

Electrocatalytic valorisation of 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 evaporation train. Based on this generic process designs will be developed to integrate electrochemical process into kraft pulp mills.

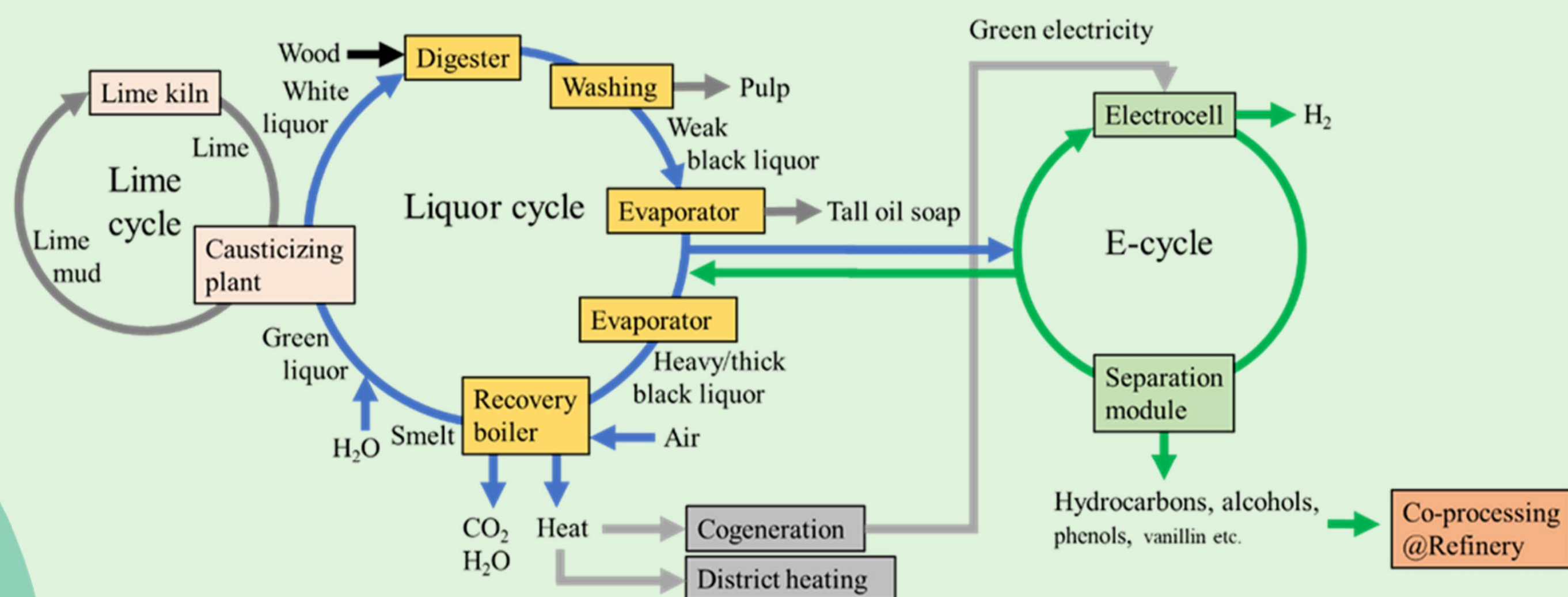
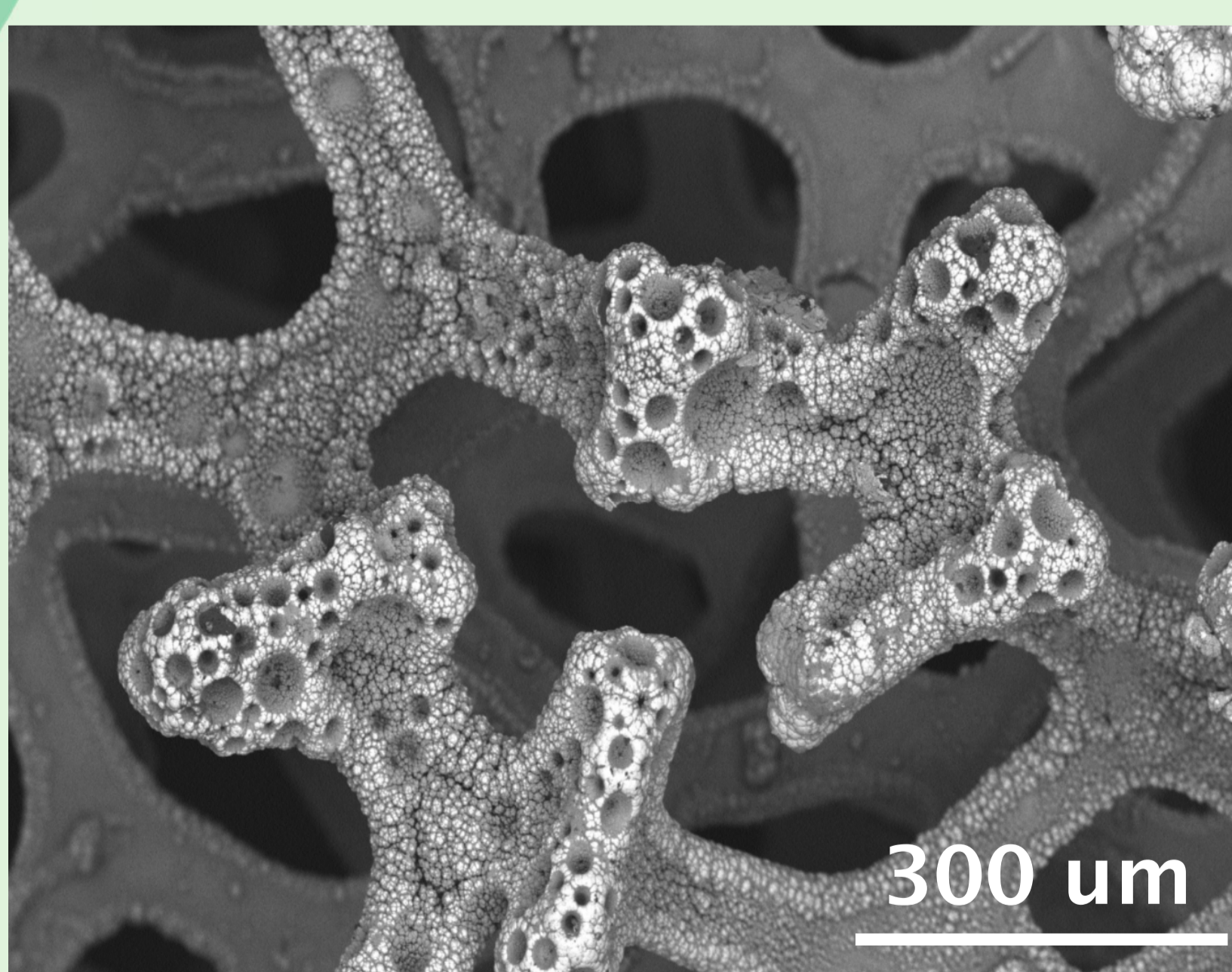


