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Development of pouch-scale cells supercapacitors using 2D materials

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Multiscale Analysis Facilities For Energy Storage
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Outline

- Introduction
- Materials characterization and processing facilities
- Aim of study
- Challenges
- Experimental study
- Results and discussion
- Conclusions

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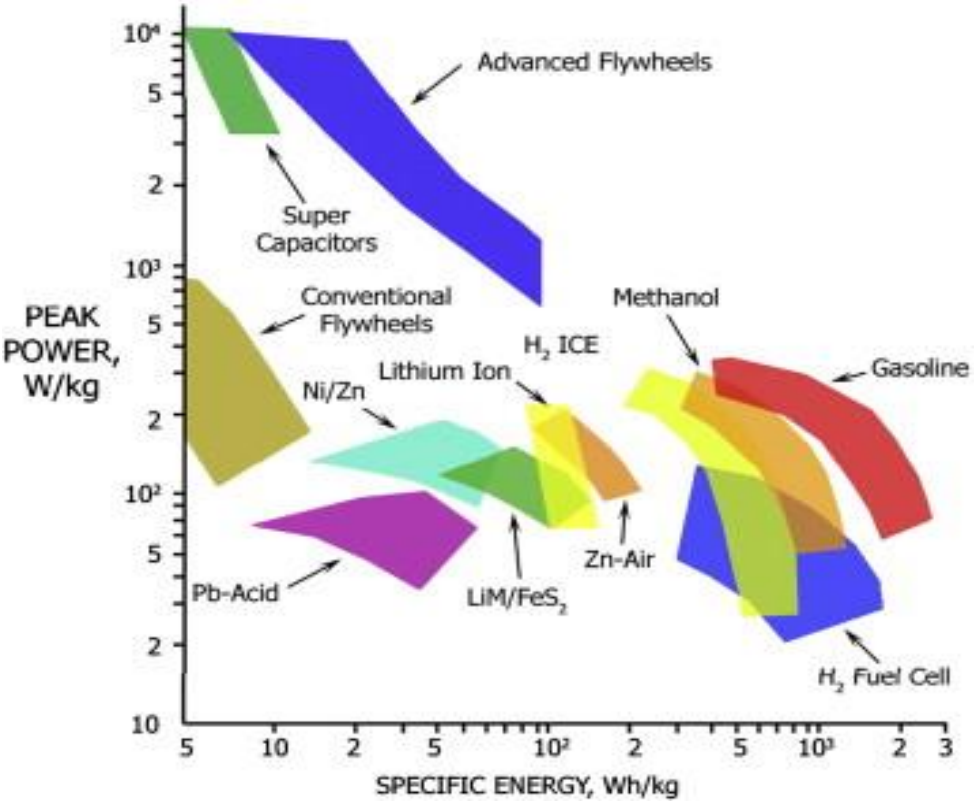
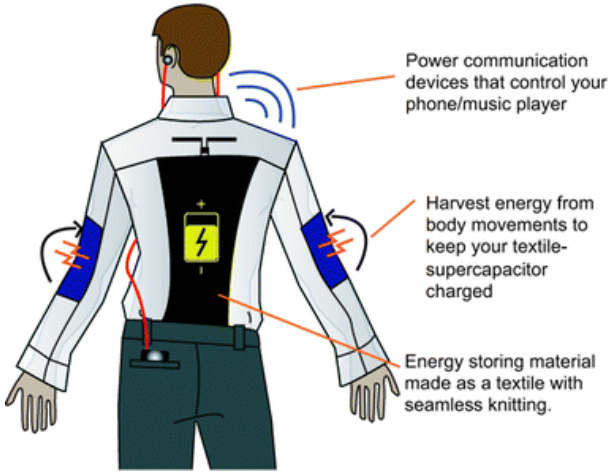
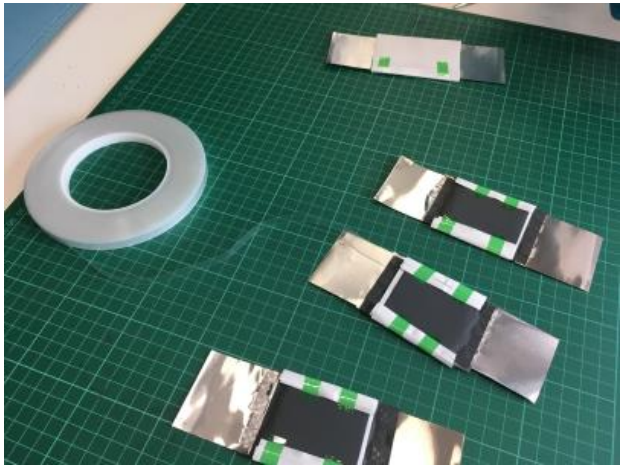
Supercapacitors





Ahmed F. Ghoniem, Progress in Energy and Combustion Science 37 (2011) 15-51

Materials Processing



Materials Characterization

Morphological Characterization

- Transmission Electron Microscopy (TEM)
- Scanning Electron Microscopy
- Atomic Force Microscopy

