





NOVEL APPLICATIONS OF FLEXIBLE CARBON SPONGES

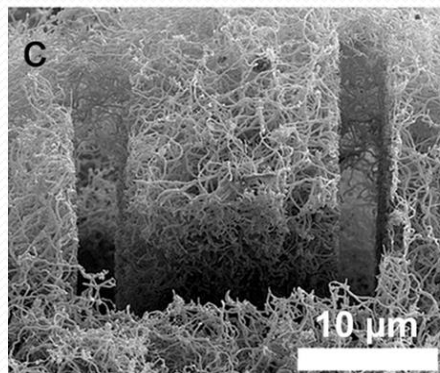
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Supervisors: - Jyri-Pekka Mikkola
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- William Larsson

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Carbon foam

- Low density
- Good mechanical strength
- Electrical conductivity
- High surface area



D. P. Hashim et al. *Scientific reports* 2012, 2



H. Sun, Z. Xu and C. Gao, *Advanced Materials* 2013

- Applications for carbon foam:
 - Adsorbents
 - Catalyst support
 - Supercapacitor
 - Solar cell electrodes..

Carbon foam

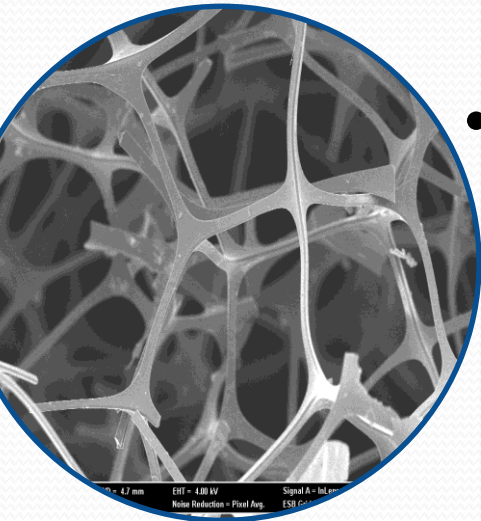
From carbon nanotubes
and/or graphene

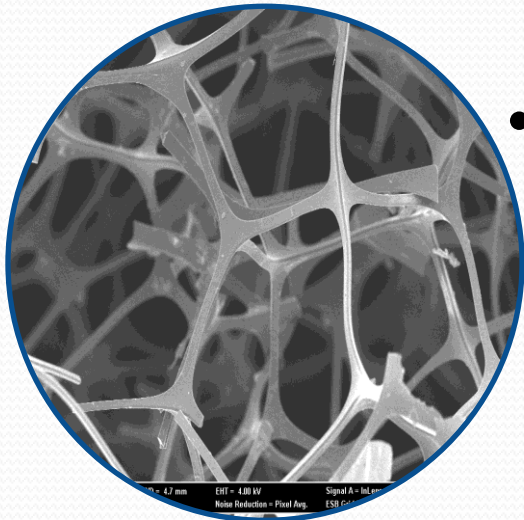
- Pros:
 - Very low density
 - High electrical conductivity
 - Flexible
- Cons:
 - Expensive
 - Difficult to be synthesized in bulk quantities

Direct from polymer foam

- Pros:
 - Simple procedure
 - Cheap
- Cons:
 - Fragile
 - Low electrical conductivity

Starting material

- A special polymer foam was used as a starting material.
 - The foam is mainly used in heat and noise insulation applications.
 - It has:
 - Low density.
 - Open cell foam (more than 99% empty).
 - Relatively cheap.
- 



