BioCarb-K: Biobased Carbons and Ceramics

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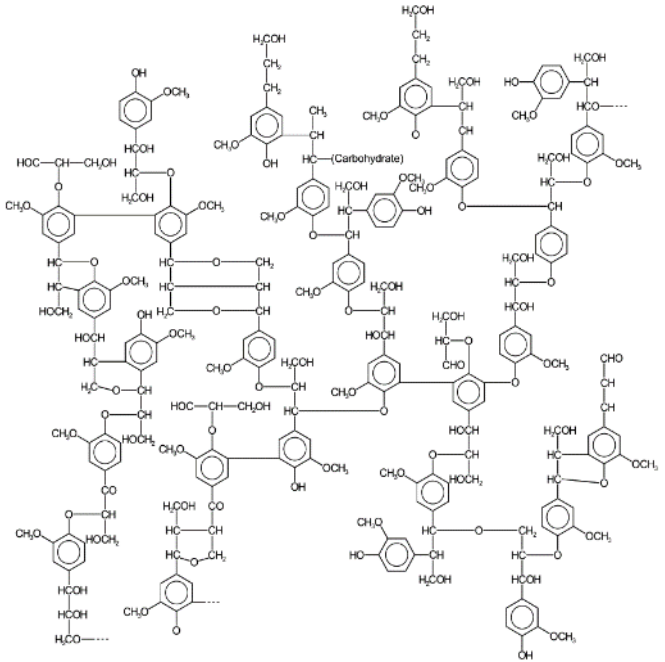
Material and process development on the basis of **lignin, cellulose** and **wood** for the preparation of:

- Carbon fibers
- Porous carbon materials
- Biobased ceramics and composite materials

→ **Low cost, sustainable, available**



Tasks

- Carbon fibers based on lignin
- Carbon fibers based on cellulose
- Porous / activated carbon materials
- Biobased ceramics
- Functionalization and characterization of surfaces

Lignin Compounds

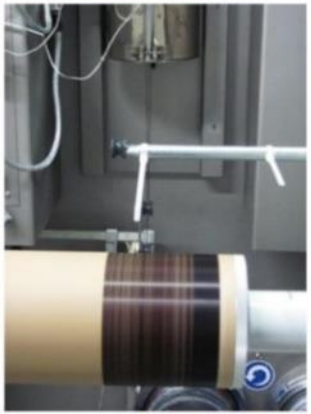
- Preparation lignin compounds for thermoplastic-like processing.
- Lignin content 80-90 %.

Melt-Spinning of Lignin Fibers

- Preparation of lignin fibers on a melt spinning machine up to 150 fibers.
- Development of different spin finishes for the lignin fibers.

Conversion of Lignin Fibers to Carbon Fibers

- Stabilisation/oxidation of the fibers with O_2/O_3.
- Carbonisation of the stabilised fibers to get carbon fibers.



Continuous Impregnation and Stabilisation of Cellulose Fibers

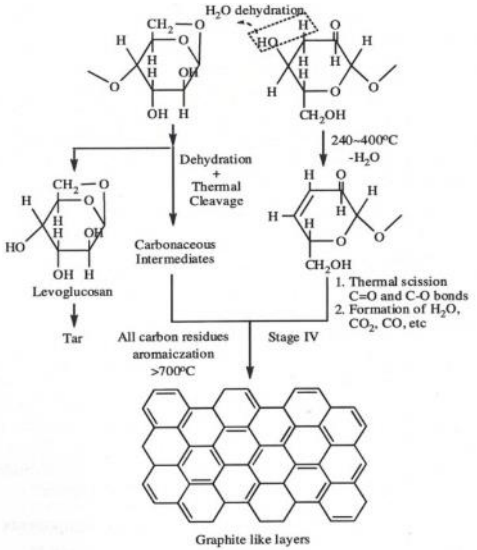
- Modification of cellulose by impregnation with aqueous reagents → **improvement of carbon yield**.
- Stabilisation of the cellulose fiber up to 300°C in air.