Surface Characterization

- BET Surface area and porosimetry measurement
- Surface profilometer

Thermal Characterization

- Thermal Gravimetric Analyser (TGA)
- Differential Scanning Calorimetry (DSC)

Materials Characterization

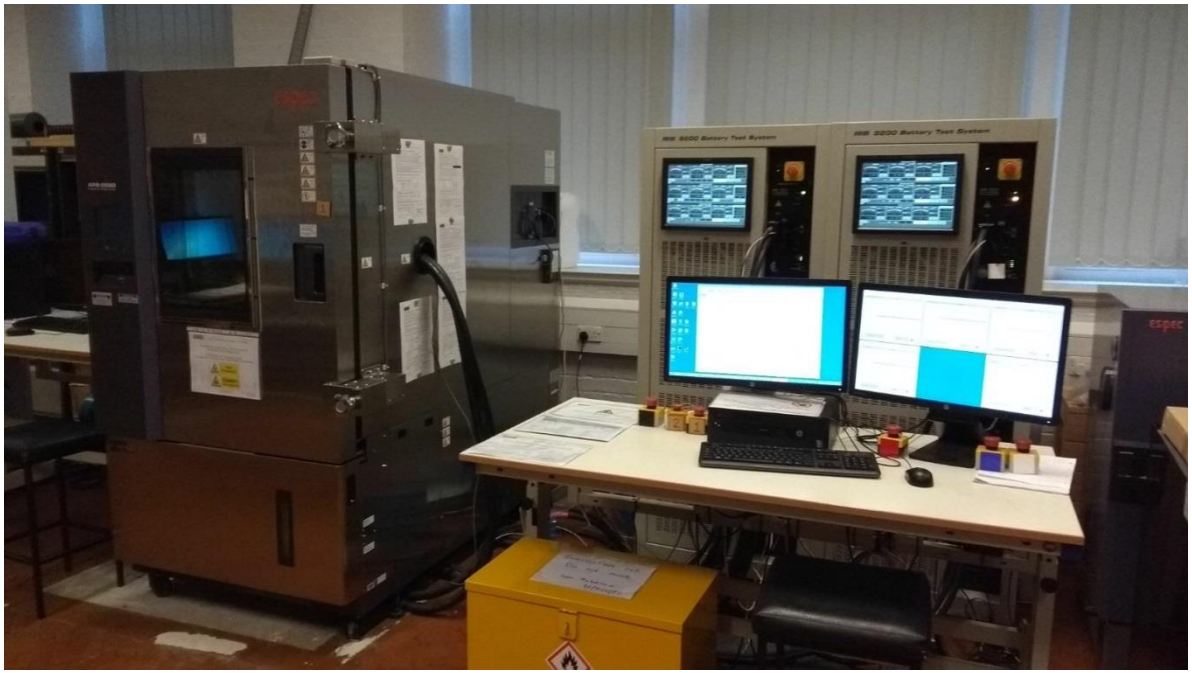
Structural Characterization

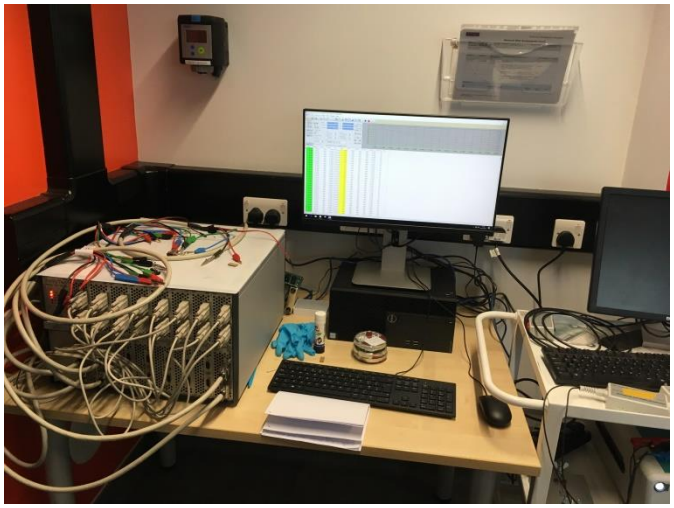
- Fourier transform infrared spectroscopy
- Raman Spectroscopy
- Near ambient pressure X-ray photoelectron spectroscopy (XPS)
- Single crystal diffractometer
- Powder X-ray diffractometer