Aim of the project

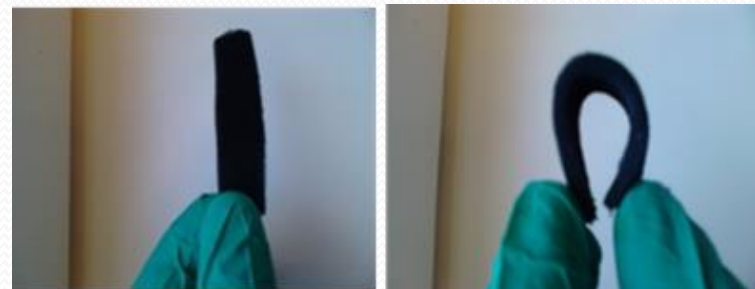
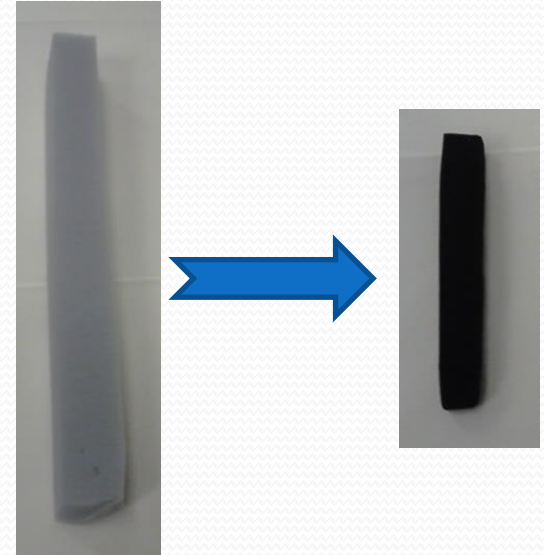
- Our aims:
 - Create a multi-purpose product:
 - Support matrix for catalysts (including photocatalysts used in water splitting process).
 - Adsorbent for removing contaminants from various liquids.
 - Electronic applications...

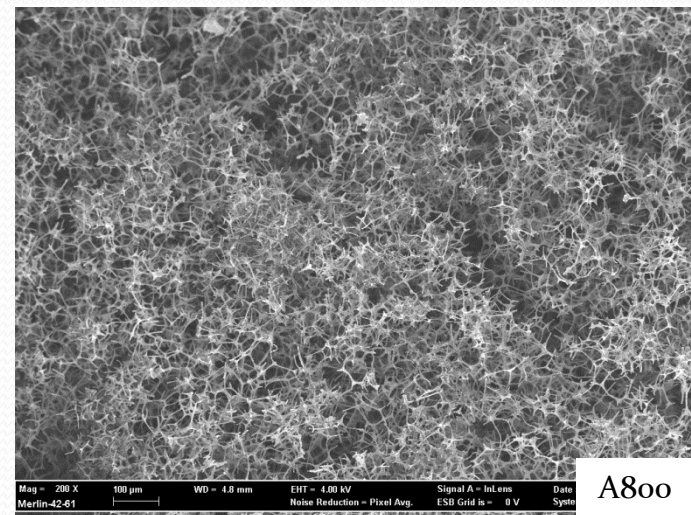
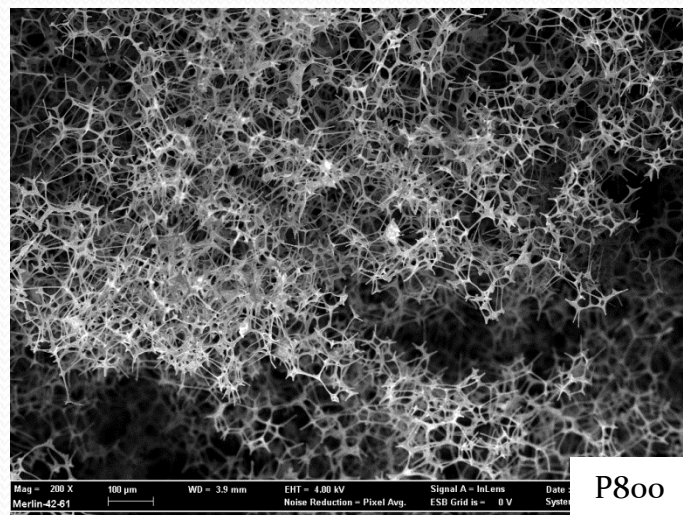
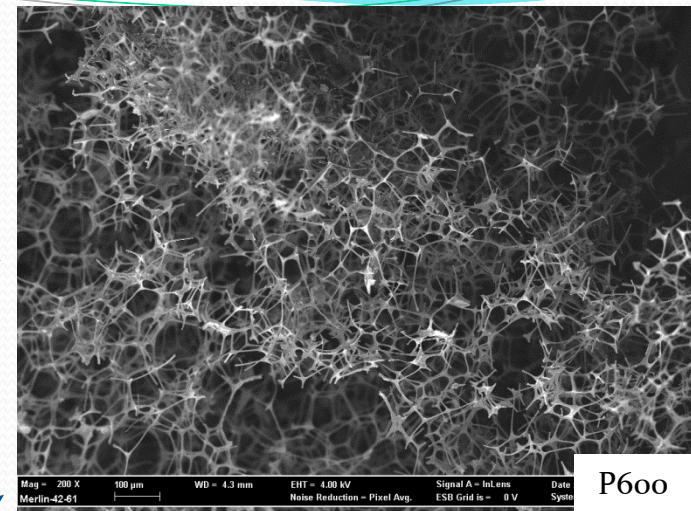
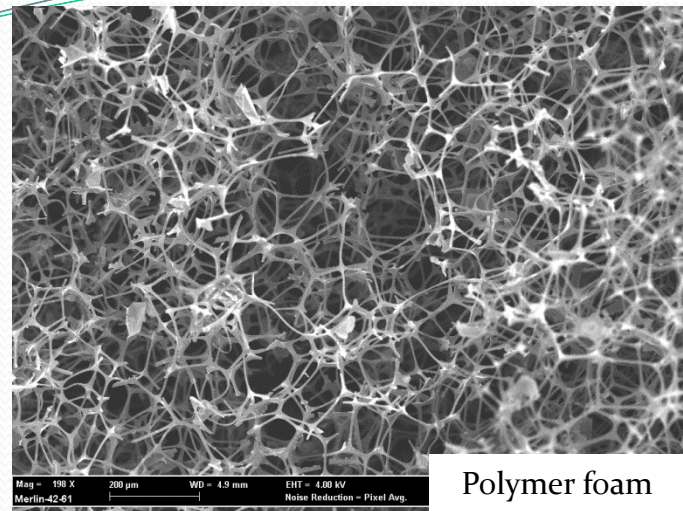
Experimental part

