EBIO Newsletter

Biofuels Through Electrochemical Transformation Of Intermediate Bio-Liquids

Issue 3 / November 2022

EBIO is a four-year project that is part of the European Union's Horizon 2020 Research and Innovation Programme. It is set to be a game changer in the field of biofuel production with the aim to generate energy dense biofuels through electrochemical transformation of intermediate liquified biomass.

The project launched in December 2020 with a budget of around 4 million euros. After some Covid-19 pandemic related start-up challenges, all PhD students have started their research and the project is now and running and in full-swing and has brought together partners from all over Europe all with the same goal: to turn low value crude bio liquids into sustainable road transport fuels.

The consortium is built on strong foundations of research, innovation, and industrial knowledge. It consists of nine beneficiaries from seven different countries, among them some of the world leaders in the field.

CONTENTS

1. EBIO presented at the 241st ECS Meeting

The 241st ECS Meeting, Vancouver, brought together the most active researchers in academia, government, and industry—professionals and students alike—to engage, discuss, and innovate in the areas of electrochemistry and solid state science and technology.

Siegfried Waldvogel presented on behalf of EBIO, on June 1st 2022: Electro-Conversion of Lignin to Highly Value-Added.

After cellulose and hemicellulose, lignin represent the most abundant part of the plant biomass. Due to the large waste stream originating from pulping processes, only Kraft lignin and lignosulfonates are of technical interest. Using electric current as sustainable reagent for degradation avoids transition metal catalysts and makes this approach very attractive. However, the natural complexity and stability of lignin make the depolymerization to useful organic building blocks a highly challenging task. The state of the art in the selective anodic degradation of Kraft lignin and other lignins will be reported. This contribution exclusively deals with the direct electrolysis and ex-cell approaches. The major focus will be given on the generation and cost efficient isolation of vanillin and related building blocks.

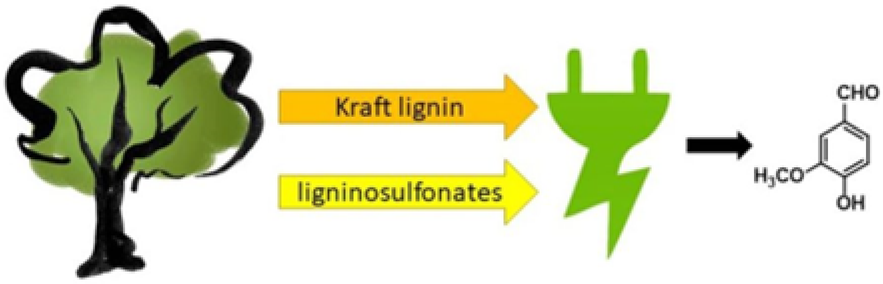
References:

[1] M. Zirbes, S. R. Waldvogel, Curr. Opin. Green Sustainable Chem. 2018, 14, 19–25.

[2] M. Zirbes, D. Schmitt, N. Beiser, D. Pitton, T. Hoffmann, S. R. Waldvogel, ChemElectroChem 2018, 6, 155–161.

[3] M. Zirbes, L. L. Quadri, M. Breiner, A. Stenglein, A. Bomm, W. Schade, S. R. Waldvogel, ACS Sustainable Chem. Eng. 2020, 8, 7300–7307.

[4] M. Breiner, M. Zirbes, S. R. Waldvogel, Green Chem. 2021, 23, 6449–6455.



EBIO presented at the 241st ECS Meeting

2. EBIO Presented at RRB Conference 2022

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Electrifying Organic Synthesis, abstract below, was presented by Siegfried Waldvogel, at RRB Conference, 1-3 June 2022 (https://rrbconference.com/programme-2022/)

The direct use of electrochemistry for the generation of reactive intermediates can have major advantages towards conventional synthetic strategies.[1] Less or no reagent waste is generated and new reaction pathways are accessible.[2] In order to exploit the electricity driven conversions for synthetic purposes and to install unique selectivity two modern approaches will be outlined:

Solvent-controlled selective dehydrogenative cross-coupling reactions:

