The capacitive performances of porous carbon electrodes investigated by novel system for electrochemical testing of supercapacitors

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What is supercapacitor?

- Energy storage devices with high power capability and long cycle life during the high charge/discharge rate, excellent reversibility and simple working principles

- Fill the wide gap between conventional capacitors and batteries in terms of specific power *versus* specific energy (Ragone plot)

Why Supercapacitors?

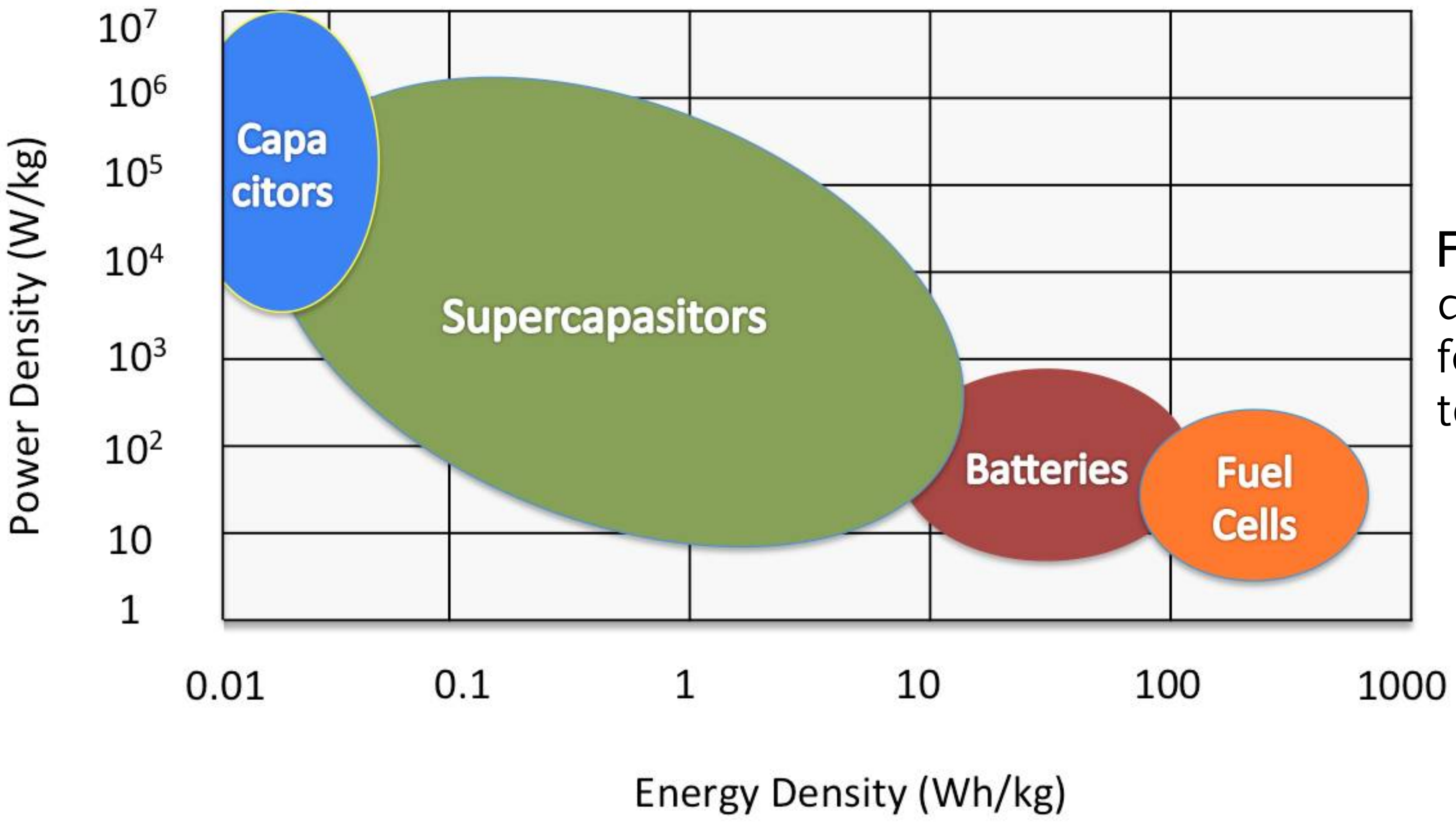

Fig. 1. Ragone plot of power density *vs.* energy density for different storage technologies.

