NANOMATERIAL REINFORCED MULTIFUNCTIONAL ENERGY STORAGE COMPOSITES

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INTRODUCTION

- Transition of energy sources in the automotive and aerospace industries towards electrically powered systems with net-zero emissions directives [2]. There is an increment in demand for next-generation e-vehicles in the transport sector, mainly in aviation. However, the performance of these e-vehicles majorly depends on the battery capacity available onboard[3].
- With a growing need for payload capacity and flight endurance, this work focuses on the structural composite components that can also act as an energy storage device. Multifunctional polymer composites made from carbon fibres (CF) will provide this feature by bringing together the load-bearing and energy storage capability with the advantage of mass and power savings [4].

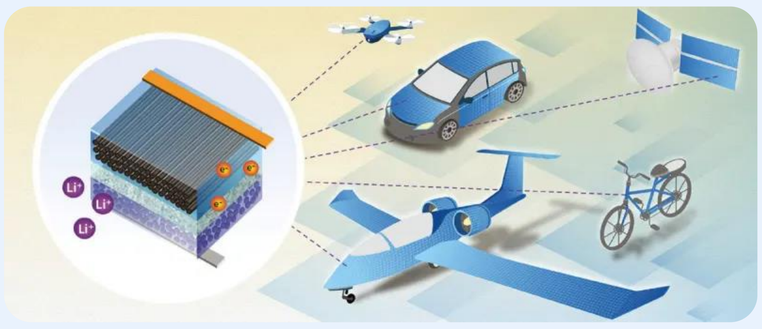

Figure1 - Application of SPCs [1].

RESEARCH METHODOLOGY

- Structural similarities among the battery technology and carbon fibre composite laminates led to the development of Structural energy storage composites[4].
- **Research problem** - However, despite a significant amount of work performed on SSCs, there are shortcomings in terms of the required amounts of energy and power density outcomes. This is due to the insufficient active surface area available for pristine CF (≈0.2 m^2/g) affecting the ionic conductivity which needs to be improved [5,6].
- **Research approach** - The proposed project will focus on developing the CF electrodes by adopting the various functionalization approaches with carbon-based nanomaterials without greatly deteriorating the mechanical properties [5,6].

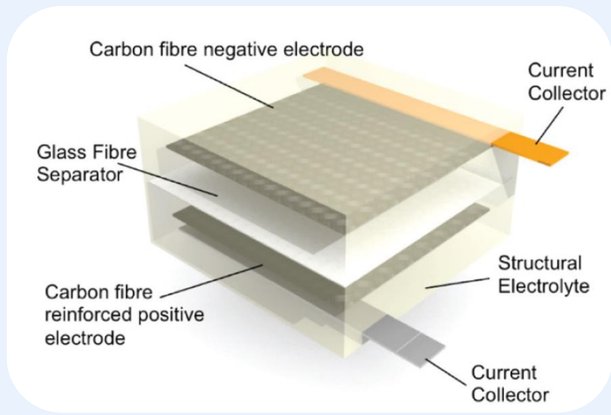

Figure 2 - Energy storage Composite [4].

MATERIALS AND METHODS

- Woven CFs, graphene oxide (GO), graphene powder, KOH, cellulose powder, cellulose paper, triethylenetetramine, 1-Ethyl-3-methylimidazolium bis(trifluoromethylsulfonyl)imide, and lithium bis(fluorosulfonyl)imide.
- In the present study, 2 sets of coatings are performed onto acetone-nitric acid treated CFs. Then SSC was fabricated out of these coated CFs.
- The first coating includes the self-assembly of rGO on CF via a hydrothermal process followed by freeze-drying.
- The second coating is of the highly viscous mixture of activated graphene and cellulose via brush coating followed by high-temperature furnace activation to give the porous network of graphene and activated carbon (G-aC) coating on CFs.

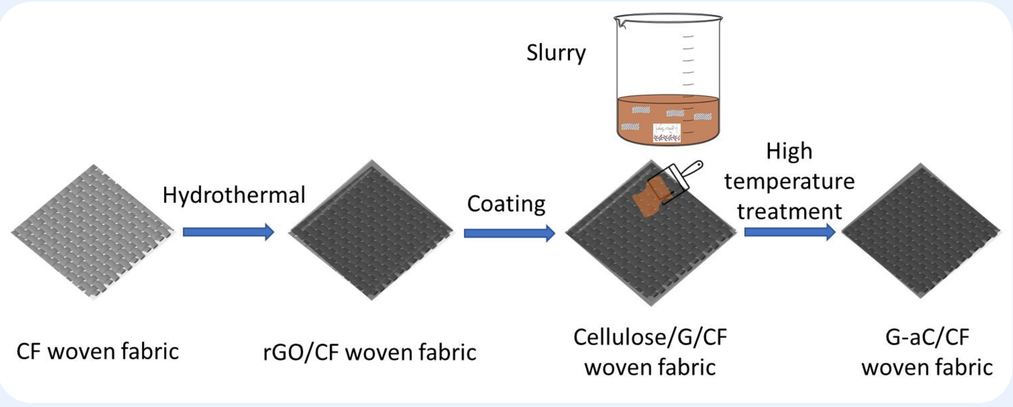

Figure 3 - Schematic of process steps to prepare G-aC/CF fabrics.

