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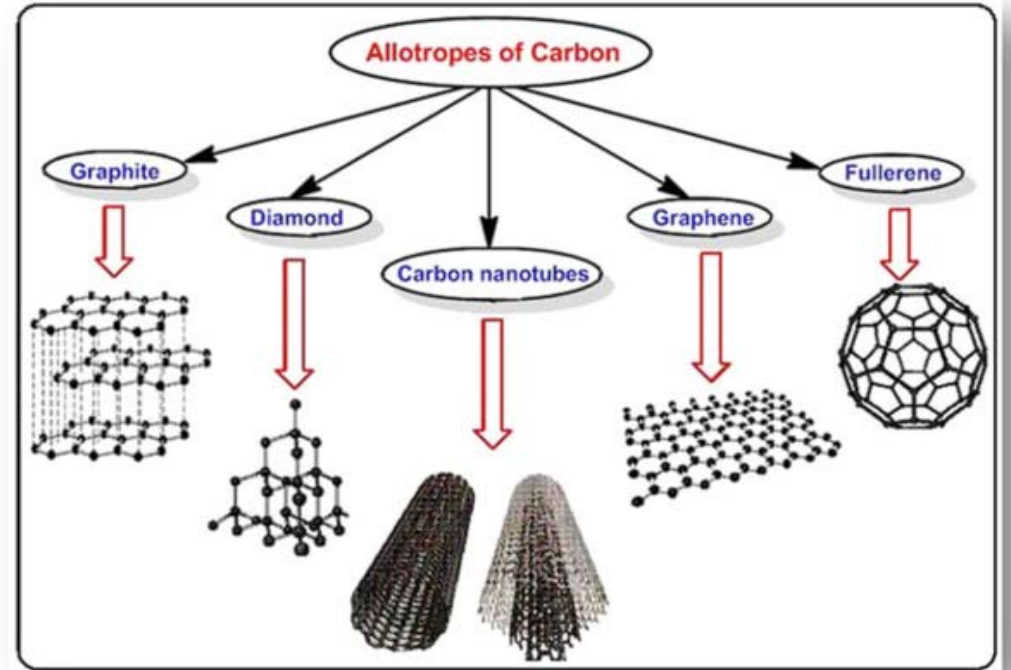
FACULTY OF SCIENCE
Charles University

BIOCHAR AS A STATE-OF-THE-ART ALTERNATIVE MATERIAL FOR ELECTROCHEMICAL SENSING

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Current State of the Problem

- **choice of a suitable working electrode (WE)** is a crucial point in the practical success;
- WE predestines the essential analytical parameters (spectrum of determinable analytes, sensitivity, selectivity).



Research Interest

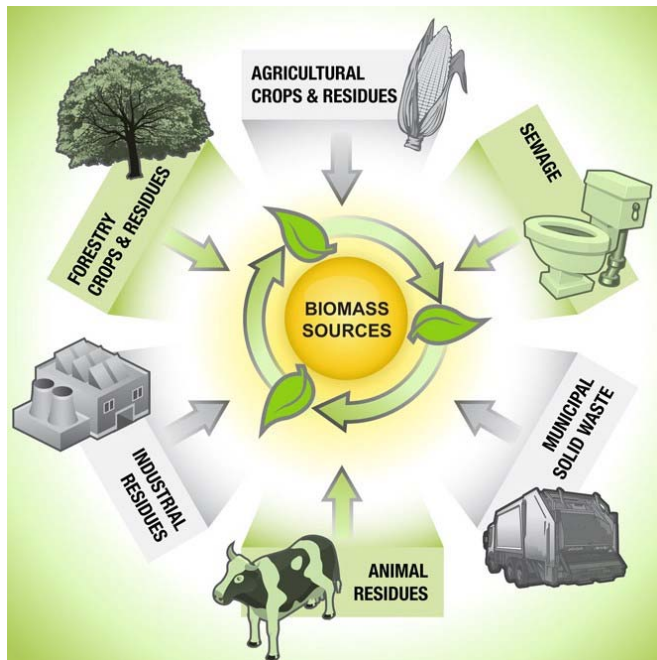
Boron-doped diamond electrode (BDDE)

Carbon paste electrode (CPE)

Biochar based electrode

What is BIOCHAR?

