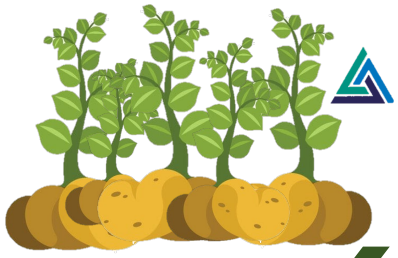
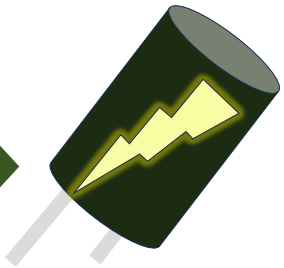


LAIDLAW FOUNDATION

Development of Sustainable Supercapacitors from Food Waste

Oliver Pugh

Durham University



INTRODUCTION

Amid growing scarcity of lithium and rising energy storage demands, we urgently need alternatives. Electrochemical double layer capacitors (EDLCs) with long lifespans and fast charge/discharge times are ideal for intermittent renewables and remote energy holding great promise.

This study explores using eco-friendly, steam-based activation of activated carbon from Maris Piper Potato peelings, rich in lignocellulosic content, for sustainable EDLCs.

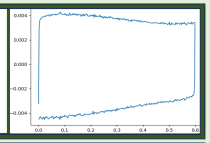
Potato Peel

>4 Million Potatoes wasted DAILY in the UK

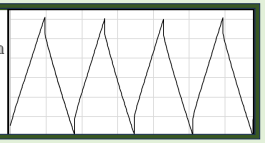
Drying & Grinding

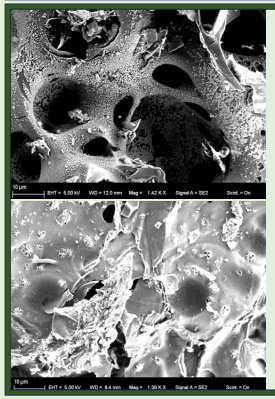
- 12H at 100°C
- Pestle & Mortar to small chunks(>2mm)
- Ball Mill to Fine Powder(>0.5mm)

Cyclic Voltammetry(CV) at scan rates 5mV/s, 15mV /s & 25mV/s between 0 – 0.6V found a specific capacitance of **(48.707 +/- 0.015) F/g**

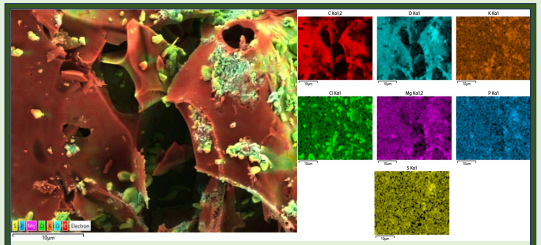


Galvanostatic Charging/Discharging between 0-0.6V to calculate Charging and Discharging ESR and coulombic/ energy efficiency





Scanning Electron Microscopy (SEM) shows the porosity of the carbonaceous structure caused activation by steam at 700°C



Energy Dispersive X-ray(EDX) giving chemical analysis of activated potato peel: majority carbon structure with significant potassium and chlorine deposits.

RESULTS

	COMMERCIAL AC	POTATO AC	VERDICT
Specific Capacitance(F/g)	74.66 ± 0.10	48.707 ± 0.015	INFERIOR
Specific Energy(J/g)	13.44 ± 0.02	8.767 ± 0.003	INFERIOR
Specific Power(W/g)	0.2222 ± 0.0003	0.21761 ± 0.00005	COMPARABLE
Coulombic Efficiency(%) - CV	98.83 ± 0.07	98.43 ± 0.06	COMPARABLE
Energy Efficiency(%) - CV	98.87 ± 0.07	98.49 ± 0.06	COMPARABLE
Charging ESR	0.4288 ± 0.0005	2.04 ± 0.02	INFERIOR
Discharging ESR	0.38 ± 0.04	2.14 ± 0.03	INFERIOR

GCD & CV revealed both test cells had comparable specific power, coulombic and energy efficiency but inferior specific energy and capacitance to the commercial AC test cell. However, values are of the same order of magnitude, and could be improved with experimental procedure refinement

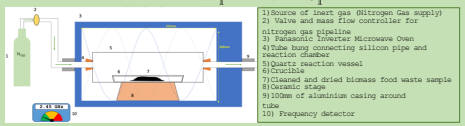
CONCLUSION

Potato peel derived AC test cell had comparable performance, and thus potato peel is a valid precursor material to AC with hierarchical porosity to be used in EDLCs.

In the UK alone, ~4.4million whole potatoes are thrown away daily[1], thus with industrial economies of scale, potato peel could be a plentiful, sustainable source of green energy storage technology.

FURTHER WORK

Microwave Oven for carbonization and activation of biomass waste. See below a potential setup:

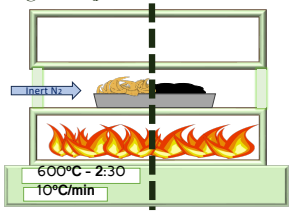


Microwave heating of biomass displays 80-85% efficiency suggestive of significantly more promise for industrial scalability

[1] WRAP, Food surplus and waste in the UK – key facts, updated January 2020, https://wrap.org.uk/sites/default/files/2020-11/Food-surplus-and-waste-in-the-UK-key-facts-Jan-2020.pdf

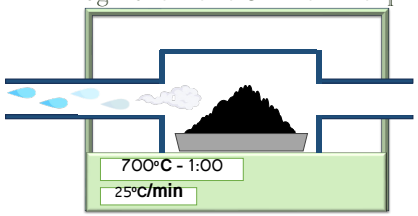
Pyrolysis

Converting potato peel to carbon powder using high temperature in inert atmosphere



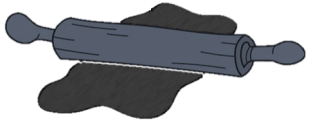
Carbon Activation

Steam + High Temperature = Activated Carbon(AC) with huge surface area & hierarchical porosity



Electrodes from Carbon Cloth

AC + Carbon Black + PTFE binder rolled out into sheet = Freestanding Potato Peel Electrodes



Creation of Super-capacitors

Assembly of test cell using KOH electrolyte

Electrochemical Double-Layer Capacitor(EDLC) Schematic