Smart Textile-based Energy Storage for a Sustainable Environment

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Introduction Sustainable energy storage is essential if we are to address climate change. Moreover, energy storage devices should ideally be produced from Earth-abundant materials that are environmentally friendly. Such devices should be small-scale, flexible, distributed and, preferably, should be wearable for sensors and medical devices. Supercapacitors are a type of energy storage device, similar to batteries, but which can be charged and discharged many hundreds of thousands of times, making them more sustainable. However, 'conventional' supercapacitors typically include rigid, brittle electrodes lacking the appropriate mechanical properties for application in wearable technologies [1,2]. Therefore, it is crucial to develop sustainable, high performance flexible electrodes for portable applications.

1 The Potential

Green energy, **Cost-effectiveness**, **Sustainability**

Imagine garments using smart materials which store energy for portable applications and help us to be less reliant on fossil-fuel derived energy. How can we achieve this using sustainable, and safe materials?

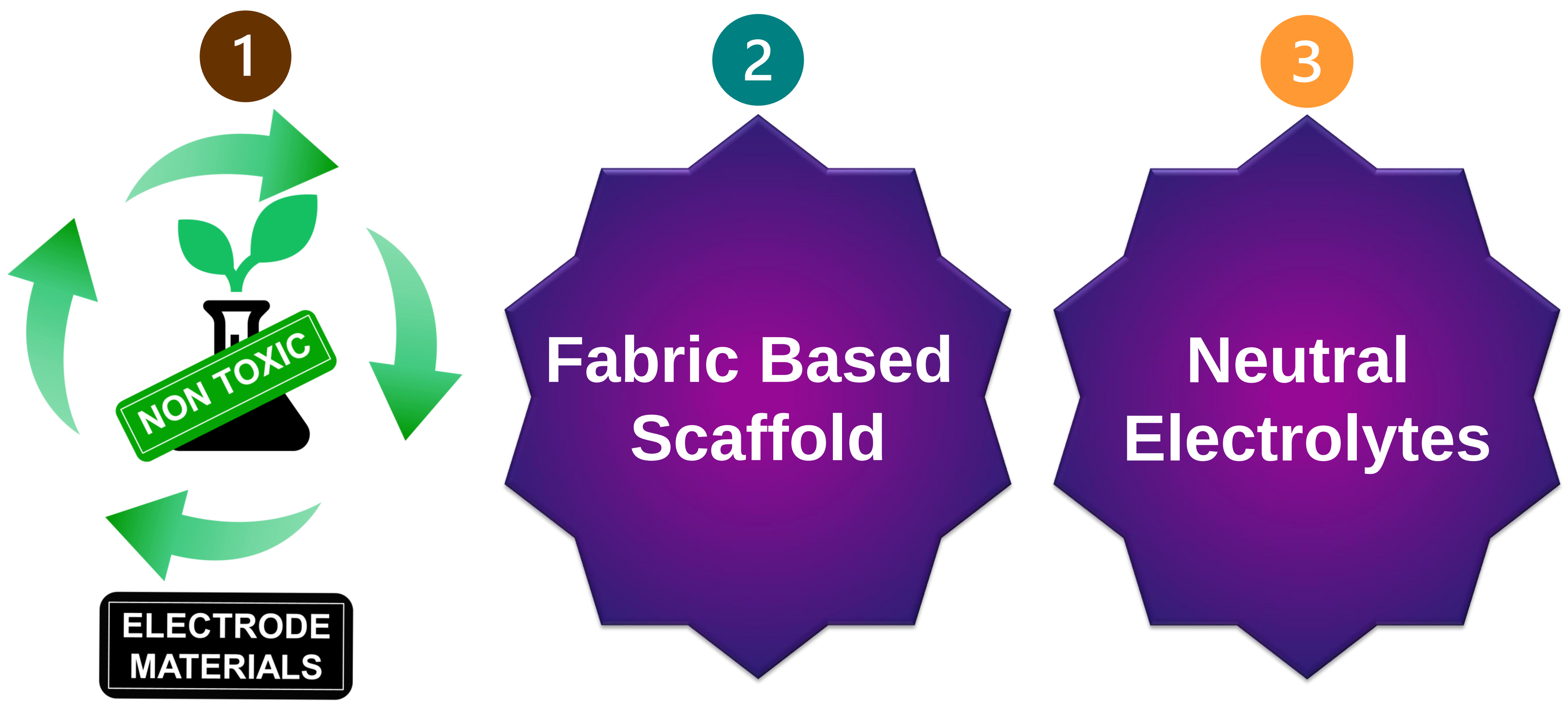
2 The Problem?