- The word "**biochar**" is derived from the Greek word *bios* "life" and "char" (*charcoal produced by carbonisation of biomass*).
- Biochar is defined by the International Biochar Initiative as "**the solid material obtained from the thermochemical conversion of biomass in an oxygen-limited environment**".

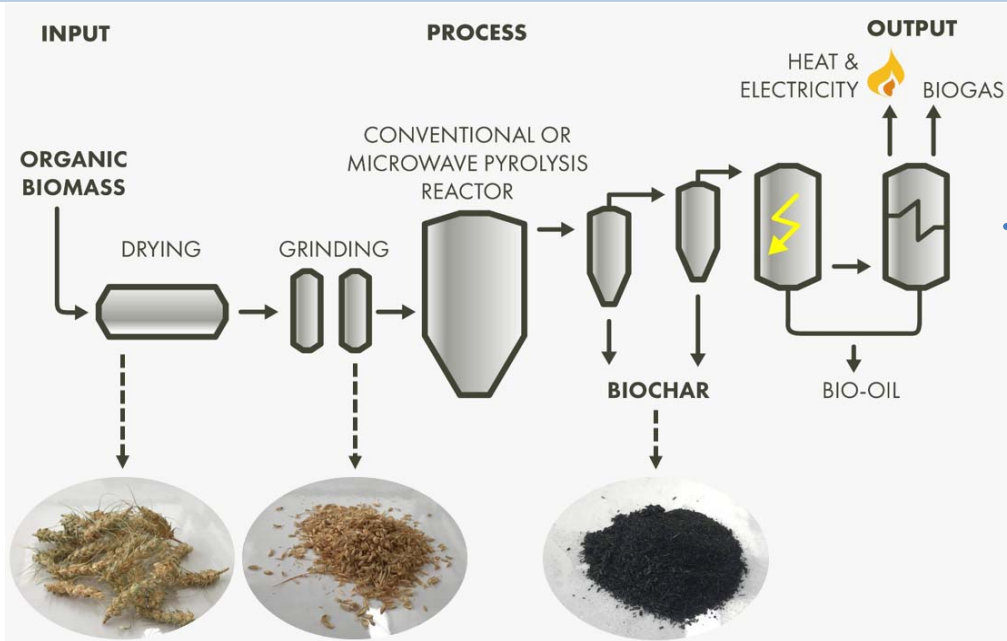


Biochar produced from residual wood



Biochar after production, in a large pile

Production of Biochar



1. Temperature (ranging from 300 to 900 °C)
2. Heating rate affects:
 - *specific surface area*
 - *porosity*
 - *functional groups*
3. Pyrolysis time

- Fast pyrolysis** → reduced particle size, carboxylic and hydroxyl surface groups
- Slow pyrolysis** → coarse particles and dominant aromatic groups

| Method | Temperature °C | Heating rate °C/s ⁻¹ | Duration (s/h/min/days) | Yields (%) |
|-----------------------|----------------|---------------------------------|-------------------------|--|
| Slow pyrolysis | 300-600 | 0.01-2 | Days | 35-45 biochar 25-35 bio-oil 20-30 syngas |
| Fast pyrolysis | > 600 | > 2 | ~ 1 s | 60 bio-oil 20 biochar 20 syngas |

Typical yields are:
60% bio-oil
20% biochar
20% syngas

Biochar Properties and Application

- ✓ High carbon content (60-95 %);
- ✓ High surface area and porosity;
- ✓ Functionalization of surface;
- ✓ Significant adsorptive qualities (similar to activated carbon);
- ✓ **Price: 1 kg of biochar ~ 2.7 USD vs. 1 kg of activated carbon ~ 20-22 USD.**

- an energy source (biofuel);
- drinking water filtration;
- sanitation of human and kitchen wastes;
- a composting agent.

In Analytical Chemistry?

