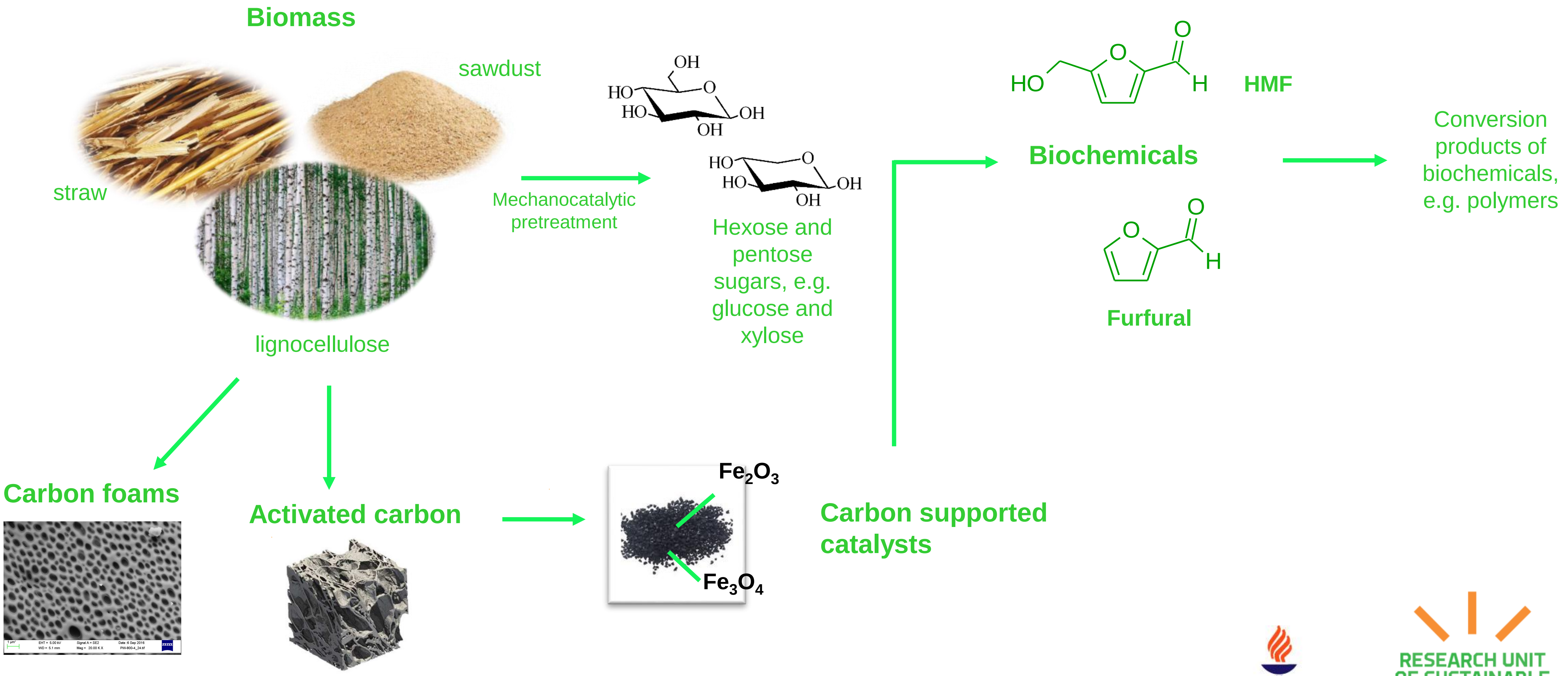
# Soveltavan kemian tutkimus biojalostuksen arvoketjussa

