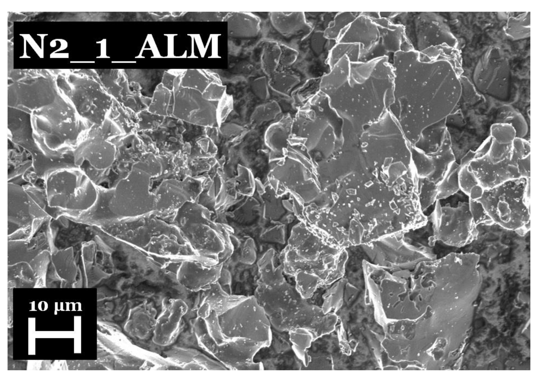
Characterization Techniques

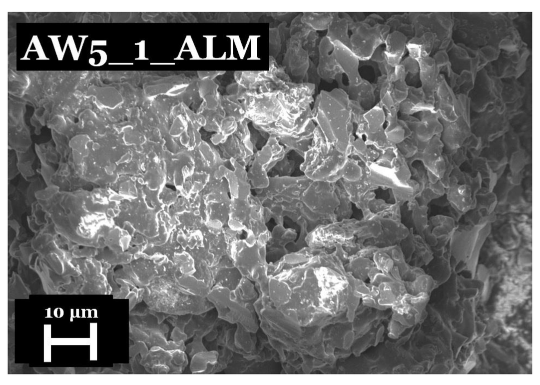
XRD and SEM



✓ CaS peaks appear due to reduction of $CaSO_4$ in almonds during carbonization

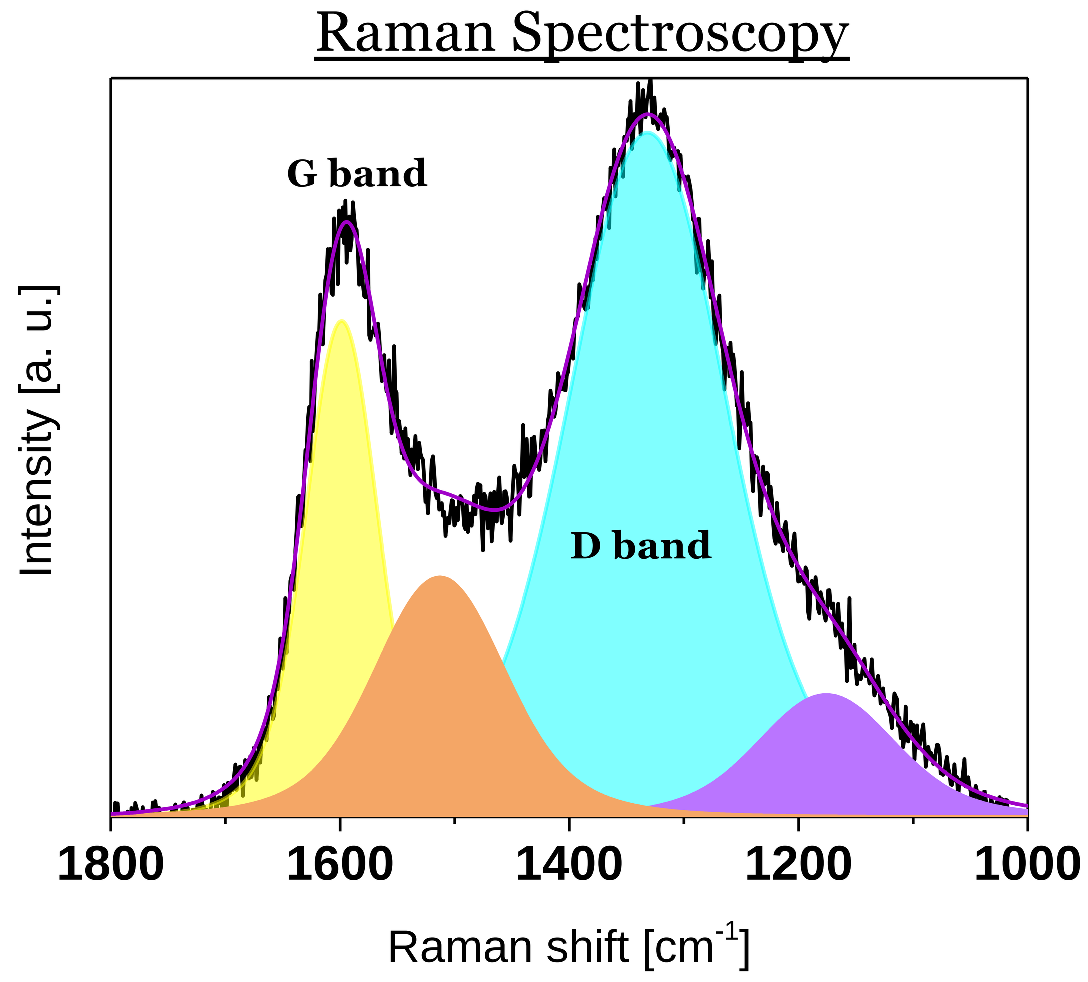






✓ Randomly shaped agglomerated carbon particles

Raman Spectroscopy