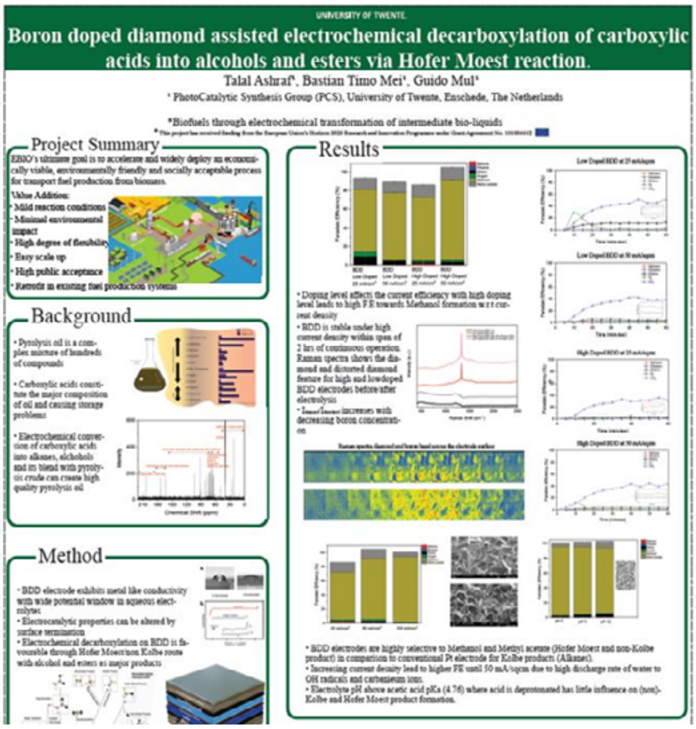
A key for this is the use of boron-doped diamond anodes and fluorinated alcohols within the electrolyte.[3] This methodology opened new pathways for innovative and scalable arylation reactions.[4]
New electrode systems for the anodic and cathodic conversion to value-added organic compounds.
These systems are capable to go beyond common limits in electro-organic synthesis. These strategies are specific use for the conversion biomass such as lignin or pyrolysis oil.
The working horse to identify suitable electrolytic conditions is the electrosynthetic screening approach.
This strategy gives also rise to fast optimization and subsequent scale-up.

References:
[1] E.J. Horn, B.R. Rosen, P.S. Baran, ACS Cent. Sci. 2 (2016) 302-307.
[2] a) S. Möhle, M. Zirbes, E. Rodrigo, T. Gieshoff, A. Wiebe, S. R. Waldvogel, Angew. Chem. Int. Ed. 57 (2018) 6018-6041; b) A. Wiebe, T. Gieshoff, S. Möhle, E. Rodrigo, M. Zirbes, S. R. Waldvogel, Angew. Chem. Int. Ed. 57 (2018) 5594-5619.
[3] L. Schulz, S.R. Waldvogel, Synlett 30 (2019) 275-286.
[4] S.R. Waldvogel, S. Lips, M. Selt, B. Riehl, C.J. Kampf, Chem. Rev., 118 (2018) 6706-6765. [5] C. Gütz, B. Klöckner, S.R. Waldvogel, Org. Process Res. Dev. 20 (2016) 26-32

3. EBIO Presented at NWO Chains annual Dutch chemistry conference

On behalf of Ebio, Talal Ashraf presented a poster at NWO Chains annual Dutch chemistry conference (Homepage – NWO Chains) on the 21st and 22nd of September.
Poster Title: Boron doped diamond assisted electrochemical decarboxylation of carboxylic acids into alcohols and esters via Hofer Moest reaction.

Motivation:
Electrochemical decarboxylation of carboxylic acids proceeds through the Kolbe/non-Kolbe pathway on platinum electrode nearby to potential range of oxygen evolution reaction (OER).
Boron doped Diamond (BBD) is an inert and stable electrode with a large oxygen overpotential and can promote decarboxylation without competitive OER. Due to BDD's inertness, the homo coupling reaction is inhibited by the direct discharge of acetic acid along with the presence of hydroxyl radicals by the water discharge. The reaction pathway proceeds through indirect electron transfer between OH– and alkyl radicals yielding methanol as the main product of the Hofer Moest reaction.BDD proved to be a choice of electrode for Hofer Moest reaction with high current efficiency.
The poster can be downloaded here.



