EBIO
BIOFUELS THROUGH ELECTROCHEMICAL TRANSFORMATION OF INTERMEDIATE BIO-LIQUIDS

Electrocatalytic kraft lignin conversion in industrial black liquor

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Introduction

Black liquor(BL) containing kraft lignin is a by-product from separation of cellulose in paper pulp manufacturing, available in large quantities in the existing pulp mills. The incineration of black liquor produces 40-50% more heat / electricity than needed by the pulp mill itself. In addition, by lignin and tall oil removal the feed rate of black liquor into existing recovery boilers can be increased, which enables an increased pulp production. This leads to large economic incitements to partly remove lignin from black liquor and valorise it more economically. EBIO targets the electrochemical lignin depolymerisation at mild conditions enabling a simple integration into the kraft pulp mill liquor cycle (Figure 1). In the envisaged industrial process, this can be performed as a part of the condensation train. Fractions of BL will be injected in an electrochemical cycle. Valuable products are separated, and the remaining liquor is fed back to the liquor cycle.

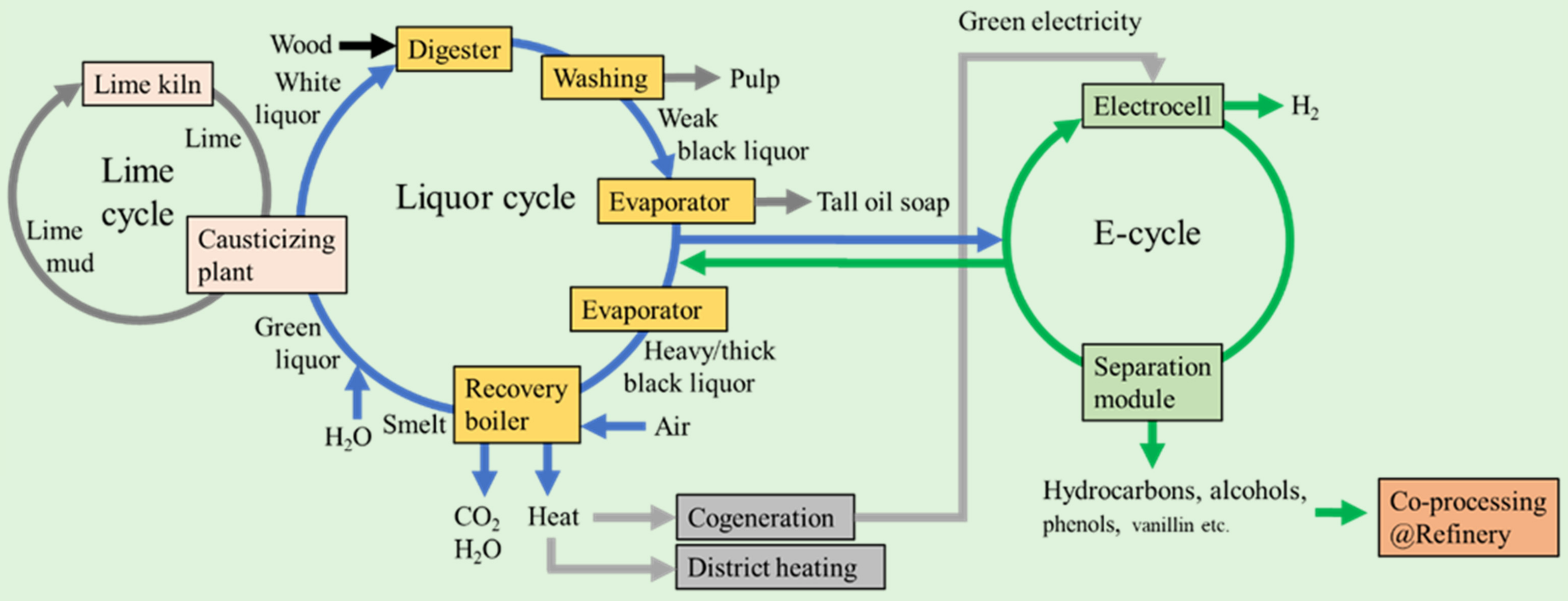

Figure 1: Integration of electrochemical BL conversion.