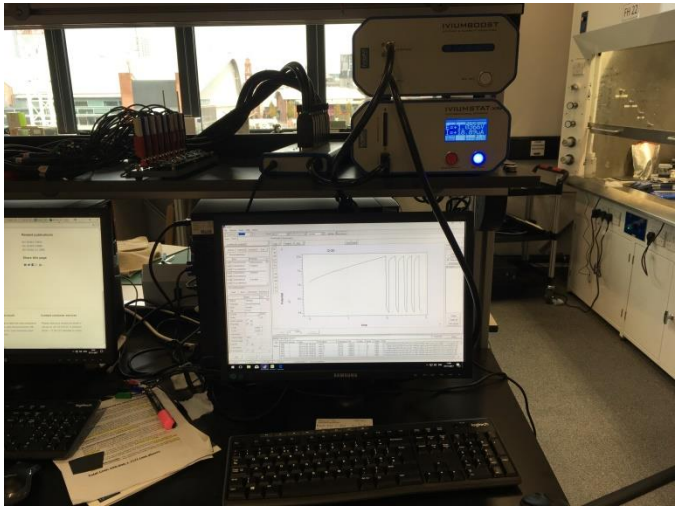
Electrochemical Characterization

- Potentiostat /Galvanostat (Cyclic voltammetry, EIS and cycling charge/discharge)
- Multi-channel galvanostatic charge-discharge tester (for coin cells and pouch cells)
- Battery Charge/Discharge Test System – 9200 (for battery packs)
- Environmental Test Chambers

Electrochemical Characterization







- Battery Charge/Discharge Test System – 9200 (for battery packs)
- Environmental Test Chambers (-75^{o}C – 180^{o}C)

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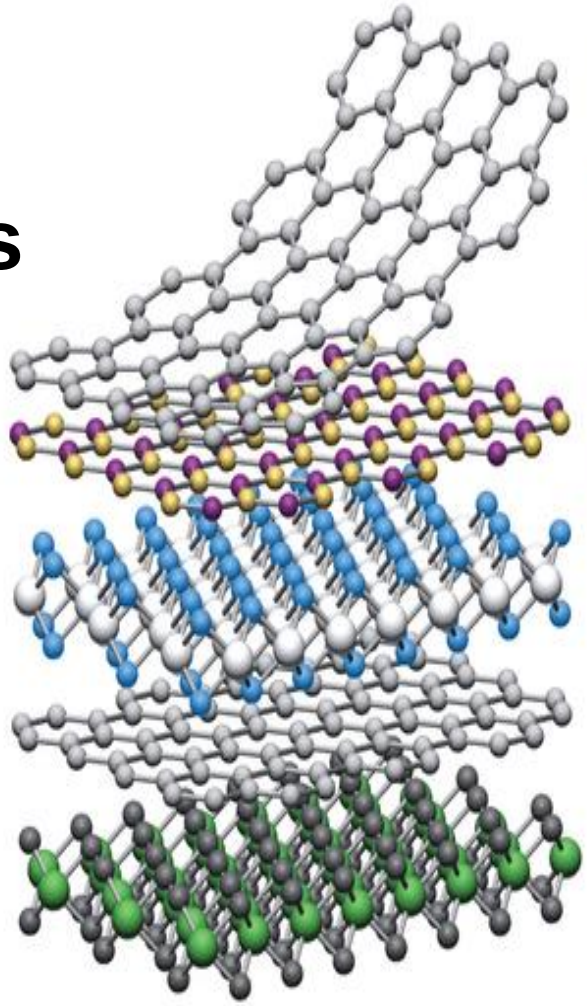
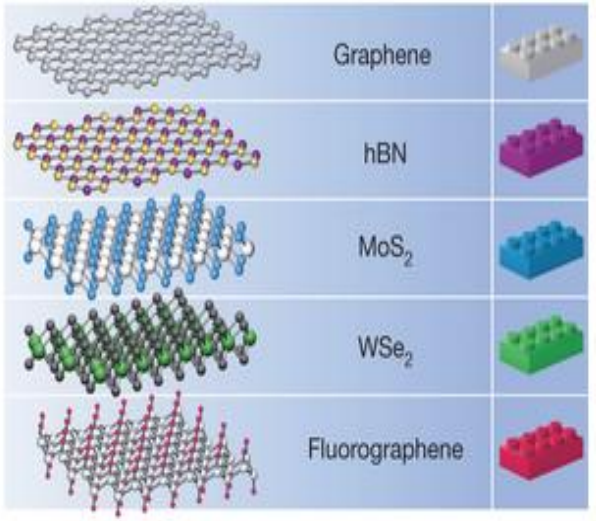
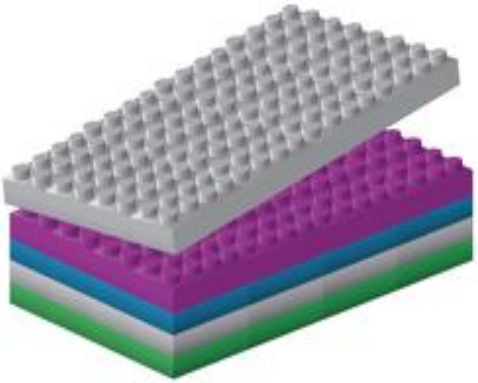
Supercapacitors