- Material synthesis:
 - Different pyrolysis temperatures (from 600 to 800 °C) were used to explore the characteristics of the material after the treatment.
 - The optimized activation conditions chosen was 800 °C.
- Structural characterizations (XPS, TEM, SEM, BET and XRD)
- Catalytic reaction test (Hydrogenation of acetone).
- Adsorption test.
- Mechanical and electrical measurements.

Results

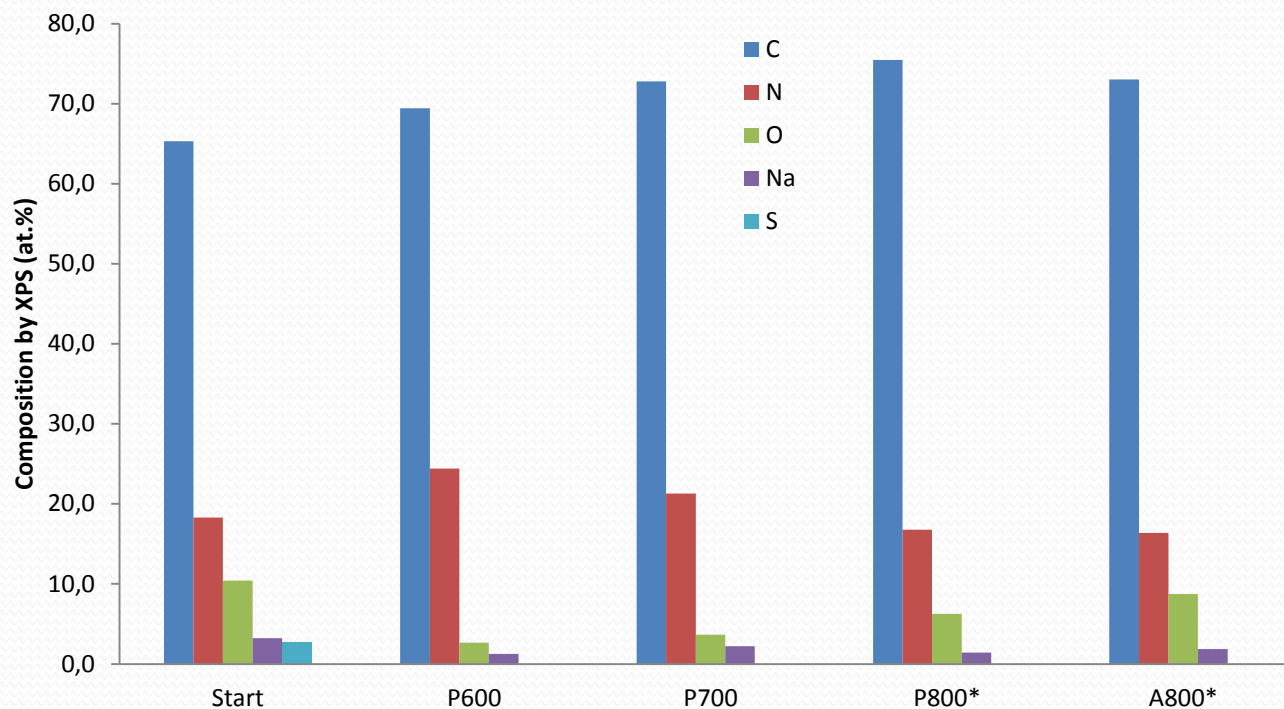
- We have carbon foam which is:
 - Low density ($< 9 \text{ mg/cm}^3$)
 - High surface area ($> 300 \text{ m}^2/\text{g}$, for activated foam)
 - and *flexible*