In-cell and ex-cell kraft lignin conversion is achieved by employment of stable high surface area electrode materials based on boron doped diamond(ex-cell) and transition metals. Application of structured supports and deposition techniques result in a ten-fold increase of specific surface areas as compared to the support structure. Optimised deposition conditions have been identified with respect to high surface areas and layer stability as well as gradient. Critical electrodeposition parameters are precursor type and concentration and applied voltage.

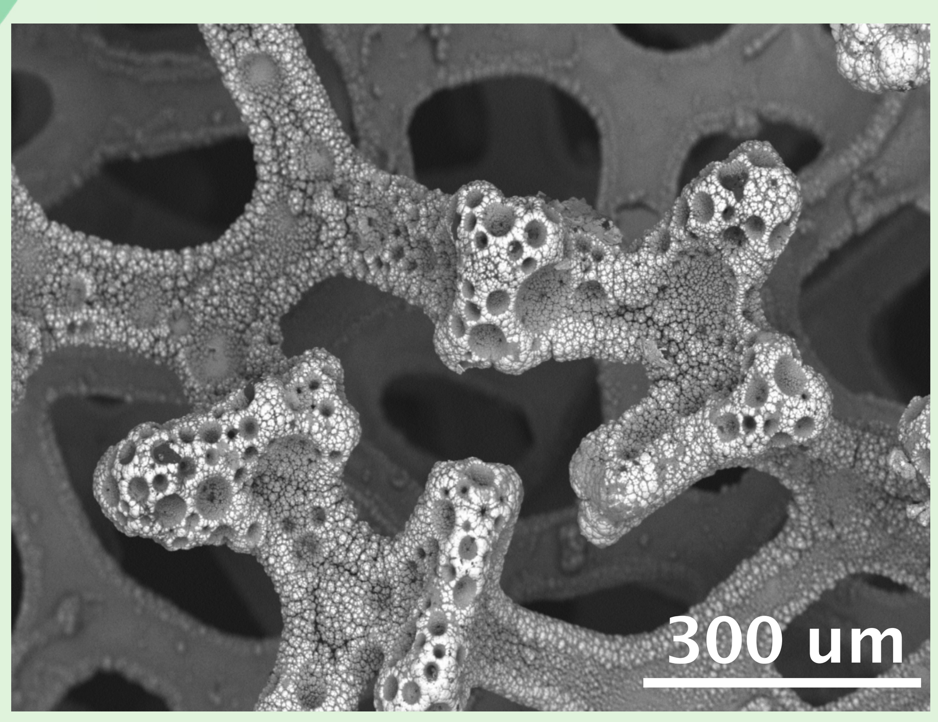

Figure 2: SEM image of Ni-deposited metal foam.

Electrochemical process optimisation

Based on chrono-amperometric measurements the optimal cell voltage ranges have been identified for several electrode combinations (Figure 3). Those are characterised by stable currents over more than 100 hours without carbon deposits formation at the electrode surfaces. Quantitative cathodic hydrogen production is observed while oxygen formation was minimal. Depolymerisation and oxidation to phenolic acids, as shown in Figure 4, proceeds in competition with minor repolymerisation and oxygen evolution. Higher cell voltages result in ring opening and C_1-C_6 acids production and oxidation to CO_2:

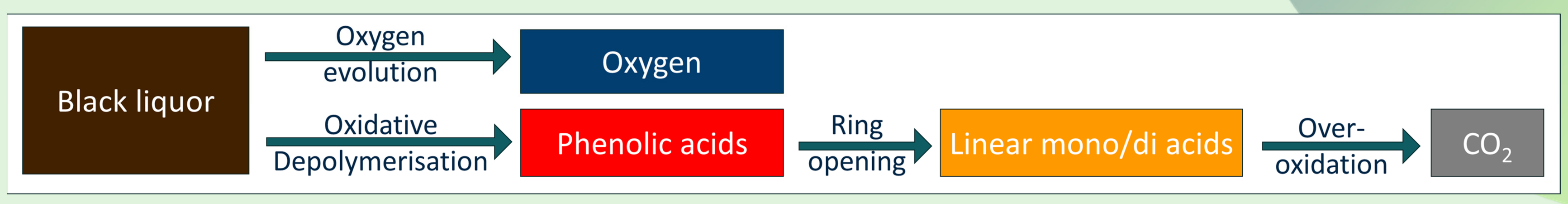

Figure 3: Simplified oxidative reaction mechanism.