Electrode materials

- The most widely used electrodes involve carbon technology in its various forms such as activated carbons, carbon cloths, carbon nanotubes, graphene *etc.*
- Petroleum coke, pitch and coal are the most common precursors for commercial productions of carbon electrodes
- Development of electrode materials from low-cost, sustainable and renewable resources can lead to replacement of energy sources based on fossil fuels

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Our research goals

- Defining simple and fast experimental procedure for the preparation of electrodes in the form of supercapacitive plates
- Investigating capacitive performances of low-cost hemp-based electrodes by using novel, two-electrode system for electrochemical characterization (cyclic voltammetry and electrochemical impedance spectroscopy)

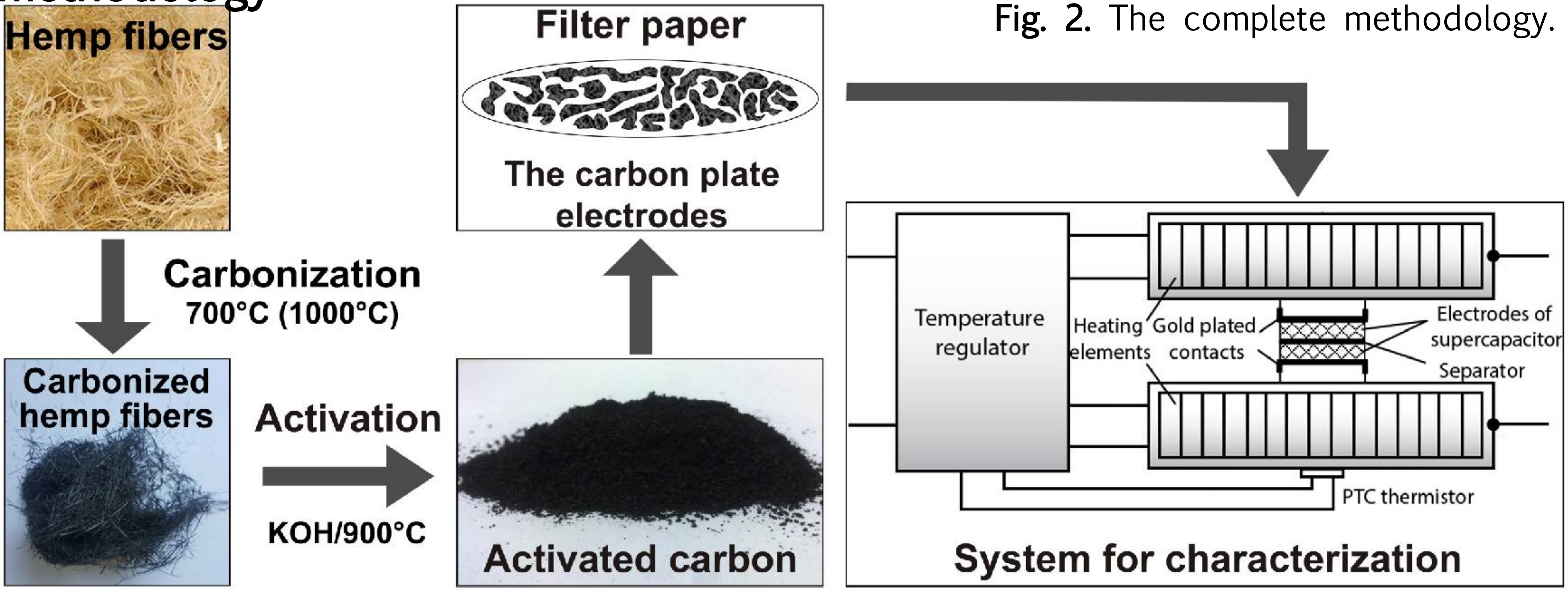
Why this research is important?

- Flexible and simple methodology for reliable characterization of supercapacitors is necessary

- Low-cost hemp fibers, obtained as a waste from textile industry, can be potentially used as precursors for production of supercapacitive electrodes

The preparation of electrodes and characterization methodology

Fig. 2. The complete methodology.