RESULTS AND DISCUSSIONS

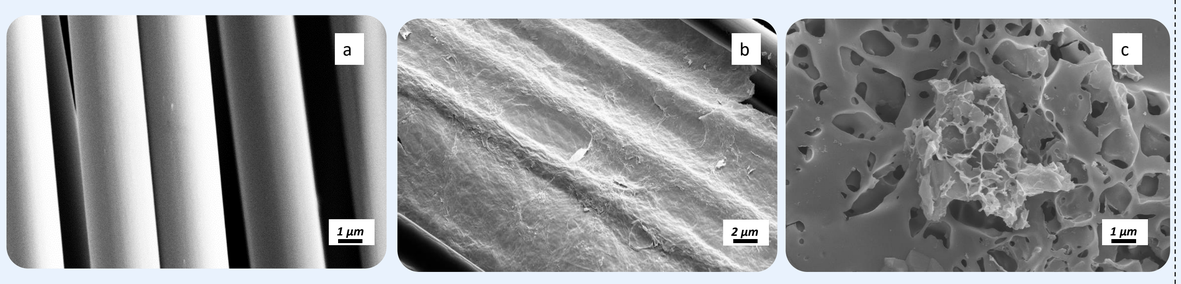

Figure 4 - SEM images of desized a) CFs, b) rGO/CF and c) G-aC/CF.

- **Surface morphology characterization -** SEM imaging of desized CFs, rGO-coated CF and G-aC coated CF are illustrated in Figure 4 revealing surface features as - a) rough surface of CFs after performing de-sizing, b) covered thin sheet of rGO on the CFs and c) porous network of G-aC on the CFs, respectively.
- **Surface area studies –** The specific surface area of the coated CF samples was assessed using the BET testing setup. The obtained surface area of desized CF is as low as 0.16 m^2/g and CFs with the dual coating(G-aC) exhibit surface area improvement which is 210 times the area of uncoated CF fabrics.

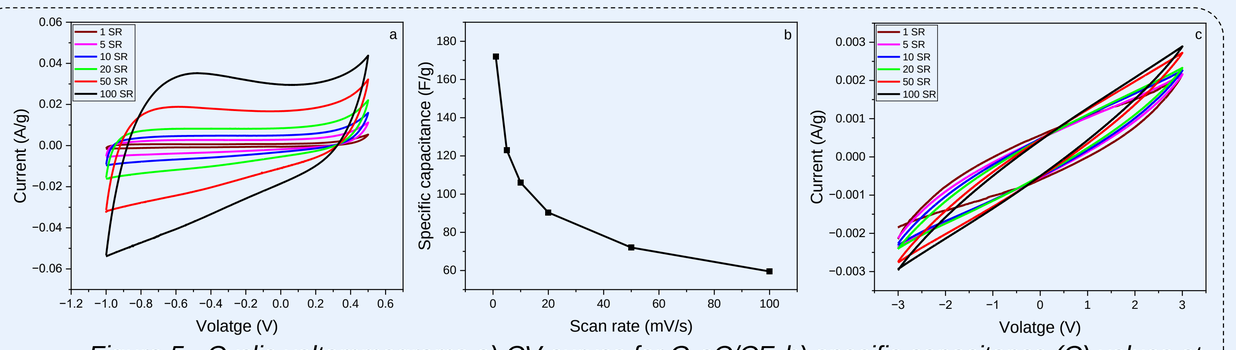

Figure 5 - Cyclic voltammograms a) CV curves for G-aC/CF, b) specific capacitance (C) values at different scan rates, c) CV curves for SSC device.

- **Electrochemical studies** – Cyclic voltammetry(CV) testing of coated fibres is performed with 3 electrode setup delivering maximum specific capacitance(C) of 172 F/g at a scan rate of 1 mV/s over potential ranging from -1 to 0.5 V due to increased surface area and formation of the porous network around CFs.
- **Device performance -** Fabricate SSC device delivers a maximum specific capacitance of 155 mF/g at a scan rate of 1 mV/s over potential ranging from -3 to 3 V . This difference in specific capacitance values is due to the conductivity difference between liquid and solid electrolytes, also resistance offered by separator [6].

CONCLUSION

- Modified CFs exhibit significant improvement of surface area by nearly 210 times greater than that of uncoated fibres, this is accompanied by the SEM images revealing CFs are adequately coated with the formation of porous structure.
- Both coated fibre and SSC device delivers excellent improvement in capacitance of 172 F/g and 155 mF/g respectively in comparison to the work of others[6-8].
- Both coated fibres and SSC devices are operated at a wide potential window of 1.5 V and 6 V respectively.

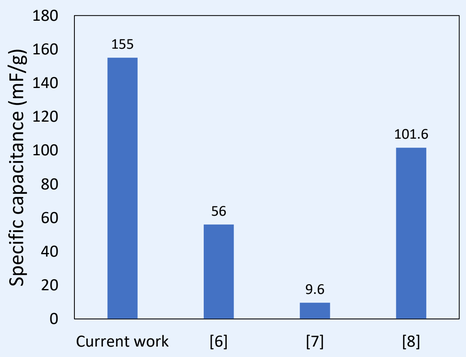

Chart 1 - Comparison of SSC device specific capacitance of current work with other studies.

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FUTURE WORK

- At this stage, more supporting data need to be collected from Raman, FTIR and XPS.
- The cyclic performance of the SSC device is need to be done.

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