Continuous Low Temperature Carbonisation

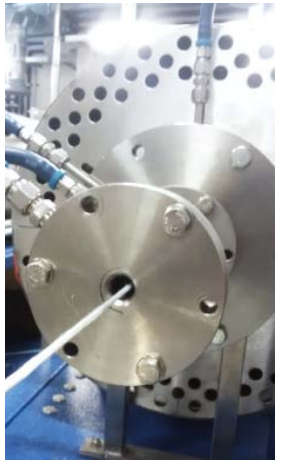
- First carbonisation step up to 900°C in inert atmosphere.
- Mass loss up to 70-75% of the initial amount of cellulose.

Continuous High Temperature Carbonisation

- Carbonisation step up to 1600°C in inert atmosphere.



Continuous operations with **defined fiber tension** → improvement of the mechanical properties of the carbon fibers.

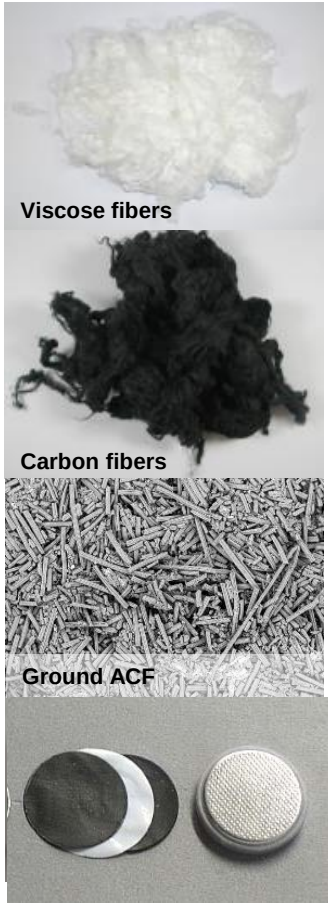


Process Optimisation

- → Increasing the carbon yield
- → Improving mechanical performance

Change of colour with temperature

Activated Carbon Fibers based on Cellulose

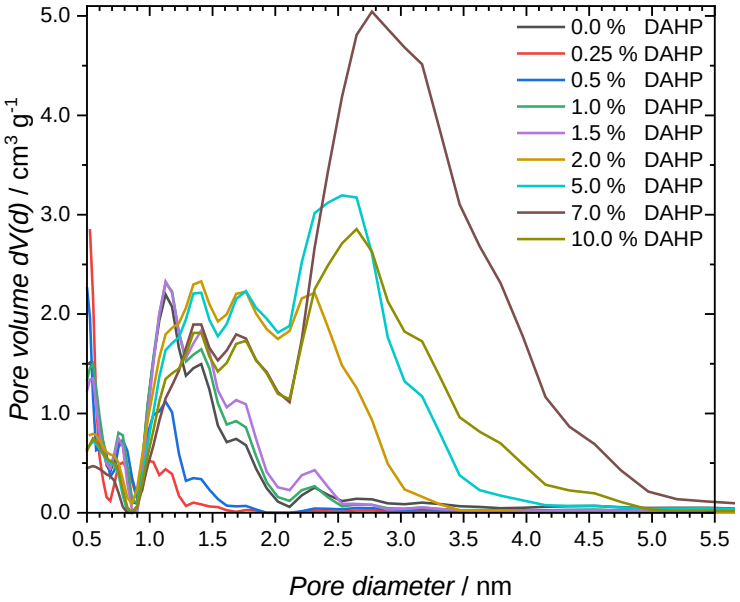


1. Impregnation
2. Drying
3. Carbonization / chemical activation
4. Physical activation (CO_2 or H_2O)
5. Fabrication of the electrodes

Bio-based precursors
(cellulose, lignin, wood, waste materials…)