Key issues with existing energy storage devices are components that are **rigid**, **not environmentally friendly**, potentially **dangerous** electrolytes (e.g. toxic or damaging to human skin) and materials which are **expensive**.

3 The Challenges – what do we need?

- Flexible electrodes with better energy storage performance.
- Non-toxic electrolytes as a medium to facilitate ion transportation.
- A wide operating voltage to maximise energy storage.
- Integration with other devices e.g. solar cells, sensors etc.
- Embedding within woven fabrics to make '**smart**' garments.

4 A Solution



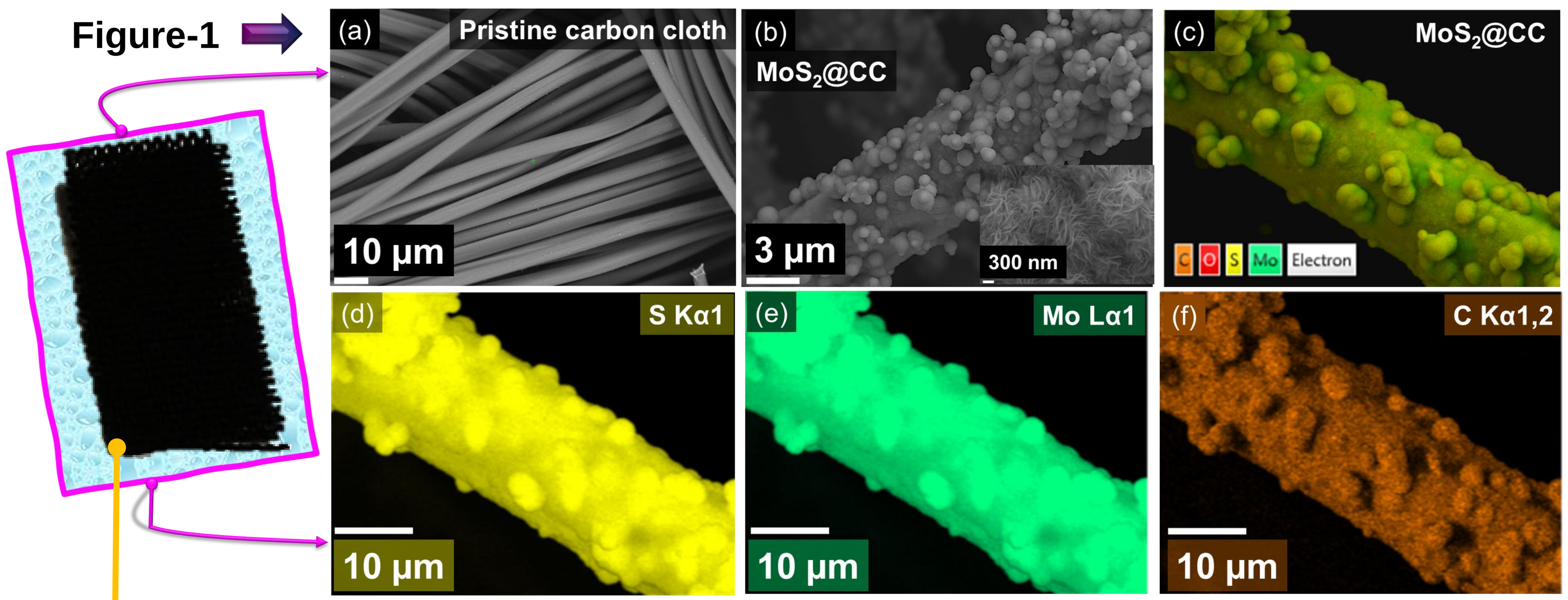
Criteria

- Earth abundant **non-toxic** electrode materials.
- **Cost-effective** solutions.
- Entirely **flexible** in nature.
- Human-friendly '**neutral**' electrolytes.