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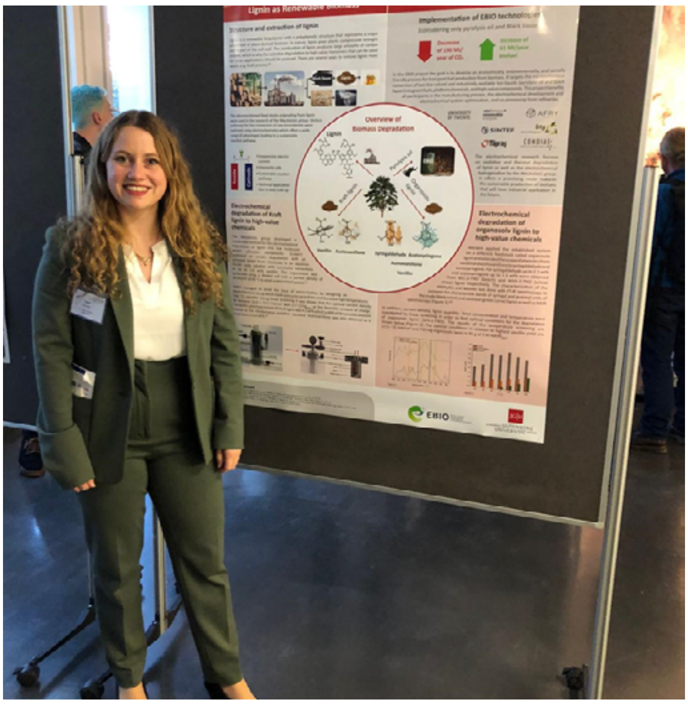
3. EBIO presented at Electrochemistry 2022

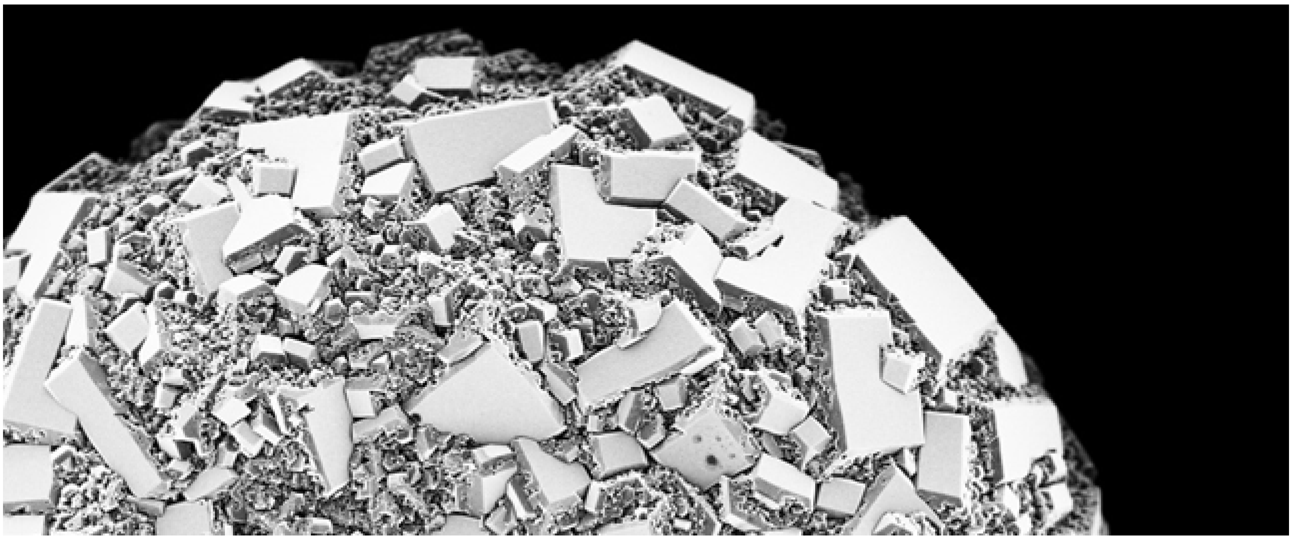
Elisabeth K. Oehl presented the following abstract as a scientific poster at Electrochemistry 2022 conference, held in Berlin, September 27 – 30: Lignin as potential sustainable and renewable feedstock for aromatic fine chemicals and fuels, by E. K. Oehl, Mainz/DE, S. R. Waldvogel, Mainz/DE
Lignin is a renewable biopolymer with a polyphenolic structure that represents a major proportion of plant-derived biomass. It accumulates as a waste material of the paper and pulping industries.
The combustion of lignin produces increasing amounts of CO_2, which is why the selective degradation to sensible monomers that can be used for other applications should be pushed towards.



The group of Professor Waldvogel successfully developed various pathways for the electrochemical conversion of raw biomaterials originating from lignin to high value chemicals like vanillin, acetovanillone and guaiacol under mild conditions. For example, vanillin was electrochemically obtained in high selectivity with 67%[1] efficiency compared to the common nitrobenzene oxidation.