✓ Bands at ~1500 and ~1200 cm⁻¹ are due to sp[3] and tetrahedral type carbons[2]

✓ Low I_D/I_G ratio, high degree of graphitization[3]

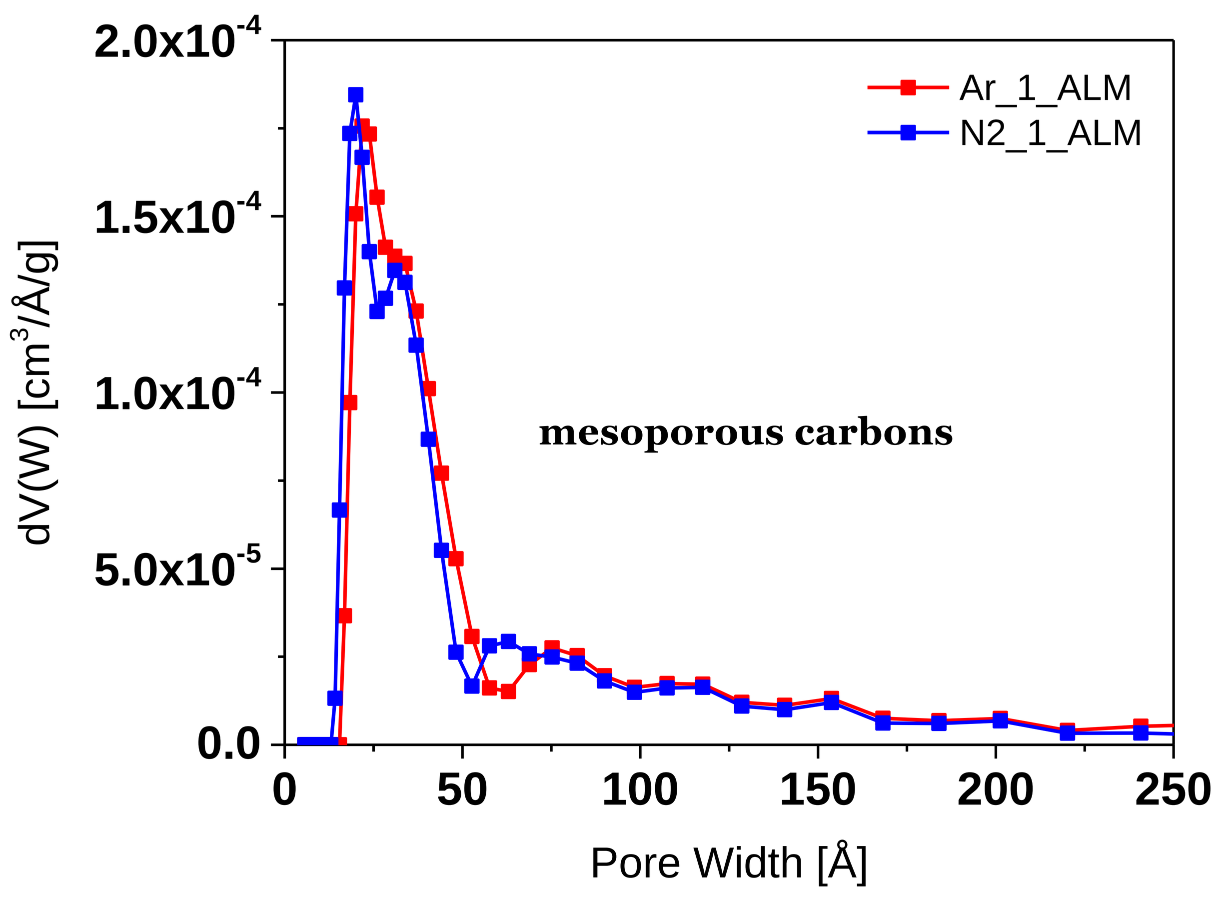
Samples	Raman shift (cm⁻¹) 1 (G band)	3 (D band)	I_D/I_G ratio
Ar_1_ALM	1600	1331	1.38
N2_1_ALM	1600	1331	1.34
AW5_1_ALM	1600	1328	1.29