Figure 1: Integration of electrochemical BL conversion.

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.

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

Optimised deposition conditions have been identified with respect to high surface areas and layer stability as well as gradient. Dominant electrodeposition parameters are electrolyte composition, precursor concentration and applied voltage.

Electrochemical process optimisation

Based on chrono-amperometric measurements the optimal cell voltage ranges have been identified for several electrode combinations. Those are indicated by the green box in Figure 3 and can be characterised by stable currents over several hours without carbon deposits formation at the electrode surfaces. Quantitative cathodic hydrogen production is observed while oxygen formation was minimal (Figure 4). Depolymerisation and oxidation to acids proceeds in parallel with significant repolymerisation by reaction of radicals with lignin fragments, resulting in a product spectrum of acids and lignols (Figure 5).

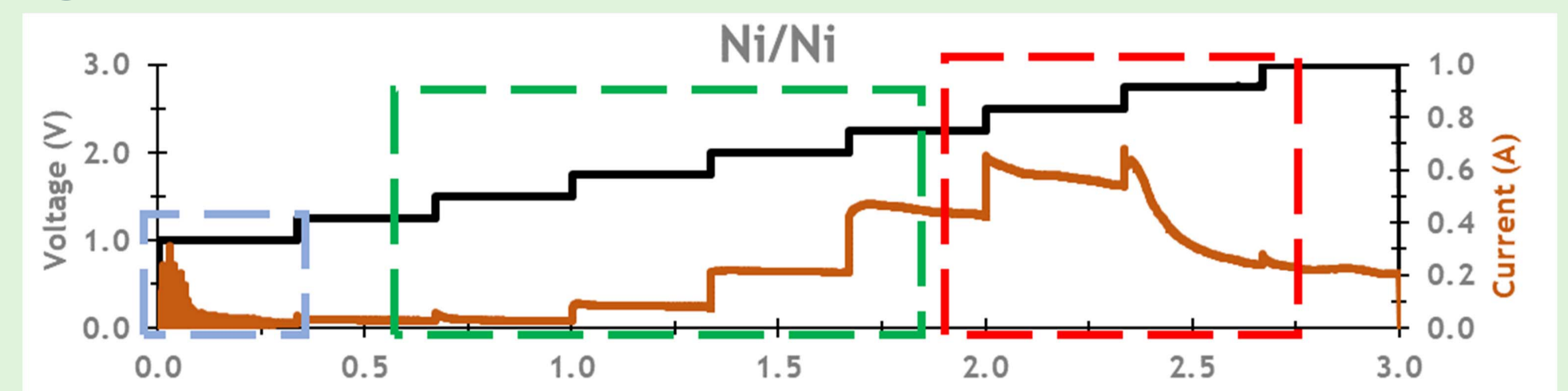


Figure 3: Chrono-amperometric scan indicating foaming (purple), stable operation (green), deposits formation (red).

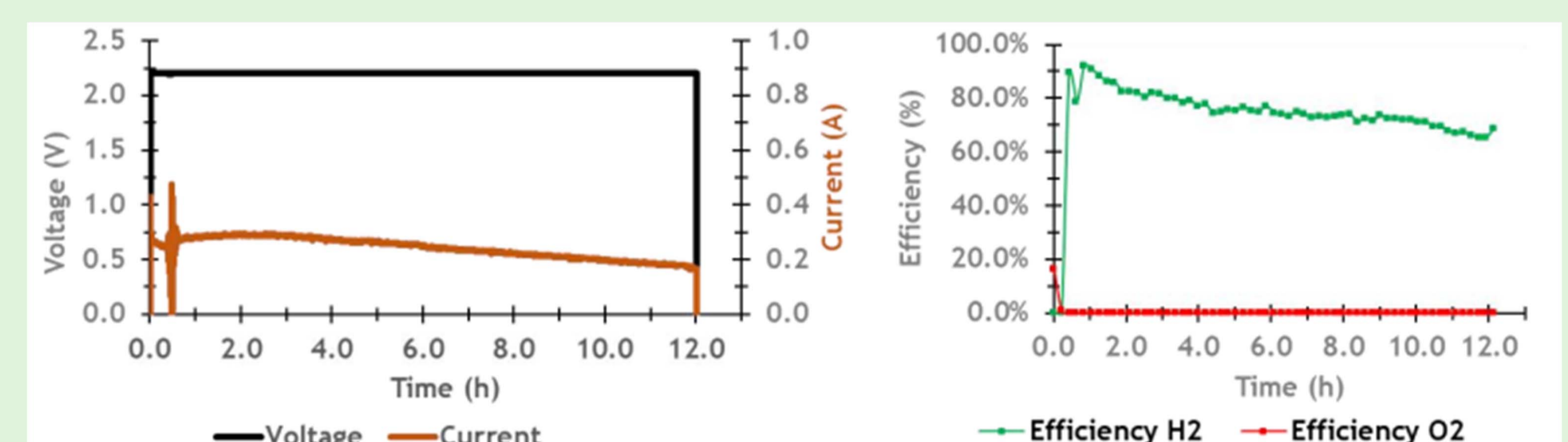


Figure 4: Current stability and faradaic efficiency towards O₂ and H₂ formation assuming water splitting.