FT Katja Lappalainen

30.9.2020

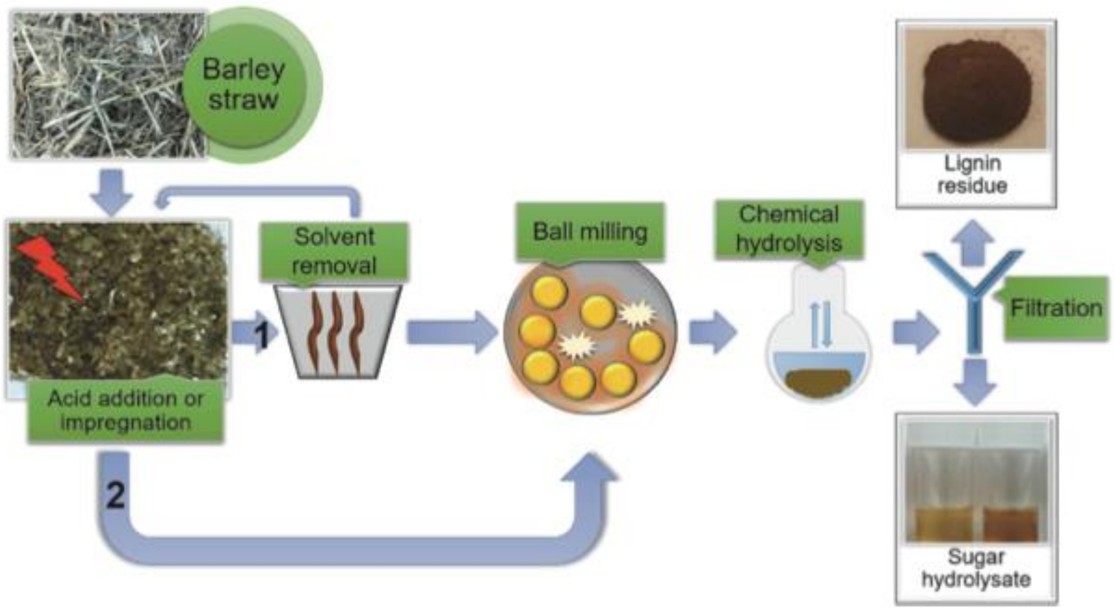
# Research Unit of Sustainable Chemistry: Refining biomass into platform chemicals and sustainable materials



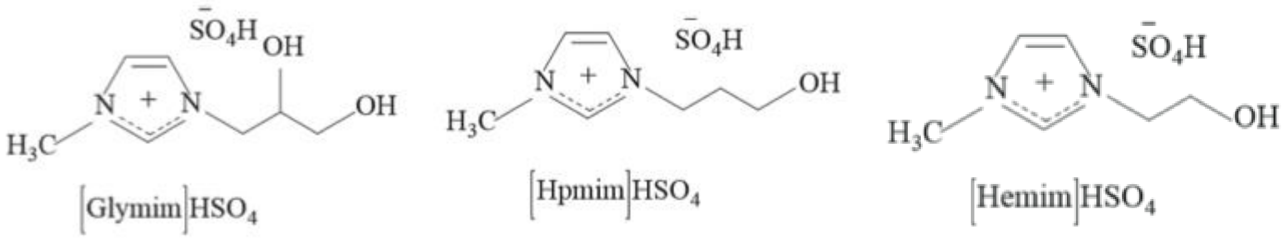

JYVÄSKYLÄN YLIOPISTO
KOKKOLAN YLIOPISTOKESKUS
CHYDENIUS

RESEARCH UNIT OF SUSTAINABLE CHEMISTRY
UNIVERSITY OF OULU

# Pre-treatment of biomass and its conversion into sugars




Ref. PhD thesis Laura Schneider




Ref. PhD thesis Yue Dong

## Mechanocatalytical treatment of biomass

- Grinding in a ball mill with a catalyst
- Barley straw, pine, willow or birch sawdust, fibre sludge

## Pre-treatment of biomass with ionic liquids

- Hydroxyalkylimidazolium hydrogensulfate-based ionic liquids
  - Partly hydrolysing
- Fibre sludge