- Energy density
- Voltage window
- Surface Area
- Conductivity

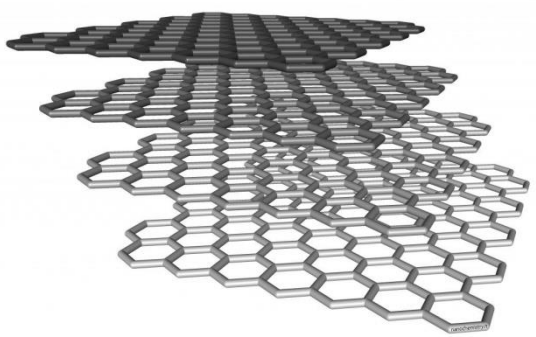






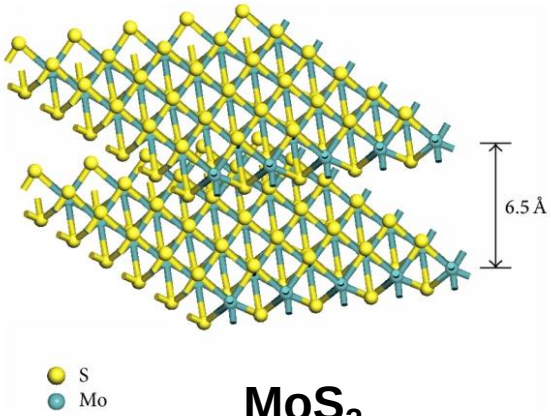
http://titus.phy.qub.ac.uk/opportunities/heterostructures/

Aim of Study



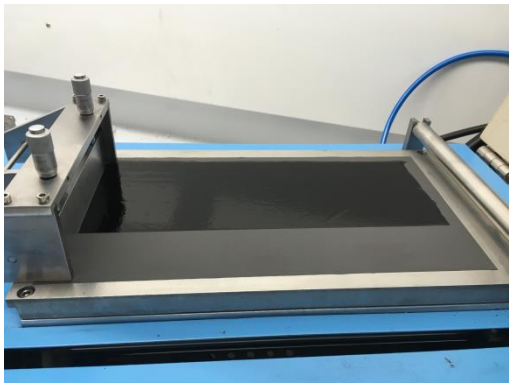
Graphene

+



MoS_2

→ **Graphene/MoS_2 Composite Electrodes**



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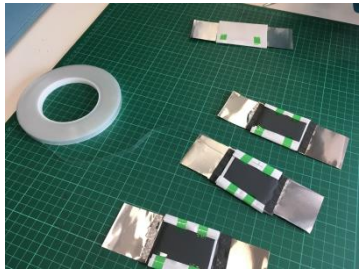

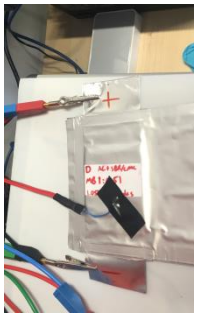

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Challenges

- What type of Graphene?
- High amounts of exfoliated MoS_2 production
- Overcome the agglomeration of 2D materials
- Provide homogenous distribution through the electrode
- Scale up of coin cell performance
- Modify the electrode preparation
- Effect of binders on the electrochemical performance of electrodes

Experimental studies

- Modify the traditional electrode preparation method. (for 2D materials)

- Find out a suitable binder (at different current density)

XG-GnP (Graphene Nanoplateles): C-750
Average diameter: less than 2 micron
Thickness: approx. 2 nm
Average surface area: 750 m^2/g

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Experimental studies

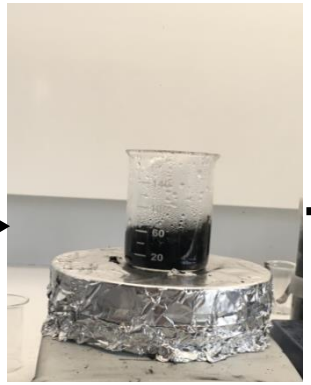
No	Polymer binders	GnP (XG-750)	Solvent	Organic Electrolyte	Aqueous Electrolyte
1	10 wt.% SBR/CMC (Targray)	90 wt.%	DI water	1 M Et_4NBF_4 :Acetonitrile	1 M Na_2SO_4 :Water
2	10 wt.% PVDF (Kynar)	90 wt.%	NMP	1 M Et_4NBF_4 :Acetonitrile	1 M Na_2SO_4 :Water
3	10 wt.% CMC (Sigma Aldrich)	90 wt.%	DI water	1 M Et_4NBF_4 :Acetonitrile	1 M Na_2SO_4 :Water
4	10 wt.% Kynar Flex (Kynar)	90 wt.%	Acetone	1 M Et_4NBF_4 :Acetonitrile	1 M Na_2SO_4 :Water