- The skeletal structure of carbon foam was retained after the pyrolysis (and activation process).

The elemental compositions (by XPS)



- *Pyrolyzed samples are hydrophobic*
- *Activated sample is hydrophilic.*

Oil adsorption measurement



- *Reusable*

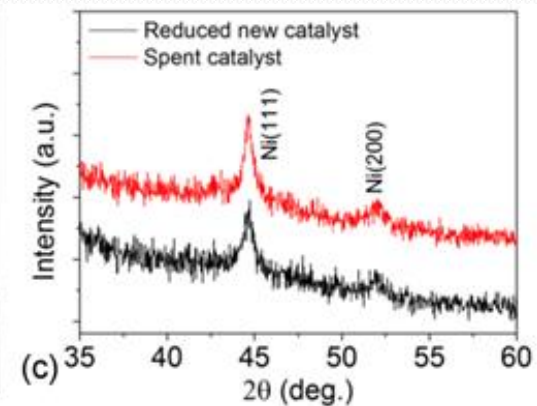
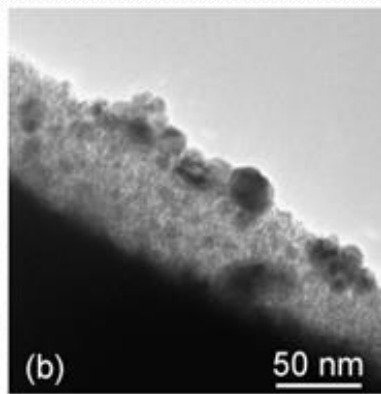
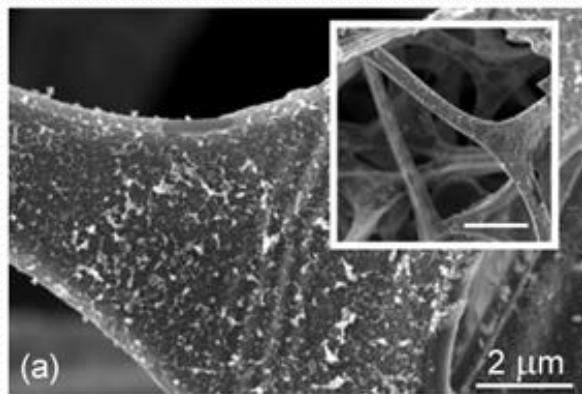
Adsorption capability