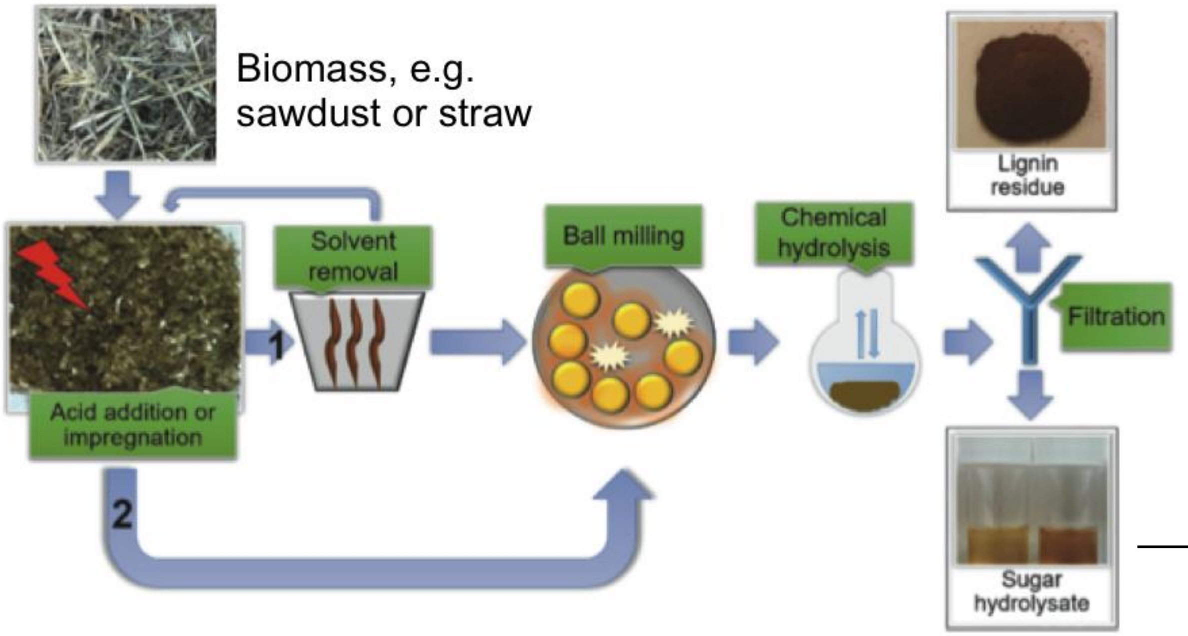
## Results:

- Sugar yields in optimized conditions:
  - pine sawdust 30%
  - willow sawdust 25%
  - fibre sludge 35%
  - fibre sludge 30% (IL)

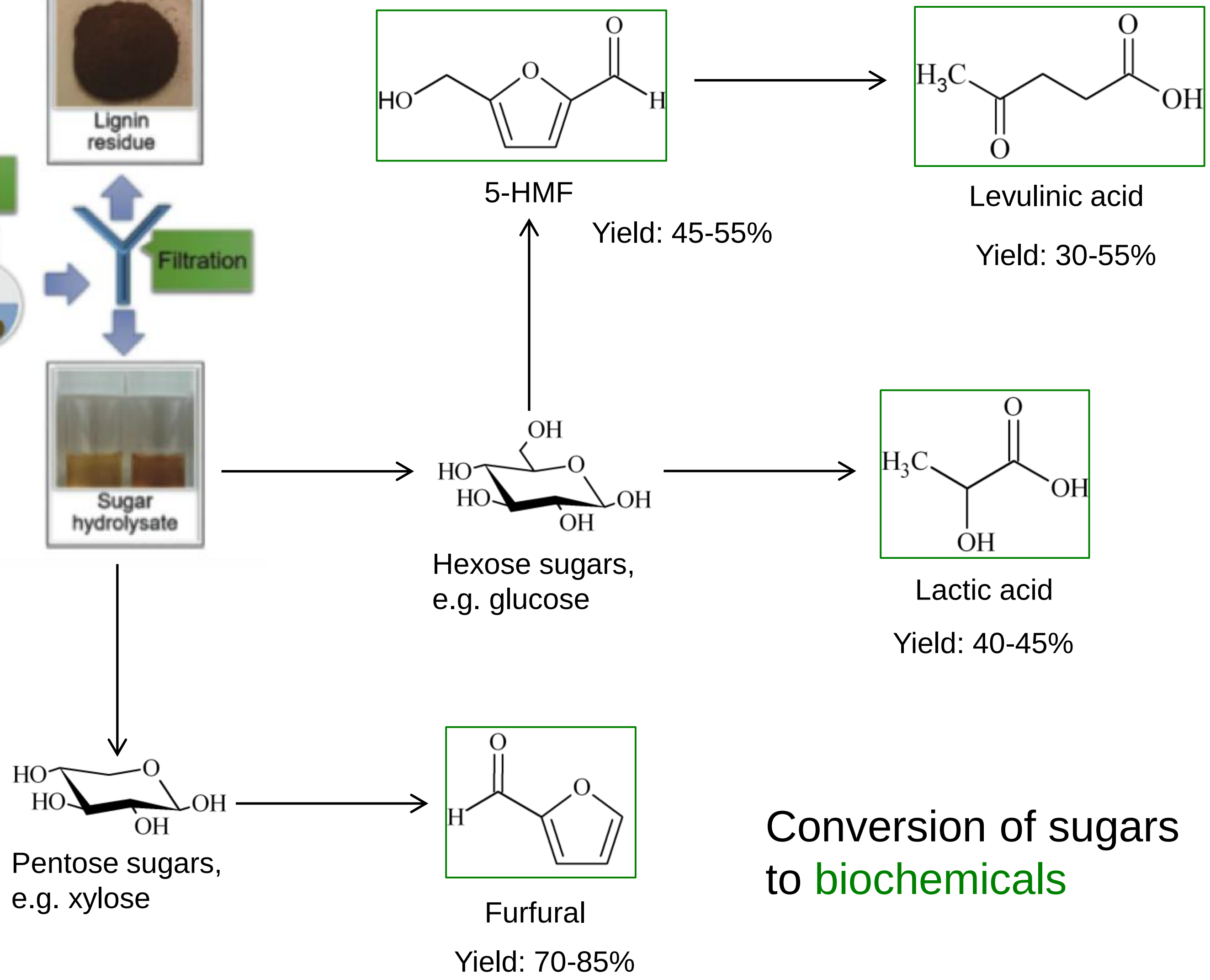
  - barley straw 40% ($H_2SO_4$)
  - barley straw 45% ($K_2S_2O_7$)