Experimental studies

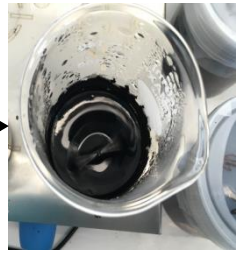
1g XG 750

Sonication for 2h

Evaporating excess solvent

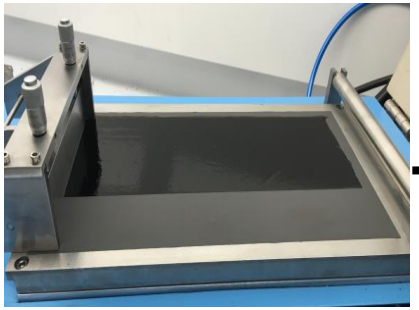


Pour into binder solution



Until become a slurry

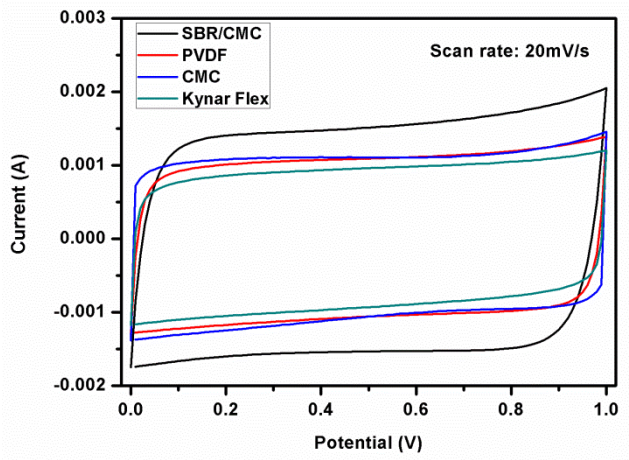
Dried at 80°C in oven

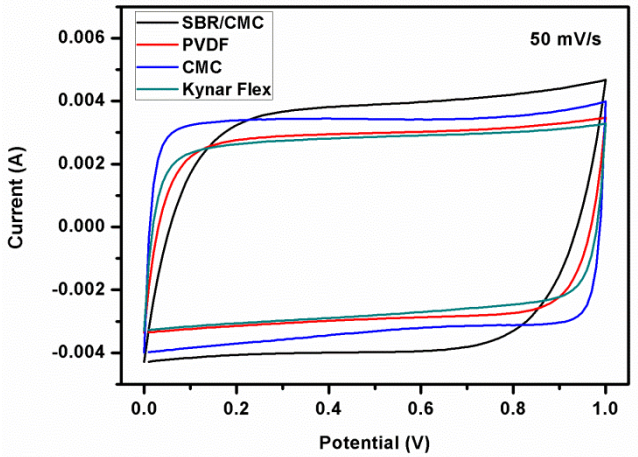


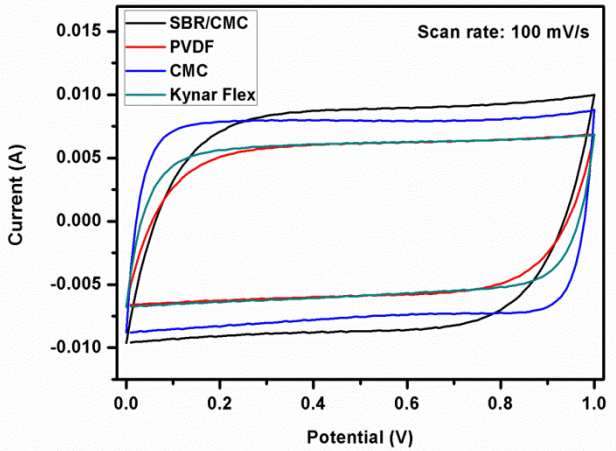
Coating of Graphene by tape casting

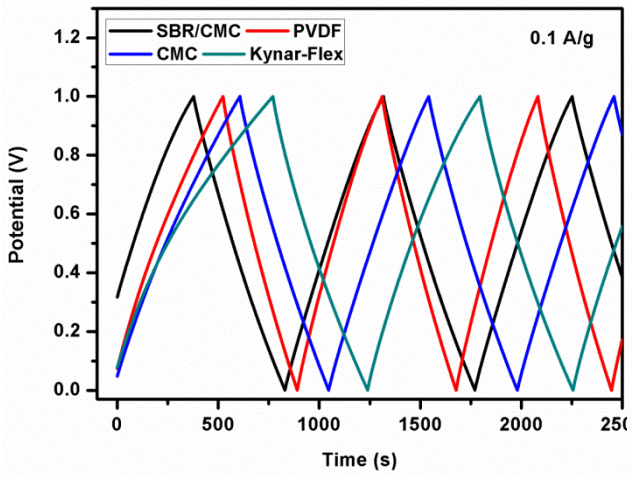
Rolling press

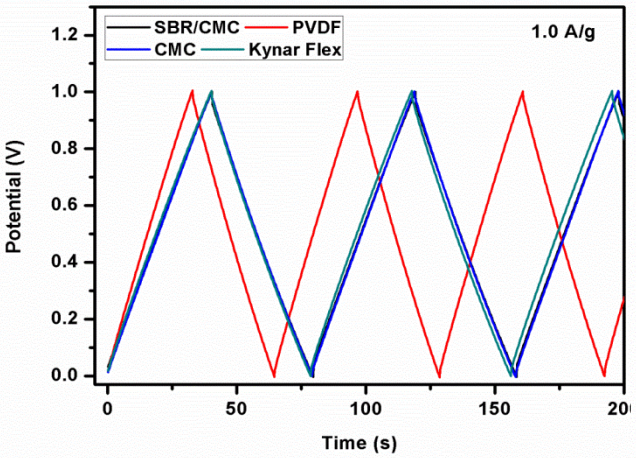
Results and Discussion
(Aqueous electrolyte)