5 The Practical Work - What are we doing?

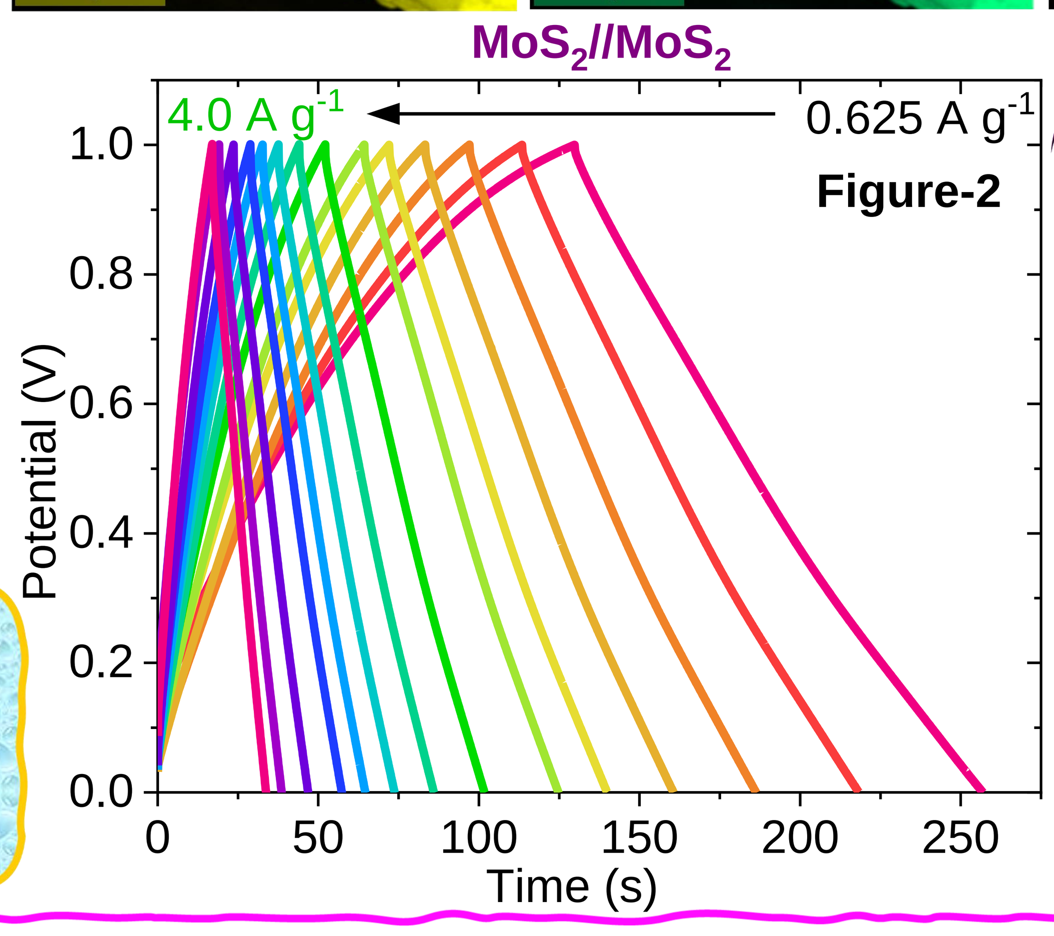
- Developing MoS_2 layers on textile-based scaffold.
- Investigating and optimising energy storage.
- Producing devices with neutral electrolytes.