- Water-solubility of the pre-treated biomass 0 → 80–90%

# Conversion of biomass to platform chemicals via sugar platform




Biomass pre-treatment




Conversion of sugars to biochemicals

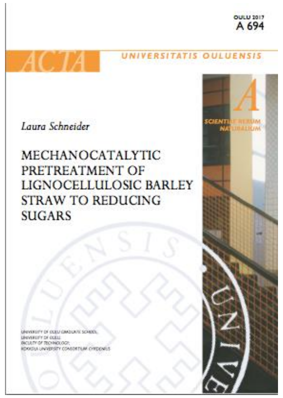
# Pre-treatment of biomass by mechanocatalysis or ionic liquids

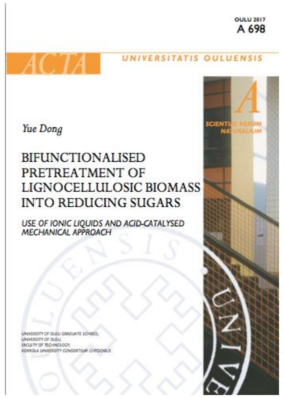
Thesis:

- Laura Schneider, Mechanocatalytic pretreatment of lignocellulosic barley straw to reducing sugars, 2017
- Yue Dong, Catalytic depolymerization of lignocellulosic biomass into reducing sugars: Use of ionic liquids and acid-catalysed mechanical approach, 2017

Doctoral students:

- Henna Lempiäinen (2017-)
  - Lempiäinen et al., The Effect of Mechanocatalytic Pretreatment on the Structure and Depolymerization of Willow, *Catalysts*, 2020, 10, 255.




## Publications related to biomass conversion to biochemicals

- Lappalainen et al., Simultaneous production of furfural and levulinic acid from pine sawdust via acid-catalysed mechanical depolymerization and microwave irradiation, *Biomass and Bioenergy*, 2019, 123, 159.
- Lappalainen et al., Brønsted and Lewis acid catalyzed conversion of pulp industry waste biomass to levulinic acid, *BioResources*, 2019, 14, 7025.
- Lappalainen et al., Microwave-assisted conversion of novel biomass materials into levulinic acid, *Biomass Conversion and Biorefinery,* 2018, 8, 965.