Black liquor, pyrolysis oils derived from lignin and electrochemically depolymerized lignin also have great potential as feedstocks for a possible biofuel. Within the EBIO project, research focuses not only on oxidative and thermal degradation of lignin but also on the electrochemical reduction. It offers a promising route towards the sustainable production of biofuels that will find industrial application in the future.

5. Nano-photography of boron-doped diamond electrodes

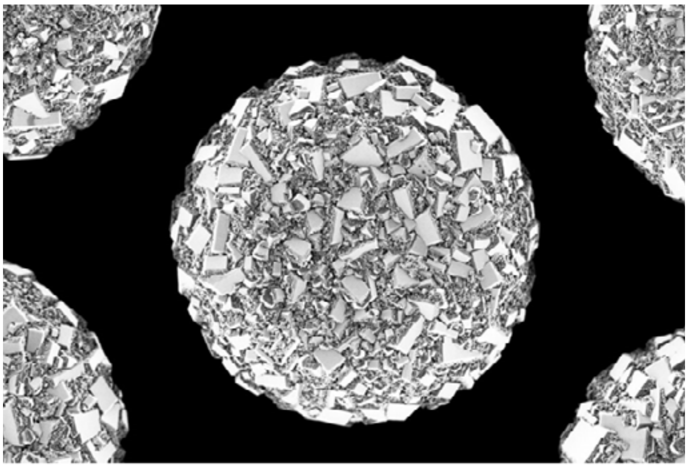


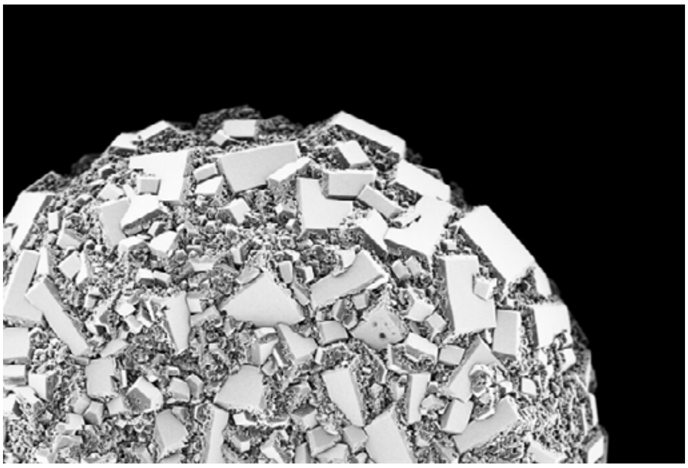
Nano-photography of boron-doped diamond electrodes

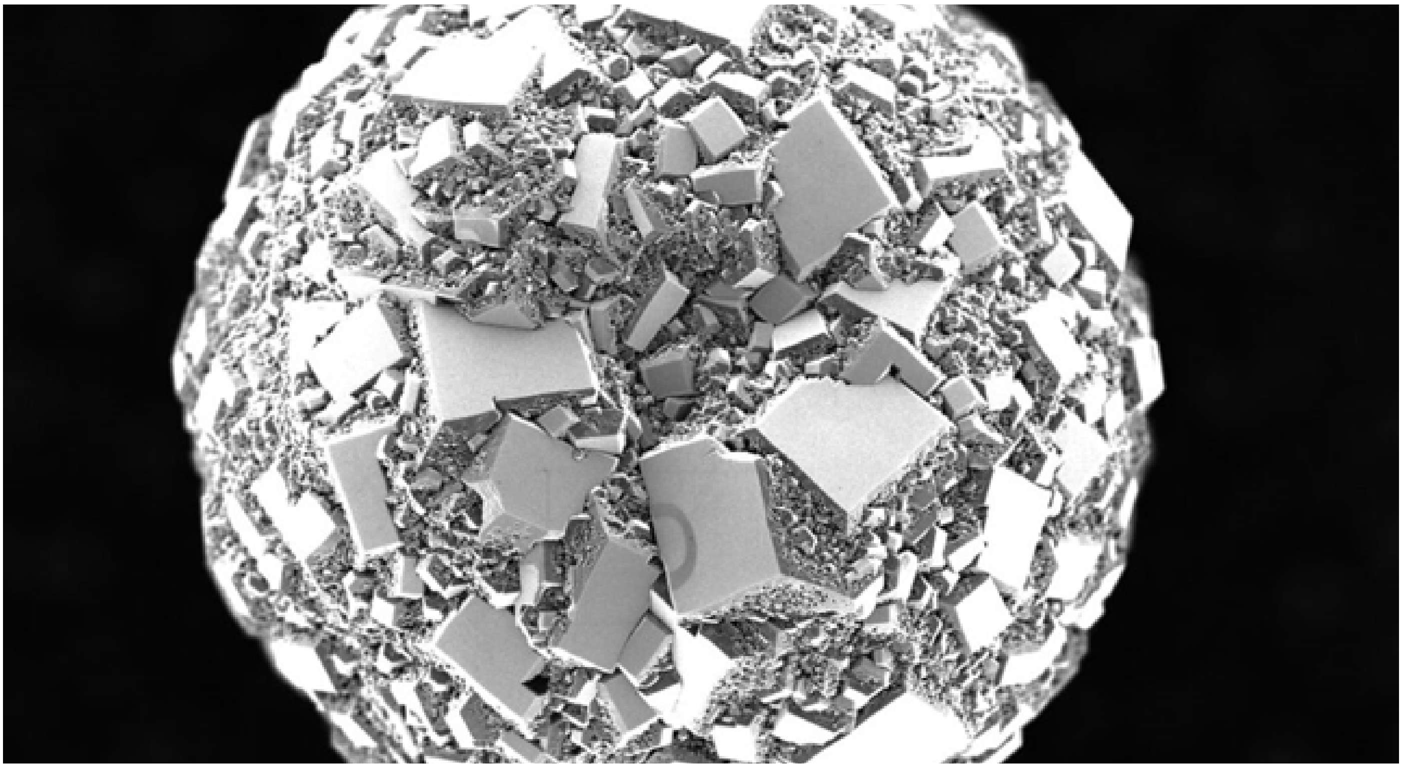
The SEM[1] images depict nanostructured boron-doped diamond (BDD) electrodes grown on boron-doped silicon pillars. In this collaborative effort Si pillars were fabricated at the MESAplus facilities at University of Twente. Subsequently BDD growth has been performed at Condias.