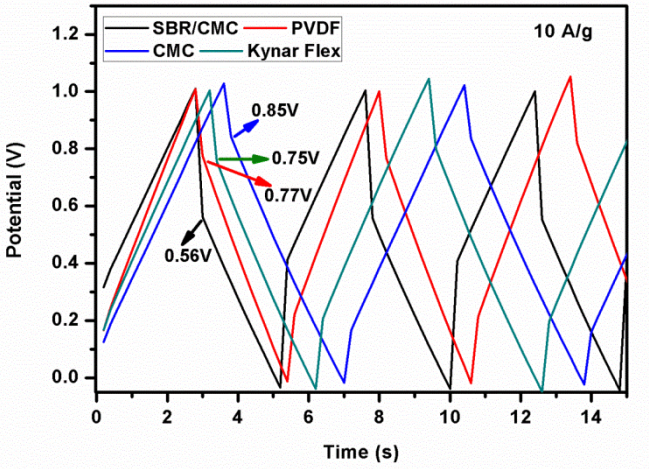




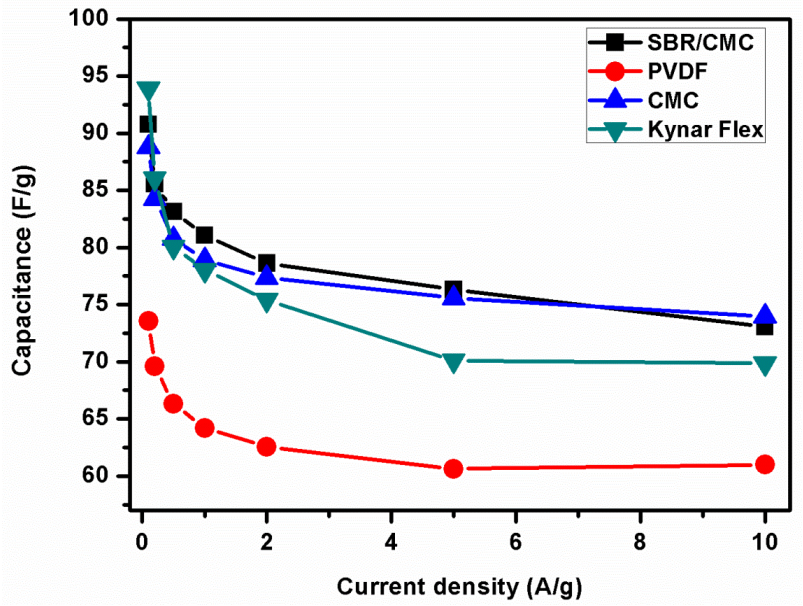


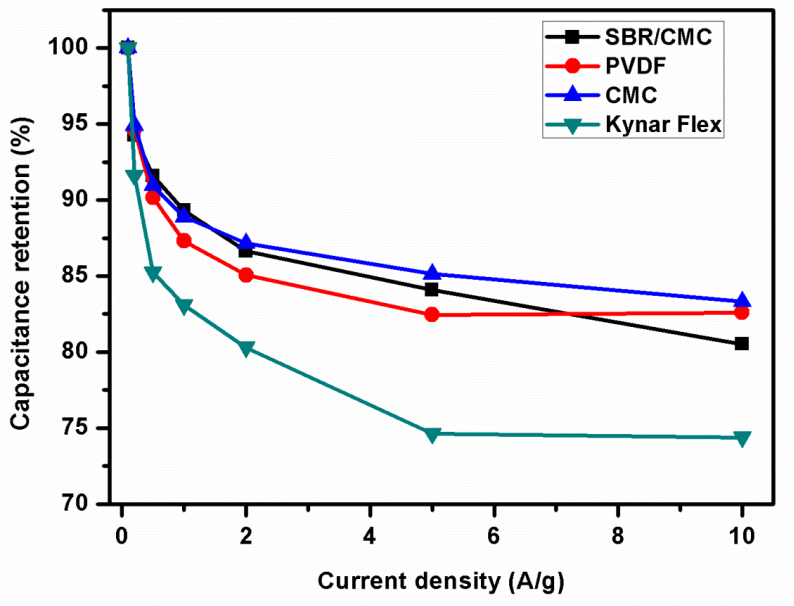






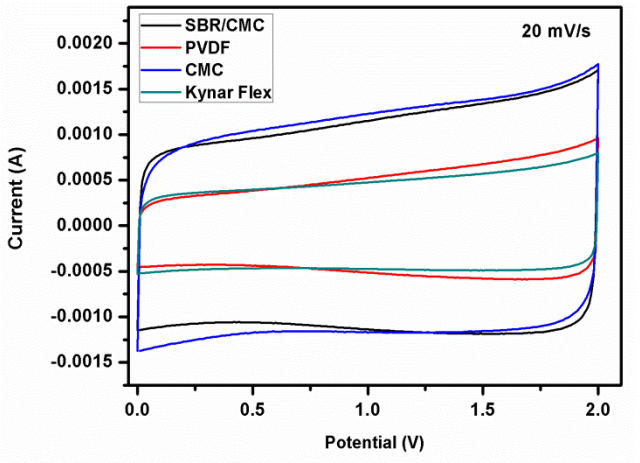
Results and Discussion
(Aqueous electrolyte)