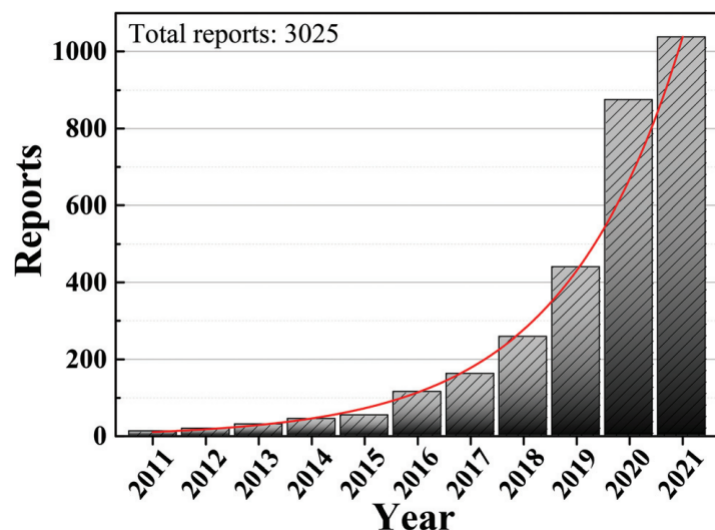


Electroanalytical Methods?



Biochar
as a Green Material for
Electrochemical Sensing

Biochar in Electrochemical Sensing



Biochar electrochemical application research through the years. Search of Web of Knowledge with the keyword “biochar electrochemical application”.

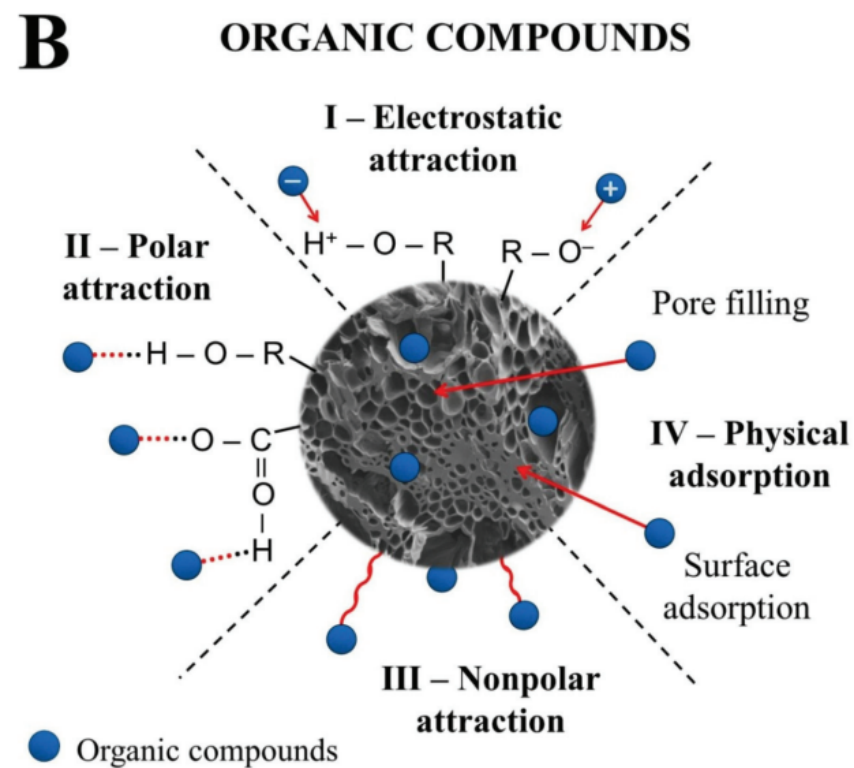
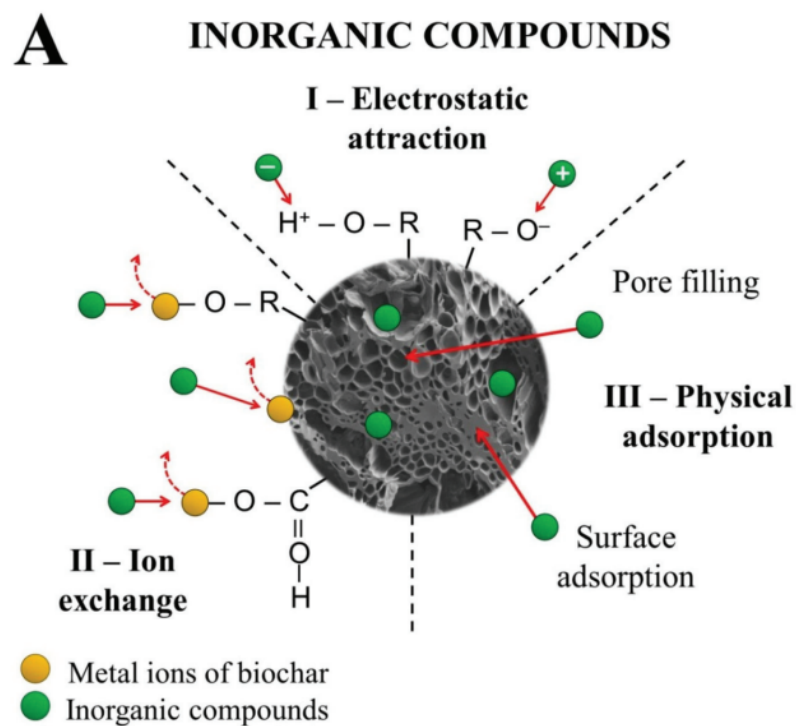
Reviews on Biochar Electroanalysis