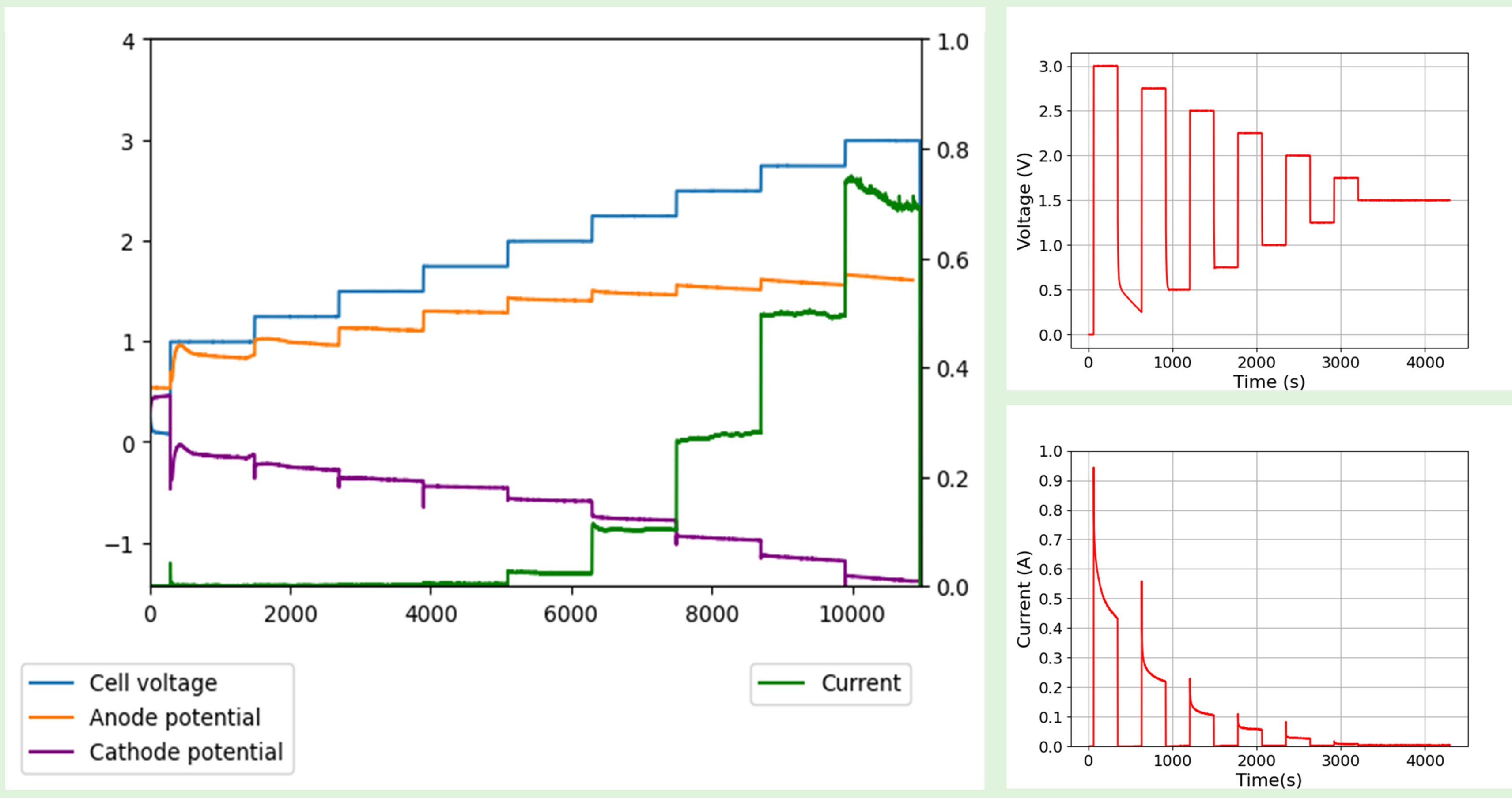

Figure 4: Chrono-amperometric scans indicating voltage ranges with stable electrode performance and electrode degradation.

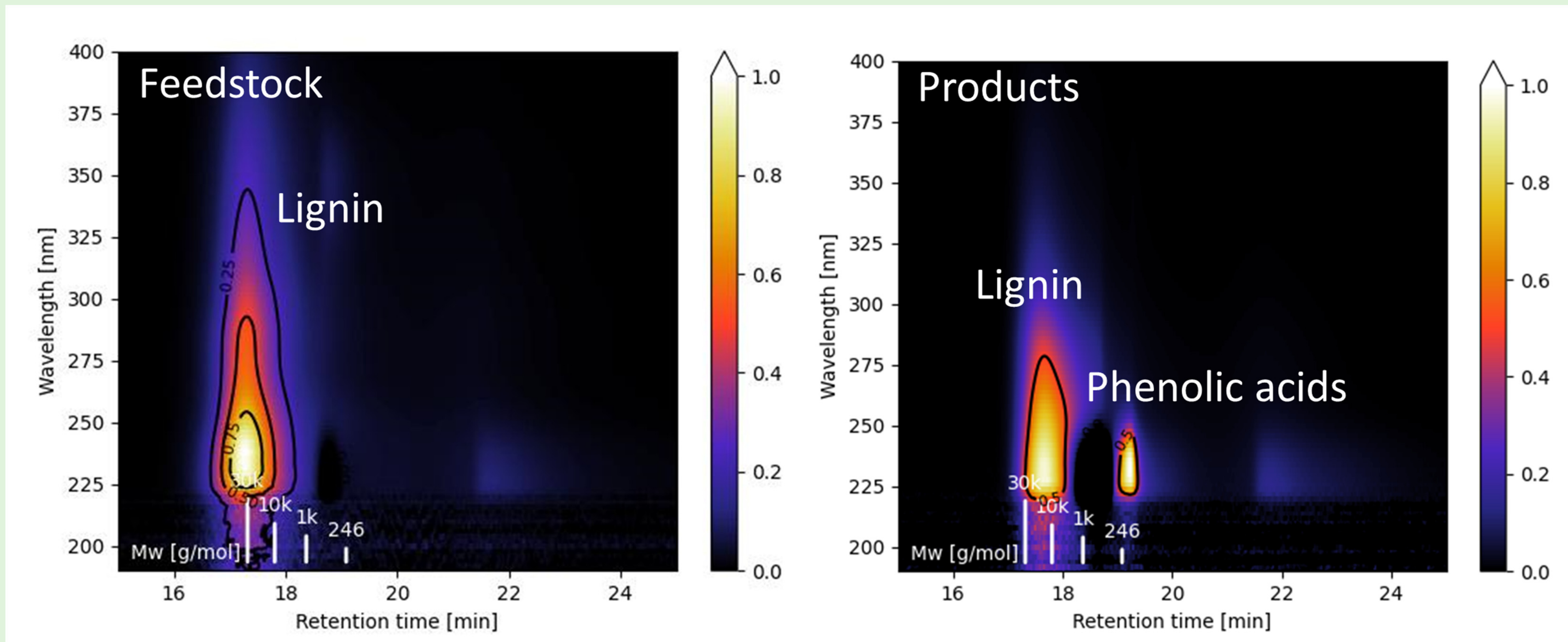

Figure 5: Chromatograms of lignin feedstock(left) and product mix of unconverted lignin and phenolic acids (right).

Project partners:

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