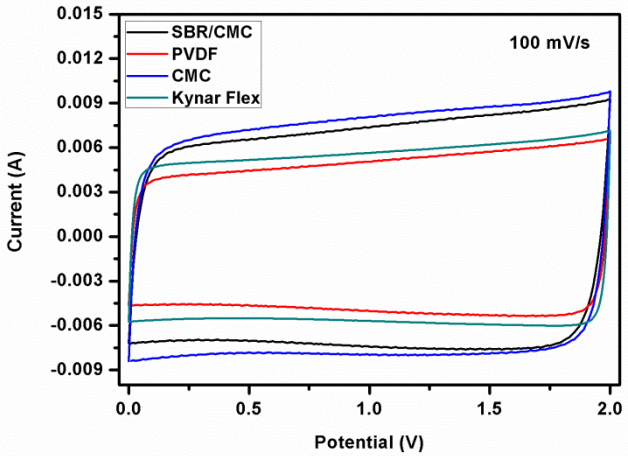


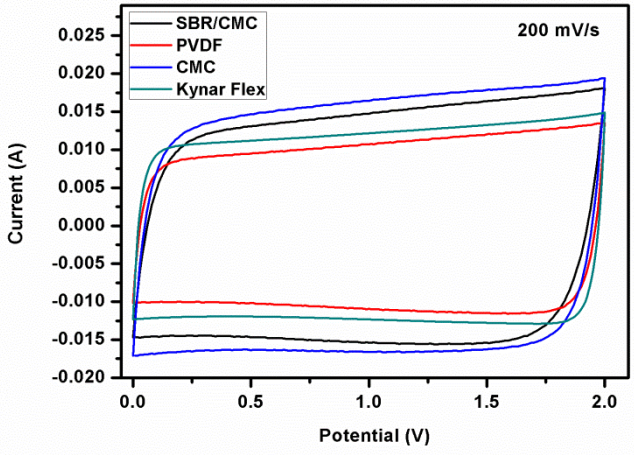


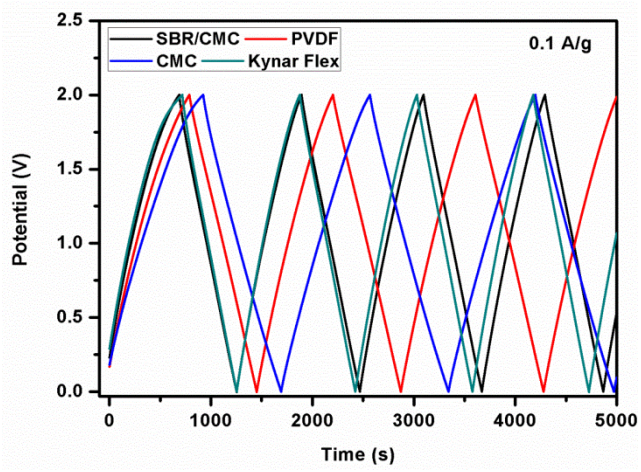
Samples	Capacitance (0.1 A/g)	Capacitance (1 A/g)	Capacitance (10 A/g)
XG750-SBR/CMC	90.77	81.07	73.09
XG750-PVDF	73.55	64.21	60.98
XG750-CMC	88.78	78.92	73.97
XG750-Kynar Flex	93.91	78.04	69.86

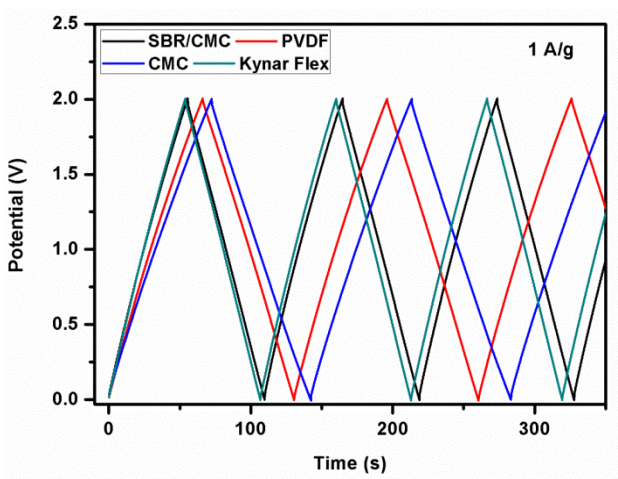
Results and Discussion
(Organic electrolyte)