D. Spanu, G. Binda , C. Dossi, D. Monticelli. **Biochar as an alternative sustainable platform for sensing applications: A review**, *Microchemical Journal*, 159 (2020), 105506.

K. Kalinke et al. **State-of-the-art and perspectives in the use of biochar for electrochemical and electroanalytical applications**, *Green Chemistry*, 23 (2021), 5272.

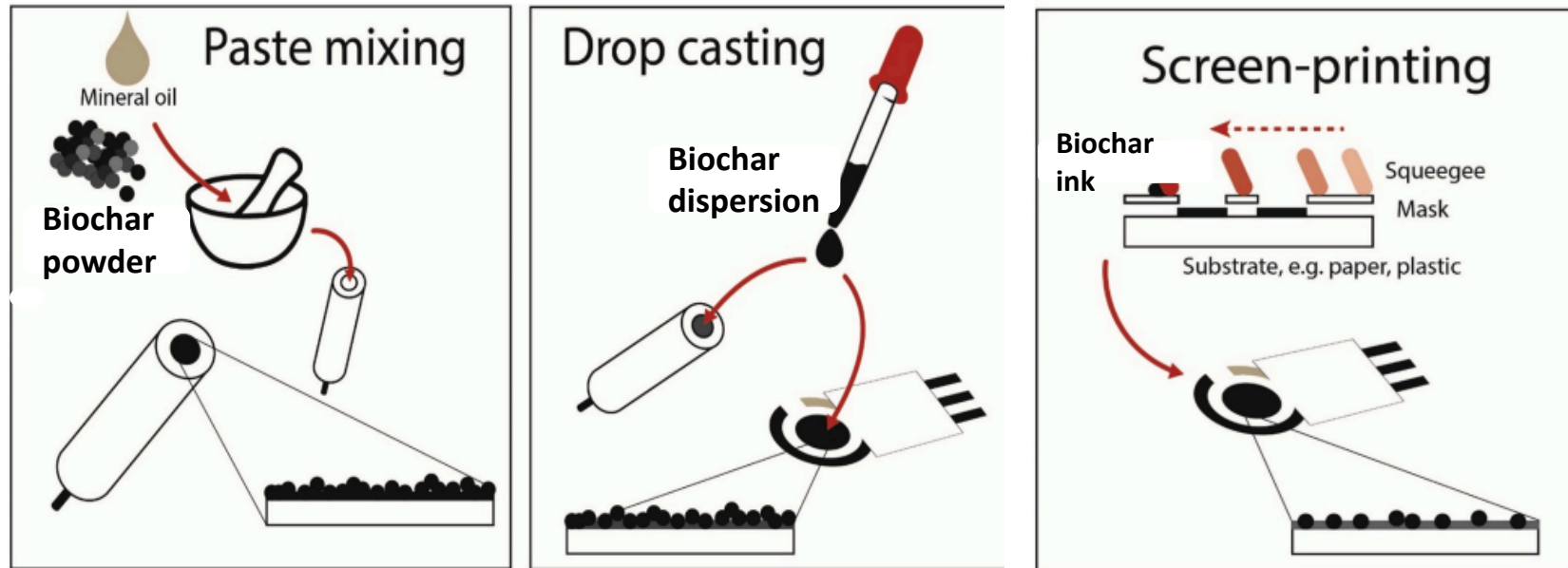
R. Cancelliere , M. Cianciaruso , K. Carbone, L. Micheli. **Biochar: A sustainable alternative in the development of electrochemical printed platforms**, *Chemosensors*, 10 (2022), 344.