Figure-1



A piece of fabric decorated with MoS_2 layers to utilize as an electrode

Real device

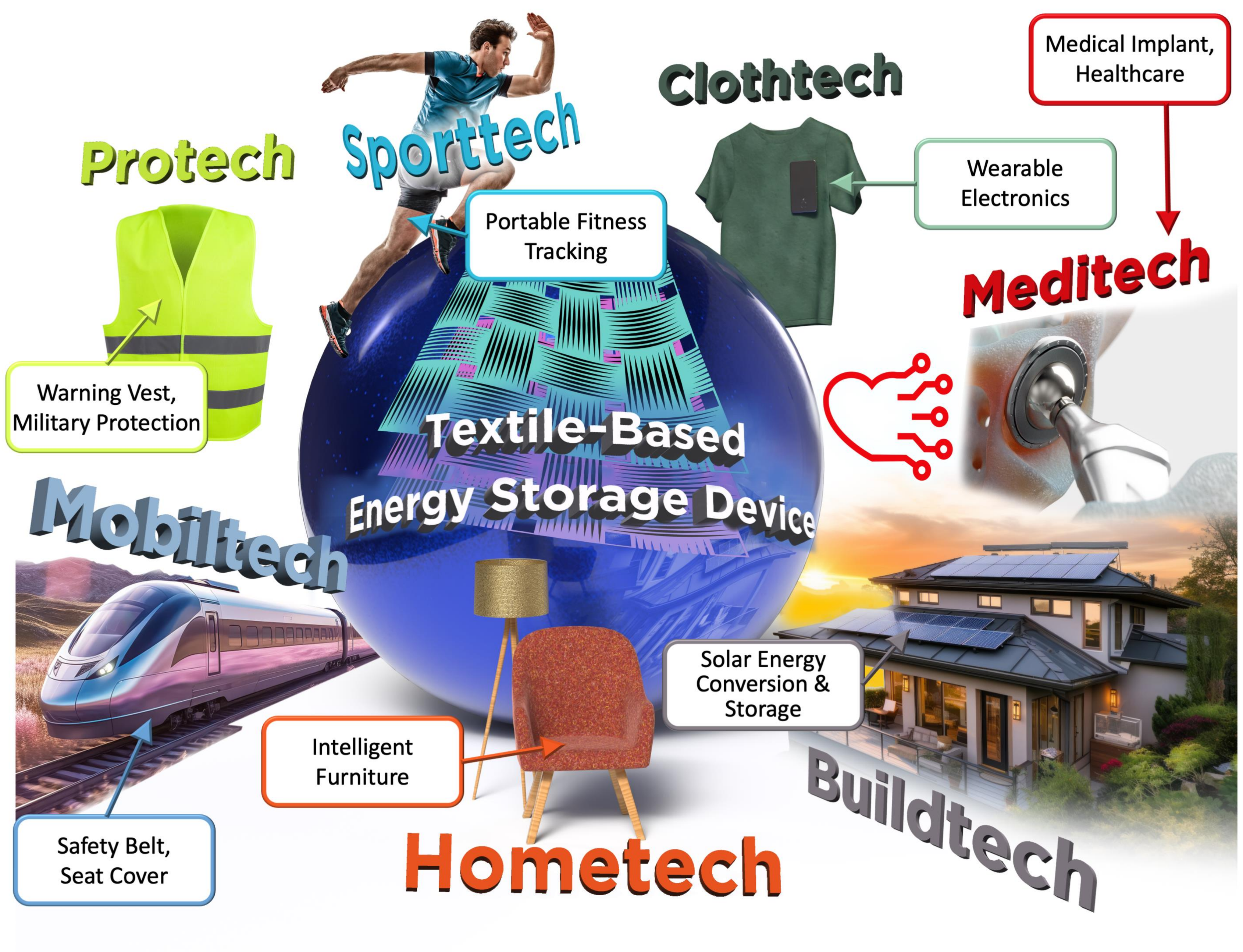


Device Energy stored
22.58 Wh kg^{-1}

Capacitance
160 ± 5 F g^{-1}
254 ± 4 F mm^{-2}

Figure-1 (a) shows a scanning electron microscope image of the woven carbon fibre, used as a substrate to support electroactive material; **(b)** the same fabric piece decorated with two-dimensional layers of molybdenum disulphide. It is evident that the fibres are now coated with the active material. Nanostructured morphology can be seen in the sub-image taken at higher resolution; **(c-f)** EDX mapped image showing presence of the corresponding elements. **Figure-2** illustrates electrochemical testing in a neutral electrolyte, by Galvanostatic Charge/Discharge which quantifies the charge stored by the electroactive material. This result indicates that the device possessed a capacitance of 160 F/g, which is highly promising explicitly for small scale applications.

6 Applications



References & Acknowledgements

1. Huang, Q., et al (2016). *Advanced Energy Materials*, 6(22), 1600783.
2. Zhang, X., et al. (2021). *Journal of Materials Chemistry A*, 9(13), 8099-8128.

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UKRI Engineering and Physical Sciences Research Council