→ **low-cost**
→ **available**
→ **sustainable**

Various application fields
energy storage, filters, gas storage…



Pore size distribution can be tailored by impregnation and activation parameters

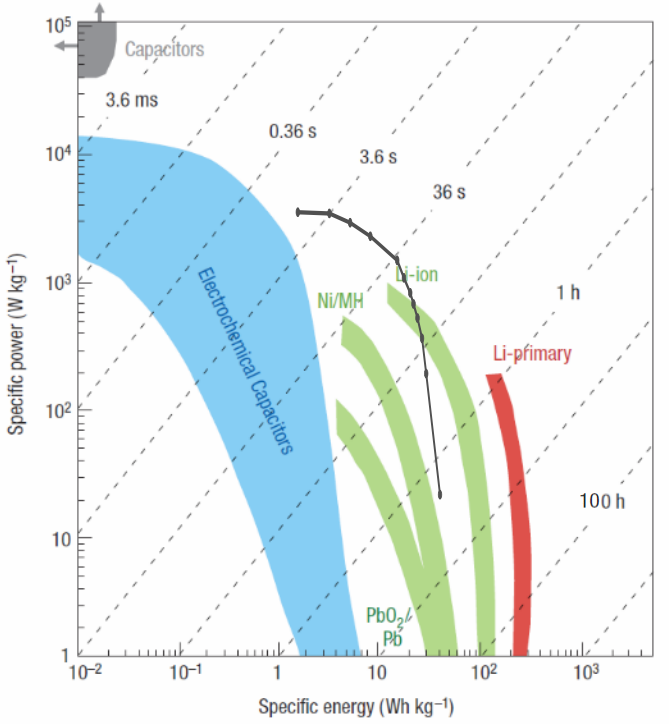
Pore size can be optimized for used electrolyte

Successful production of **supercapacitor electrodes from activated carbon fibers based on cellulose.**

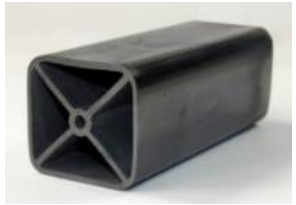
Supercapacitors with activated carbon fiber electrodes have very low internal resistance.

Significant outperformance over commercial activated carbon.

Further improvement of porosity and electrochemical properties by additional water vapor activation.



P. Simon, Y. Gogotsi, Materials for electrochemical capacitors, *Nature Materials* **7** (2008) 845–854.



Natural Fibers, Polymers, Additives

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Extrusion / Injection Molding

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Green-Bodies (WPC)

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Carbonization

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Porous Carbon-Templates

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Liquid Silicon Infiltration

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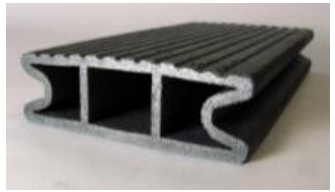
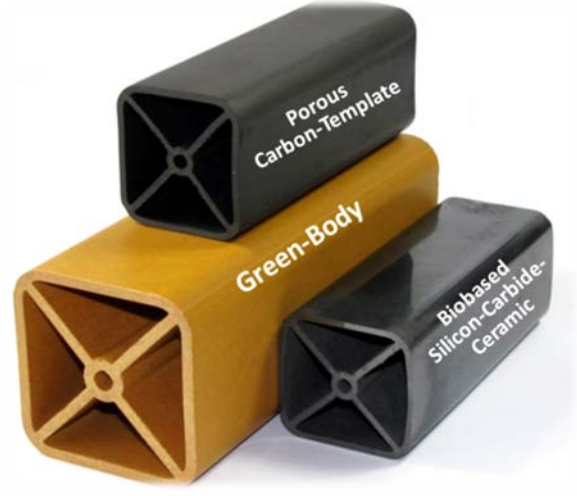
Biobased SiC-Ceramics (C/Si/SiC)