Experimental procedure

- Two round Blauband filter papers were impregnated by 2.0 vol% mixture of commercial Nafion® solution

- Aqueous suspensions of activated carbons (3 mg cm^{-3}) were ultrasonically homogenized for 45 min, pipetted in the total amount of 100 μl onto dried nafion-impregnated filter papers and left to dry in the air for 24 h

- Symmetrical supercapacitor was prepared using dried filter papers with the active material as electrodes, sandwiched with the same, larger, round filter paper as a separator previously soaked in 1.0 mol dm^{-3} H_2SO_4 solution

Results from cyclic voltammetry

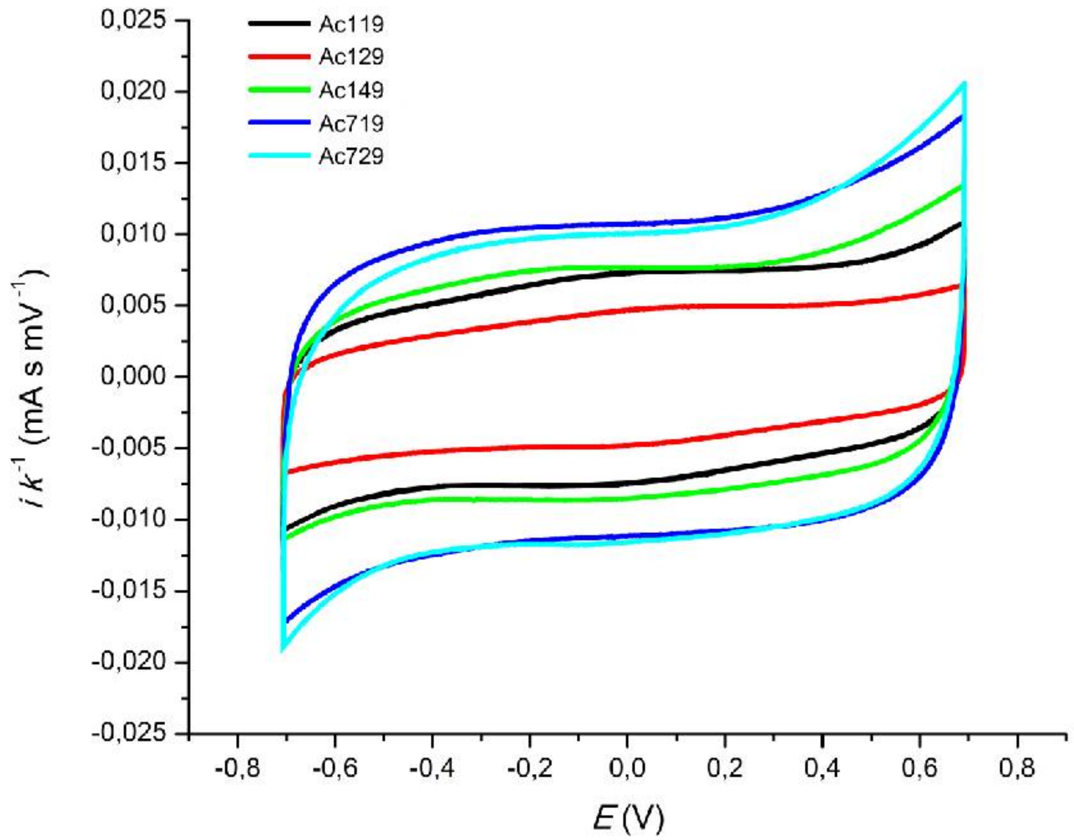


Fig. 3. Cyclic voltammetry curves of activated carbons (sweep rate: 10 mV s^{-1}).

Why specific capacitance is important?