[2]M. Doeff, et al., *Electrochemical and Solid State Letters*, 2003.
[3]E. Irisarri et al., *Journal of the Electrochemical Society*, Review, 2015

BET Surface Area

Samples	Surface Area (m²/g)	Total Pore Volume (cm³/g)*
Ar_1_ALM	4	8x10⁻³
N2_1_ALM	4	8x10⁻³

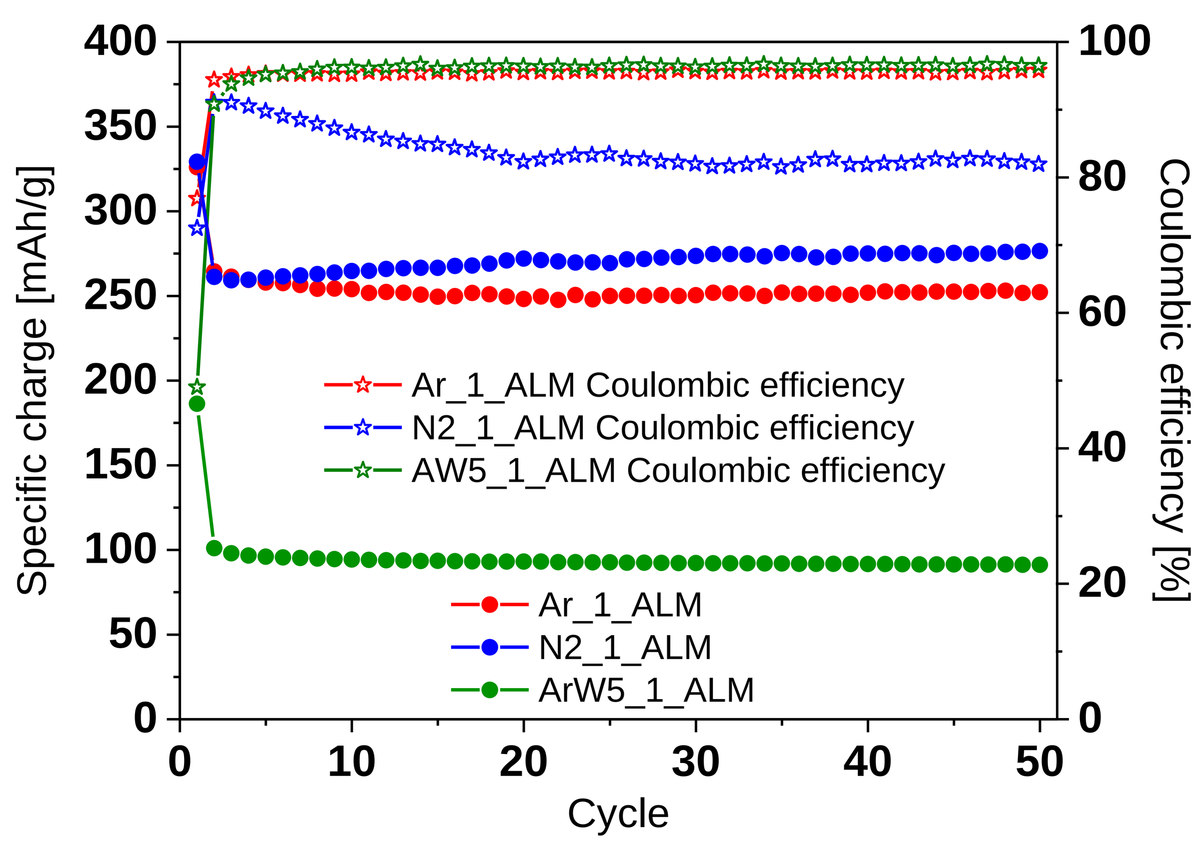
*at P/P_o = 0.98897



✓ Similar surface area, total pore volume and pore size distribution for carbons synthesized under Ar and N_2