→ Patent Wood K plus: WO/2018/213859



Biobased Silicon Carbide Ceramics



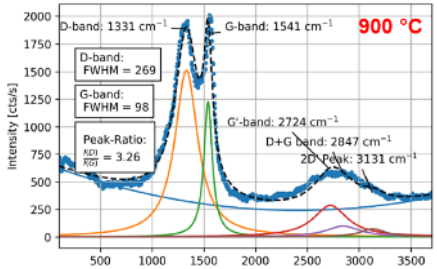
Green-Bodies
155 x 50-90 x 3-25 mm^3
Different profile geometries

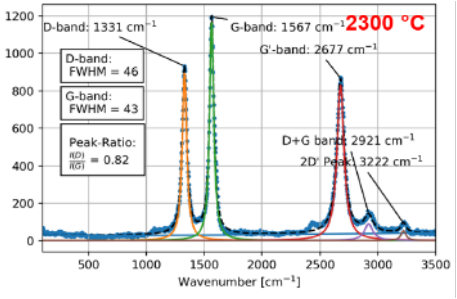
Carbonisation
Isotropic shrinkage up to 30%

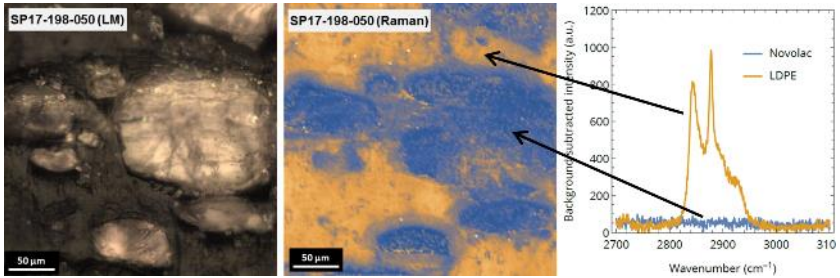
C/Si/SiC-Ceramics
Mechanical properties comparable to sintered SiC-ceramics

Raman Spectroscopy

- Determination of the degree of graphitization of the carbon fibers
- Morphology analysis

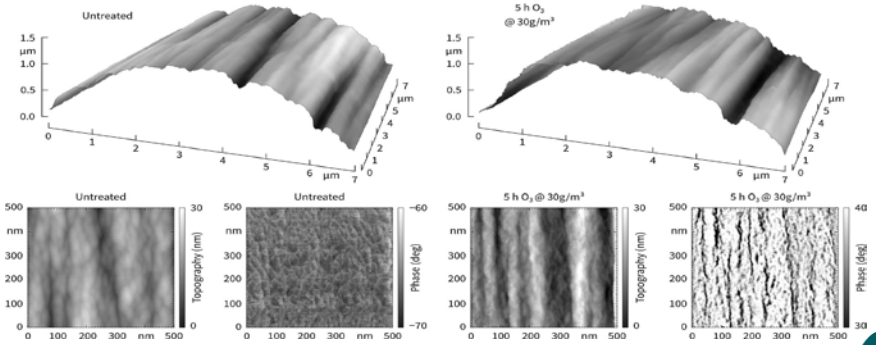






Atomic Force Microscopy (AFM)

- Determination of the surface roughness of (oxidized) carbon fibers

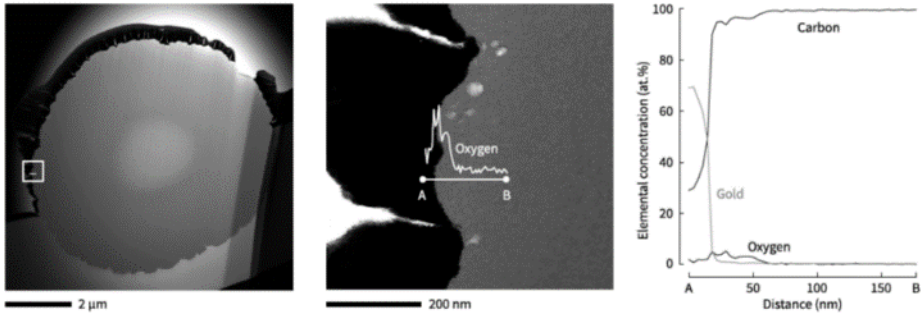


X-ray Photoelectron Spectroscopy (XPS)