Interaction Mechanisms



Biochar interaction mechanisms proposed for **(A)** inorganic and **(B)** organic compounds.

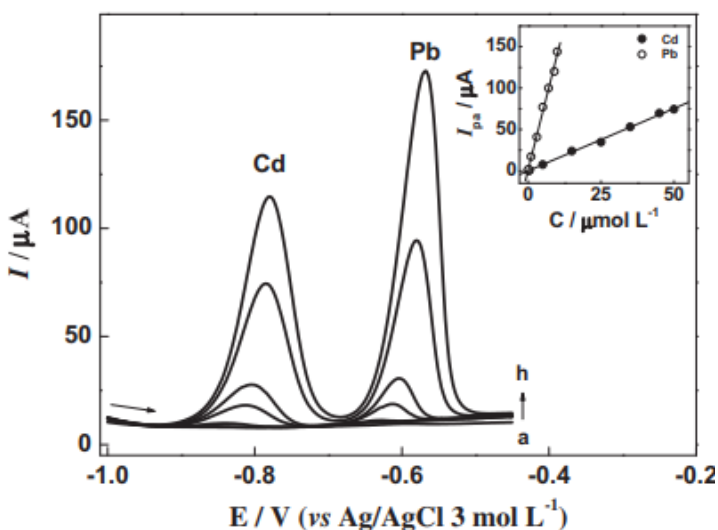
Biochar in Electrochemical Sensing



Different procedures to fabricate biochar-based (bio)sensors.

Role of Biochar in Electrochemical Sensing

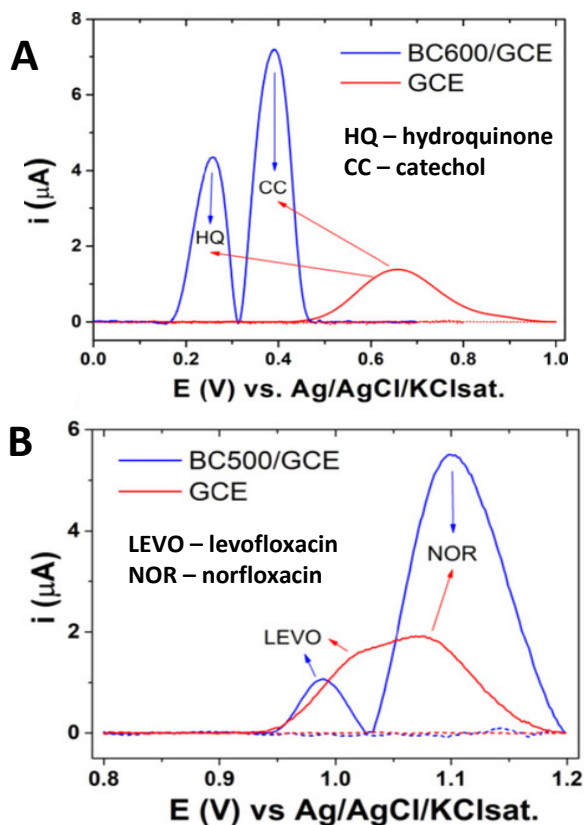
✓ adsorbent



DPAdSV of Cd(II) and Pb(II) with different concentrations at CPE modified with 25% biochar in PBS (pH 5.0) after preconcentration by **1200 s** in solution (pH 7.0).