# Biomass-based activated carbon

Preparation of activated carbon/carbon support materials

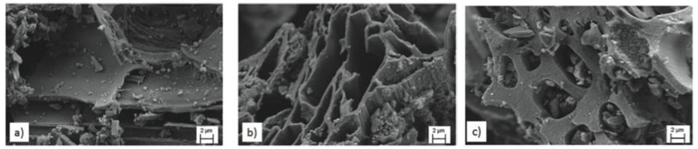
Biomass
- Sawdust
- Lignin
- Peat

Doctoral students:

- Riikka Kupila
- Riikka Juhola
- Toni Varila

Carbonization and activation

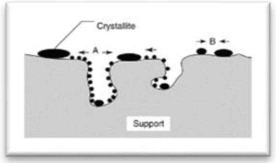
Activated carbon
- High value technical carbons



Utilization of activated carbon as an adsorbent

Preparation of catalysts

Surface modification




Active metal impregnation, e.g. with $ZnCl_2$

Me/C catalyst

Utilization of modified carbon in biomass conversion

# Activated carbon preparation and use as an adsorbent in water treatment

Thesis:

- Davide Bergna, Activated carbon from renewable resources: carbonization, activation and use, 2019
- Hanna Runtti, Utilisation of industrial by-products in water treatment. Carbon- and silicate-based materials as adsorbents for metals and sulphate removal, 2016
- Sari Tuomikoski, Utilisation of gasification carbon residues: activation, characterisation and use as an adsorbent, 2014


- Bergna et al., Activated carbon from renewable sources: thermochemical conversion and activation of biomass and carbon residues from biomass gasification. In *Waste Biomass Management – A Holistic Approach*, 2017, 187-213, Springer.
- Bergna et al., Comparison of the properties of activated carbons produced in one-stage and two-stage processes. *C-Journal of Carbon Research*, 2018, 4, 41.
- Bergna et al., Physical activation of wooden chips and the effect of particle size, initial humidity, and acetic acid extraction on the properties of activated carbons. *C-Journal of Carbon Research*, 2018, 4, 66.
- Bergna et al., Effect of some process parameters on the main properties of activated carbon produced from peat in a lab-scale process. *Waste and Biomass Valorization*, 2019, 11, 2837.
- Varila et al., Activated carbon production from peat using ZnCl2: characterization and applications. *BioResources,* 2017, 12, 8078.
- Lahti et al., Physico-chemical properties and use of waste biomass-derived activated carbons. *Chemical Engineering Transactions,* 2017, 57, 43.
- Siipola et al., Effects of Biomass Type, Carbonization Process, and Activation Method on the Properties of Bio-Based Activated Carbons. *BioResources*, 2018, 13, 5976. (Joint publication with Luke.)


**Use of biomass based activated carbon in water treatment**


- Tuomiķoski et al., Zinc Adsorption by Activated Carbon Prepared from Lignocellulosic Waste Biomass, *Applied sciences*, 2019, 9, 4583.

# Biomass-based activated carbon supported catalysts

**Furfural conversion into 2-methylfuran over Ru/C, Ni/C and Pt/C catalysts**

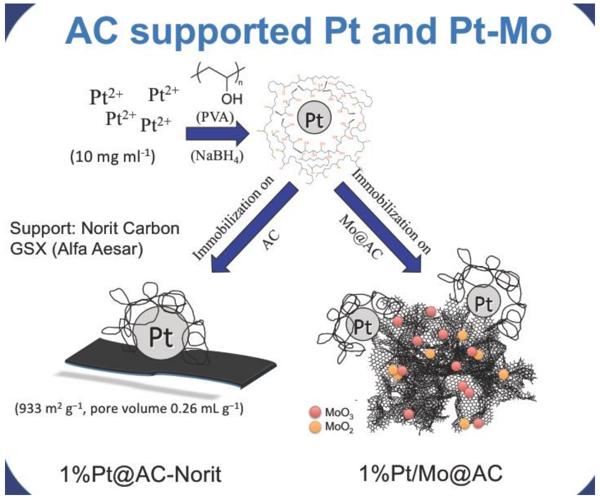
- Mäkelä et al., Study of Ni, Pt and Ru catalysts on wood-based activated carbon supports and their activity in furfural conversion into 2-methylfuran, *ChemCatChem*, DOI: 10.1002/cctc.201800263