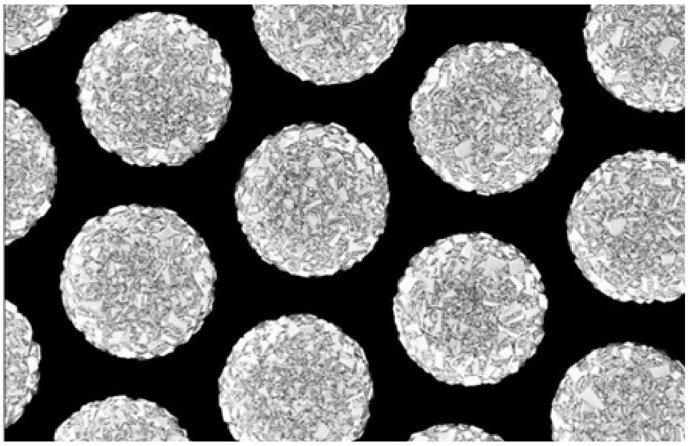
The high-quality sp3 carbon BDD electrodes exhibit excellent stability and activity for organic electrosynthesis reactions as shown by Talal Ashraf (PhD student at UTwente).

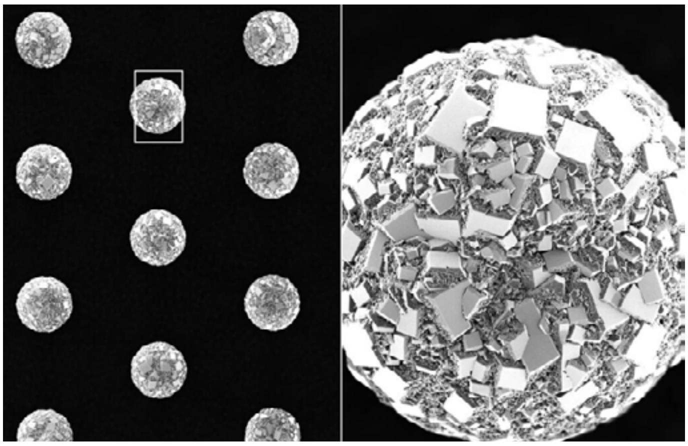
[1]A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning the surface with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that contain information about the surface topography and composition of the sample.











6. EBIO Second Press Release: Electrochemical treatment of industrial bio liquids is technically feasible reducing the cost of sustainable renewable energy

On the 11th November 2022, EBIO published the projects second press release in which the projects latest results are summarised, such as the identification of suitable electrode materials which lays the ground works for paired electrochemical tests combining anodic oxidation and cathodic reduction processes.

The full press release can be read here: [Press Release #2](#)

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