T. M. Suguihiro et al. *Bioresource Technology*, 143 (2013), 40-45.

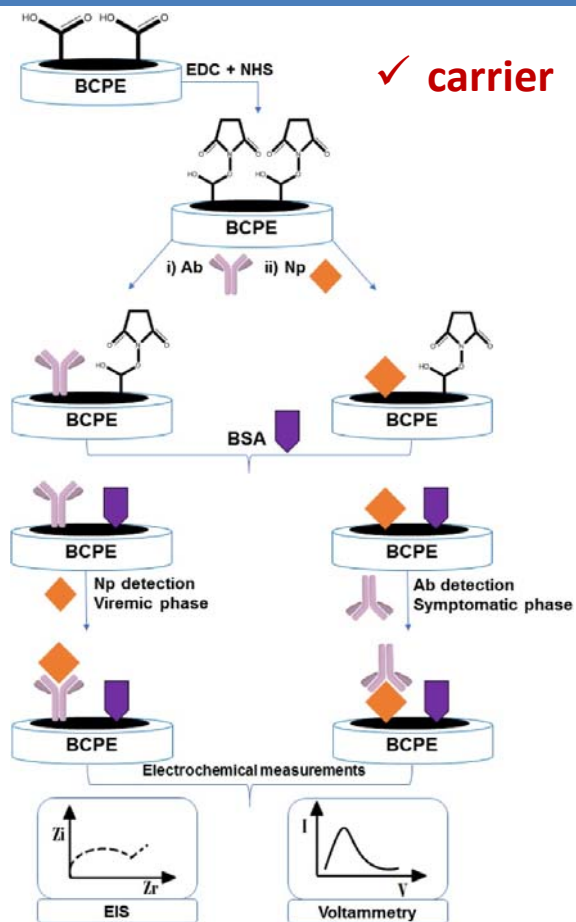
✓ catalyst



SWV curves obtained on a BC/GCE and GCE in presence of **A**) HQ and CC; and **B**) LEVO and NOR (10 $\mu\text{mol L}^{-1}$ each).

P. A. Ferreira et al. *Electroanalysis*, 30 (2018), 2233 – 2236.

✓ carrier



Immunosensor for hantavirus (i) antibodies (Ab) or (ii) nucleoprotein (Np) detection in viremic or symptomatic phases.

G. Martins et al. *Talanta*, 204 (2019), 163-171.

Conceptualization

1. Fabrication of disposable and fully screen-printed three-electrode systems with biochar-based working electrodes.

1.1 Biochar powder characterization.

1.2 Electrochemical characterization.

1.3 Studies of electrochemical behavior of model analytes using constructed systems. Optimization of experimental conditions.

1.4 Analytical performance of the proposed systems.

2. Practical applicability of biochar-based electrodes.



Conclusions and outlooks

- ❑ For the first time, a fully screen-printed electrochemical sensors, based on biochar/ethylcellulose-modified carbon working electrodes, was introduced.
- ❑ The effect of ethylcellulose concentration, pH study of supporting electrolyte, mechanism of oxidation reaction of the analyte and selection of pulse parameters were investigated.
- ❑ The performances of the bare carbon electrode, biochar electrode and biochar-modified carbon electrode for the determination of PAR was compared.
 - *The influence of pyrolysis temperature will be investigated;*
 - *The longer time of the preconcentration should be tested;*
 - *The impact of “pretreatment” of screen-printed biochar-based electrodes will be evaluated;*
 - *Different modification of screen-printed biochar-based electrodes will be tested.*

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**Registrační číslo
projektu**

CZ.02.2.69/0.0/0.0/18_053/0016976

Název projektu

Mezinárodní mobility výzkumných, technických
a administrativních pracovníků na UK

Název příjemce

Univerzita Karlova

Thank you for your attention!