Electrochemical Performance

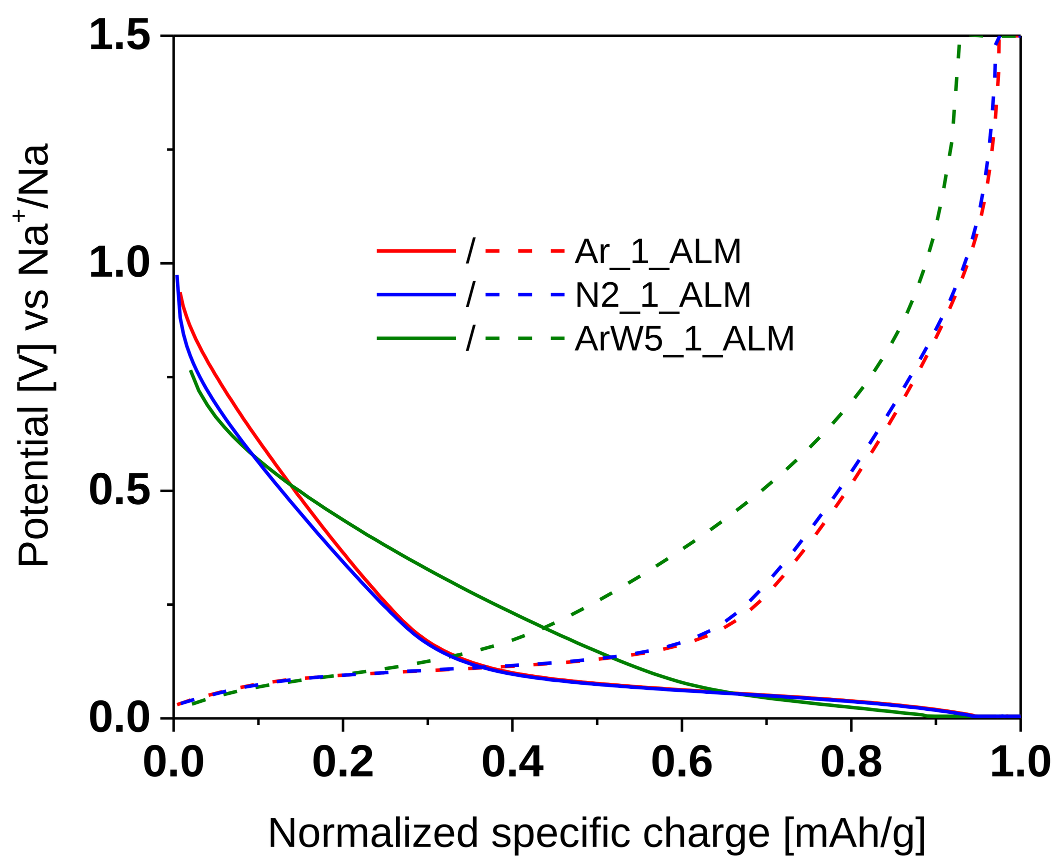
Cycling Performance and Galvanostatic Profiles



Electrolyte: 1 M $NaClO_4$ in PC
Cycling rate: C/10
Voltage window: 5 mV to 1.5 V

✓ Identical galvanostatic profiles and initial specific charge for Ar_1_ALM and N2_1_ALM

✓ Increasing specific charge for N2_1_ALM possibly due to electrolyte decomposition



Conclusions

✓ Disordered carbon anodes were successfully synthesized from a biowaste material

✓ Synthesis under a reductive atmosphere (AW5) led to a carbon anode with poor electrochemical performance

✓ Synthesis under Ar and N_2 led to carbonaceous materials with the same physical properties

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