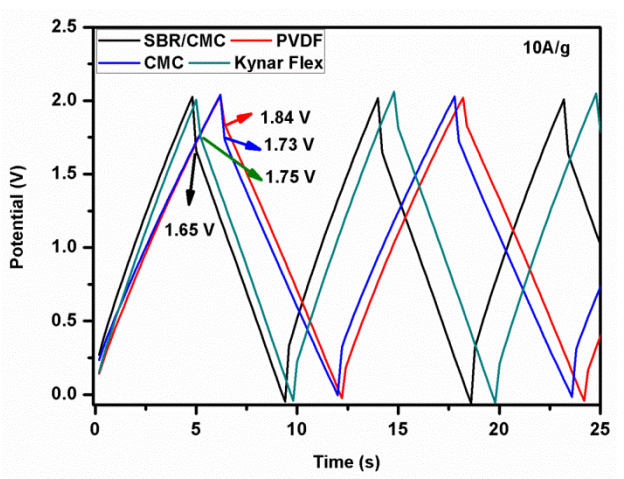




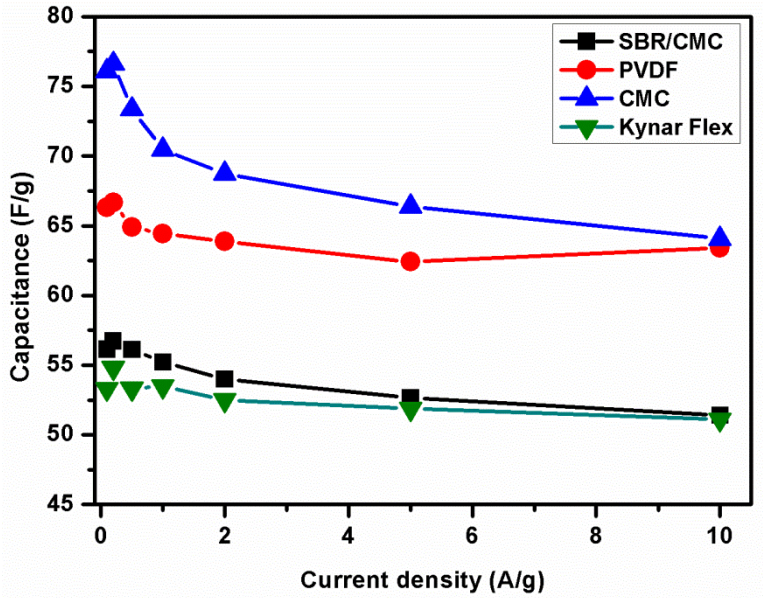


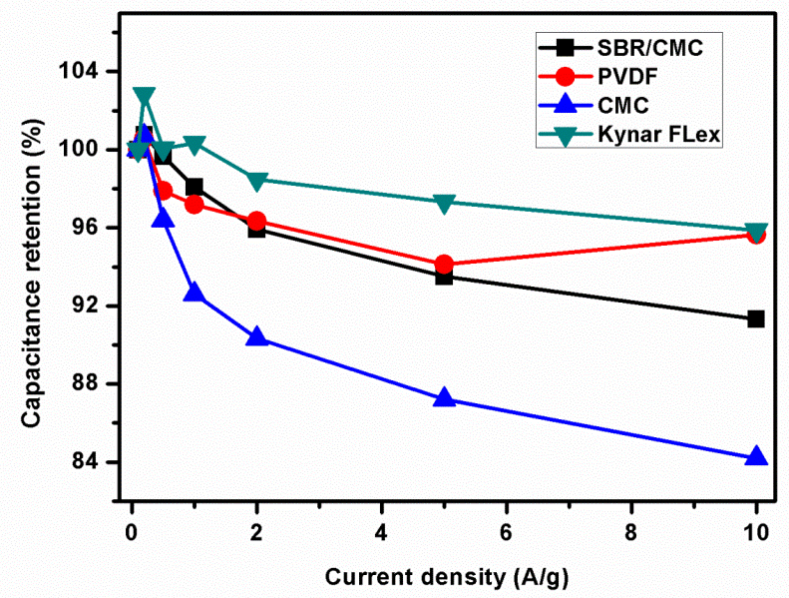






Results and Discussion
(Organic electrolyte)





Samples	Capacitance (F/g) (0.1 A/g)	Capacitance (F/g) (1 A/g)	Capacitance (F/g) (10 A/g)
XG750-SBR/CMC	56.13	55.22	51.41
XG750-PVDF	66.13	64.43	63.42
XG750-CMC	76.10	70.47	64.07
XG750-Kynar Flex	53.30	53.48	51.10

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Conclusions

- Although, SBR/CMC shows the highest capacitance values at 0.1 A/g and 1.0A/g with 90.77 F/g and 81.07 F/g, respectively in aqueous electrolyte, it has the lowest capacitance value in organic electrolyte.
- PVDF shows the best capacitance retention depending on the current density in both electrolytes.
- While CMC indicates the highest capacitance only at high current density (10A/g) in aqueous electrolyte , it shows the highest capacitance values at all current densities in organic electrolyte.
- Kynar Flex shows the highest capacitance at low current densities in aqueous electrolyte. However, it shows the lowest capacitance at all current densities in organic electrolyte.

Acknowledgments

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THANK YOU FOR your ATTENTION!

ANY QUESTIONS?