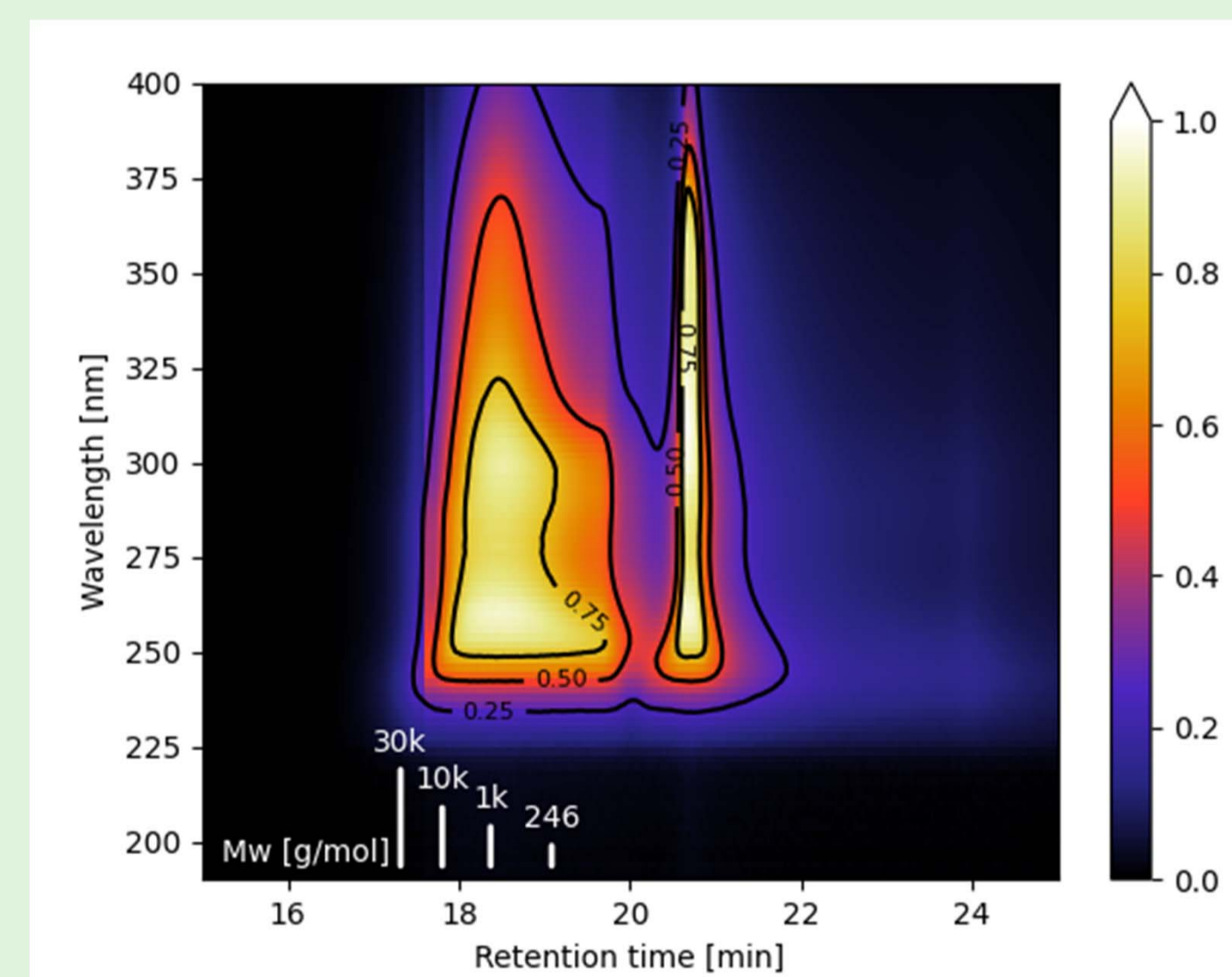


Figure 5: Product spectrum of monomeric acids (right) and mono, oligo- and polymeric lignols (left).

Project partners:



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