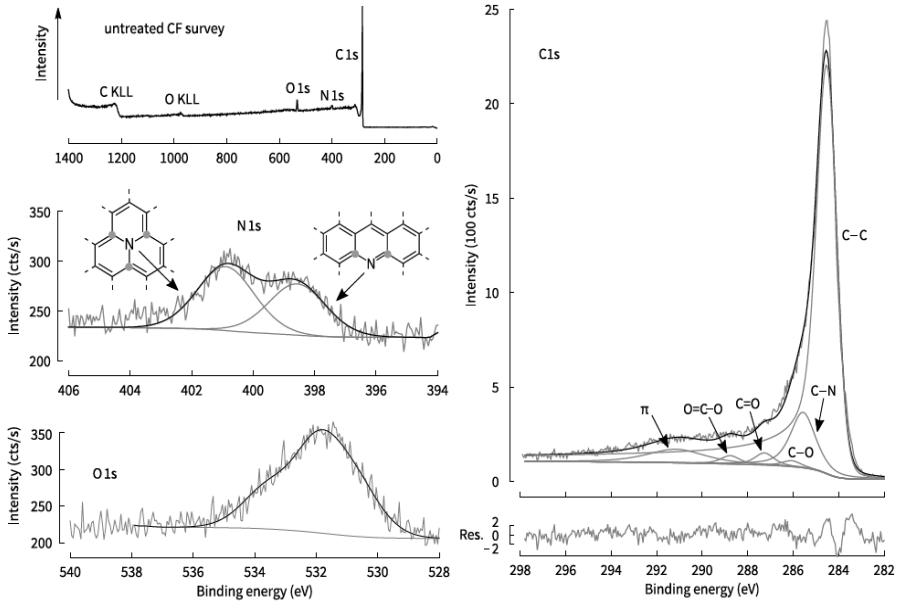
- Determination of functional groups on the surface of carbon fibers

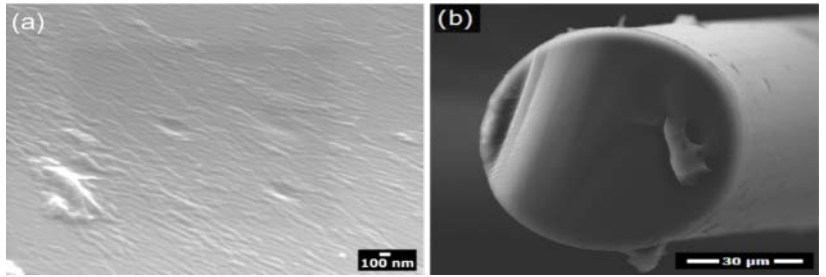
Raster and Transmission Electron Microscopy (REM, TEM with EDX)

- Determination of the oxygen distribution of an oxidized carbon fiber surface
- Fotos of fiber surface and cross section



Oxygen distribution in cross section of oxidised carbon fiber (TEM+EDX)





Surface and cross section of carbon fiber (REM)

- BioCarb-K gave the opportunity to acquire a **knowledge base for** the development of **biobased carbon** and **ceramic materials on the basis of lignin, cellulose and wood**.
- Processes for the preparation of **carbon fibers** derived from lignin and cellulose with competitive properties have been successfully developed.
- Cellulose fiber based highly porous **activated carbons** are suitable for supercapacitors and outperform commercial activated carbons.
- Biobased **silicon carbide ceramics** with competitive properties can be produced from natural fiber reinforced composites which can be shaped by extrusion, injection moulding and other standard processing techniques.

Carbon and ceramic materials derived **from lignin, cellulose and wood** have interesting and competitive properties and **are capable of substituting fossil based carbon materials**.

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