•The overall capacitance (C):

$$C = A/2\Delta E \qquad (1)$$

A is the enclosed area of CV curve and ΔE is the potential window;

•The overall capacitance of the two electrodes in series with the same active mass (m):

$$1/C = 1/C_1 + 1/C_2 \qquad (2)$$

•The specific capacitance (C_s) of a single electrode:

$$Cs = 2C/m \qquad (3)$$

Sample	C (mF)	C_s (F/g)
Ac119	6.6	88.6
Ac129	4.2	55.6
Ac149	7.6	101.3
Ac719	10.9	145.2
Ac729	10.6	141.7

Table 1. Capacitance values of carbon samples obtained from the CV measurements.

Results from electrochemical impedance spectroscopy

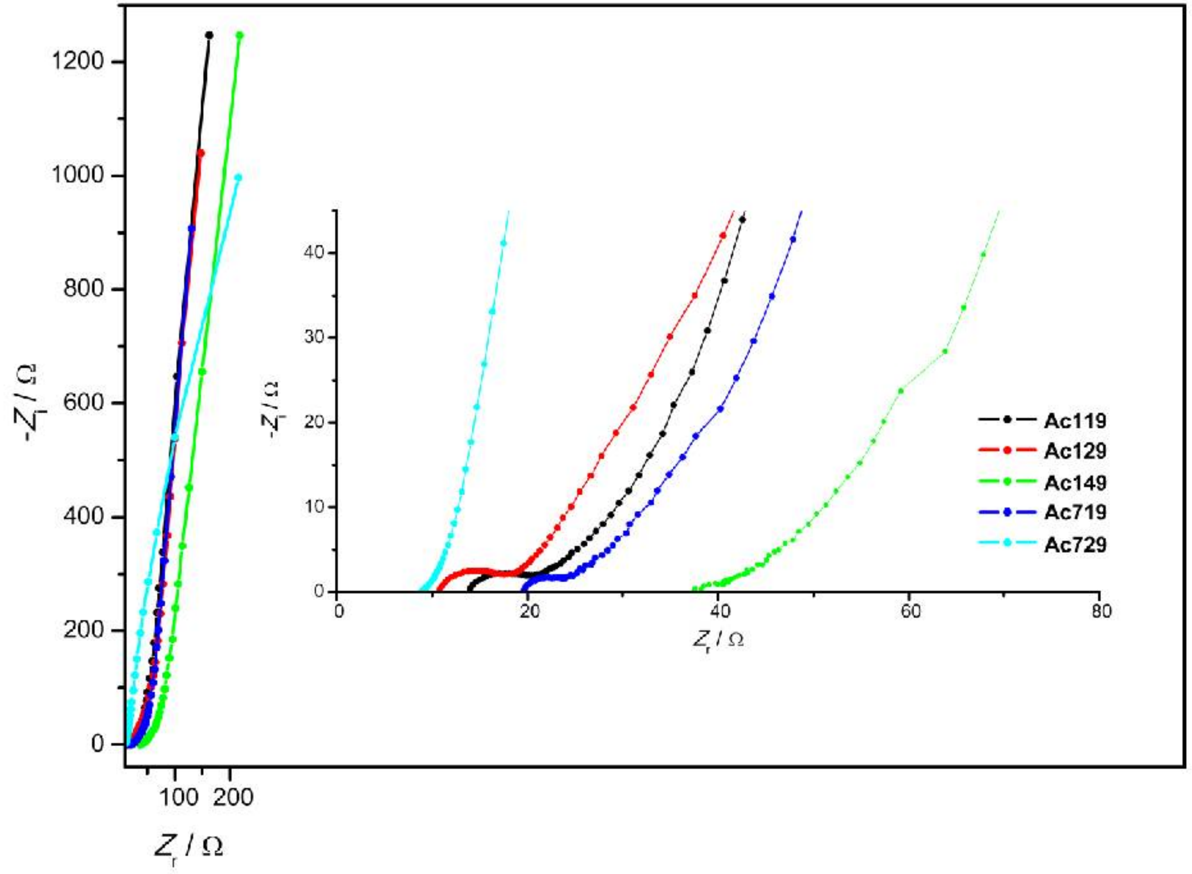


Fig. 4. The complex plane impedance plots in the investigated frequency range.

Conclusions:

- The process of preparation porous carbon electrodes combined with system for characterization provides fast and reliable method for investigations of capacitive properties

- Waste hemp fibers, obtained as a waste from a textile industry, can be used as a starting material for electrode material