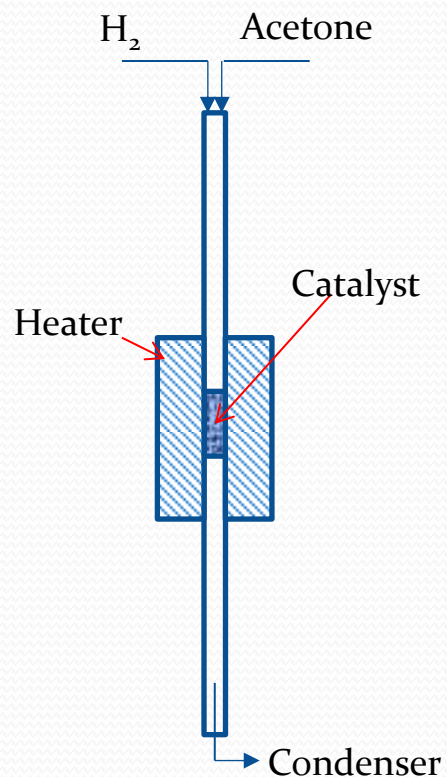
- Pyrolyzed samples are capable of taking up large amounts of non-polar solvents.

Liquid (and its density)	$\Delta m/m_o$
Silicone oil (1.402 g/cm ³)	106
Benzene (0.879 g/cm ³)	101
Turpentine oil (0.856-0.867 g/cm ³)	95
Crude oil (0.847-0.862 g/cm ³)	79
Iso-Hexane (0.653 g/cm ³)	76

Catalytic reaction test

- Activated carbon foam with high surface area ($\sim 345 \text{ m}^2\text{g}^{-1}$) was used as support material for nickel catalyst.
- Nickel decorated activated carbon foam was used for the hydrogenation reaction of acetone.





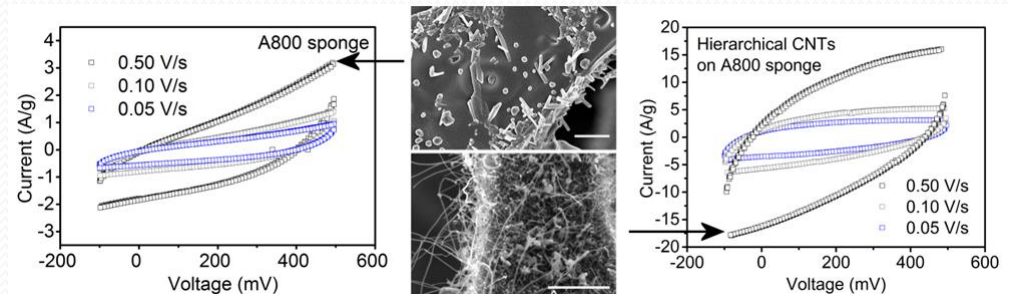
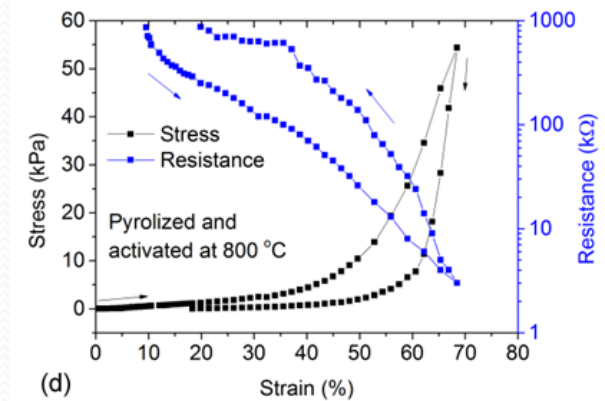
- GC and GC-MS were used to identified the composition of products.
- Simplifying the process and reducing the costs associated with packing and recovering the catalytic materials.

Temperature (°C)	Acetone conversion approx. (%) [*]	Selectivity approx. (%)		
		2-propanol	MIBK [*]	4-Methyl-2-pentanol
150	86	99	0.4	0.4
250	44	86	11	1

^{*} Methyl isobutyl ketone

Mechanical and electrical measurements

- The carbon foam has:
 - Very high compressibility with viscoelastic characteristics ($>70\%$ volume reduction).
 - High gauges factors value (between ~ 20 and 50).
 - Growing carbon nanotubes structures suitable for electric double-layer capacitor electrodes with specific capacitance of ~ 40 F/g



Conclusions

- Carbon foams can be used for multi-various purpose such as:
 - Adsorbent for both hydrophobic and hydrophilic chemicals.
 - Support material for catalyst
 - Electrical and other applications: flexible electrodes, strain gauges..

Acknowledgments

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Thank you for
listening