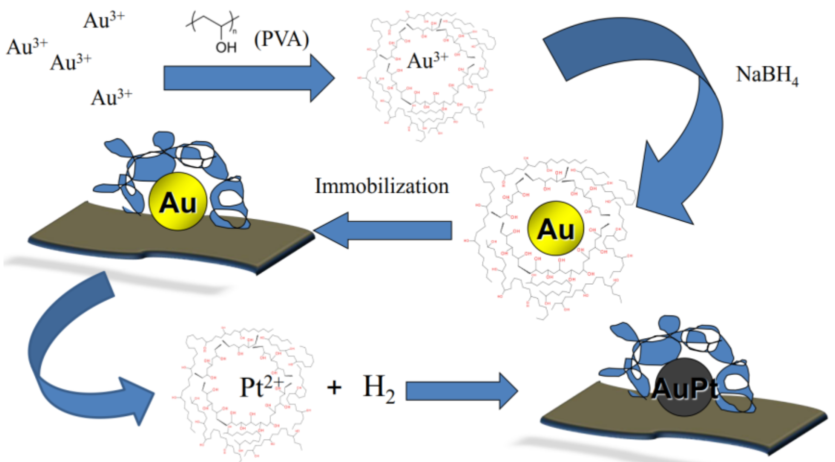
**Co/C catalysts**

- Lahti et al., Characterization of cobalt catalysts on biomass-derived carbon supports, *Topics in Catalysis*, 2017, 60, 1415.

**Glycerol oxidation over 1% AuPt/C catalysts**

- Prati et al., Carbons from second generation biomass as sustainable supports for catalytic systems, *Catalysis Today* 2018, 301, 239.




Prof. Laura Prati, Milan Technical University, Italy

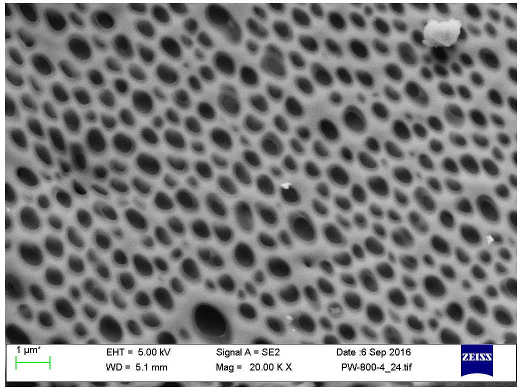
**Mo/C and W/C catalysts**

- Capelli et al., Hydrogenation of muconic acid into adipic acid with biomass-based Mo and W catalysts, manuscript
- Stucchi et al., A Pt-Mo hybrid catalyst for furfural transformation, *Catalysis Today*, 2019 (In Press)

**Brönsted and Lewis acid catalysts**

- Rusanen et al., Catalytic conversion of glucose to 5-hydroxymethylfurfural over biomass-based activated carbon catalyst, *Catalysis Today*, 2019.
- Rusanen et al., Conversion of Xylose to Furfural over Lignin-Based Activated Carbon-Supported Iron Catalysts, *Catalysts*, 2020, 10, 821.

# Carbon foams





- Biomass-based carbon catalysts made by foaming process in the presence of an activator
- Well-formulated porous structure with very high mechanical strength

- Varila, T., Romar, H., & Lassi, U. (2019). Catalytic effect of transition metals (copper, iron, and nickel) on the foaming and properties of sugar-based carbon foams. *Topics in Catalysis*, 62(7–11), 764–772.
- Varila, T., Romar, H., Luukkonen, T., & Lassi, U. (2019). Physical activation and characterization of tannin-based foams enforced with boric acid and zinc chloride. *AIMS Materials Science*, 6(2), 301–314.
- Varila, T., Romar, H., Luukkonen, T., Hilli, T., & Lassi, U. (2020) Characterization of lignin enforced tannin-furanic foams. *Heliyon*, 6(1), e03228.
- Varila, T., Mäkelä, E., Kupila, R., Romar, H., Karinen, R., Puurunen, R., & Lassi, U. (2020). Conversion of furfural to 2-methylfuran with CuNi catalysts supported on bio-based carbon foams. (*Catalysis Today*, revised)
- Varila, T., Brännström, H., Kilpeläinen, P., Hellström, J., Romar, H., Nurmi, J., & Lassi, U. (2020). From Norway spruce bark to carbon foams, characterization and applications. *BioResources*, 15(2), 3651–3666

**Doctoral Thesis:**

- **Varila Toni, New, biobased carbon foams, defense 30.11.2020 in Kokkola**

# Kiitoksia mielenkiinnostanne!

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