EBIO
BIOFUELS THROUGH ELECTROCHEMICAL TRANSFORMATION OF INTERMEDIATE BIO-LIQUIDS

EFFECTS OF ELECTROLYTE COMPOSITION AND ELECTRODE MATERIAL ON DIRECT ELECTROCHEMICAL LIGNIN DEPOLYMERIZATION

C. Roux, C. Ecrabey, M. Gravez, R. Tschentscher, SINTEF, Oslo, NORWAY

Introduction

Lignin is an important internal by-product of the pulping industry accounting for up to a third of biomass weight. Today, it is mainly burned for energy production and chemicals recycling at the mill. With the efforts of diversify the pulp mill product portfolio the valorisation of lignin into phenolic compounds is explored by several research groups. In this work we present the optimisation of electrochemical depolymerisation of lignin from black liquor and the influence of electrolyte composition and electrode materials. Preliminary studies using industrial intermediate black liquor have revealed that its conversion results in significant repolymerisation of lignin fragments. Modifying the electrolyte composition with chemicals already available at the mill will minimise this effect and enable a process integration.

Effects of electrolyte composition

The chronoamperometry experiments have been conducted on an electrochemical flow through cell (surface area: 3.14 cm^2) in the range of 1 to 3V. They show that diluting black liquor (BL) by water (W) and white liquor (WL) (aqueous solution of Na salts) improves the electrode stability against deposits formation. It also significantly increases the electric conductivity, reduces the viscosity and the thickness of the diffusion layer. The ratio of depolymerised lignin vs. repolymerised lignin is higher for low concentrated lignin solutions. (Figure 1).

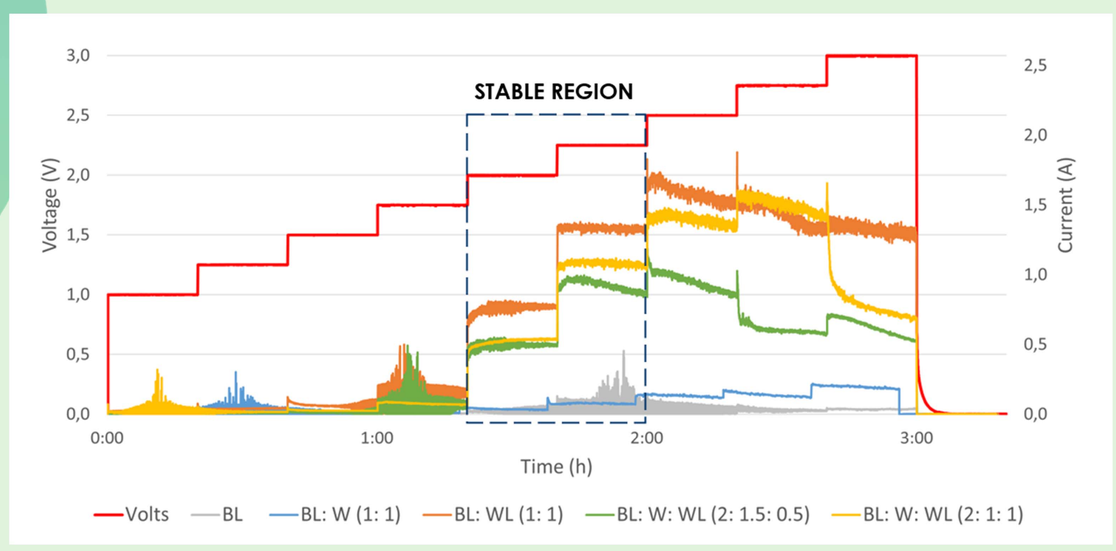

Figure 1: Chronoamperometry step test for BL: W: WL in different ratios with Ni electrodes.

Increase of the salt content shows a maximum beyond which ion clusters and aggregates are formed. (Figure 2)

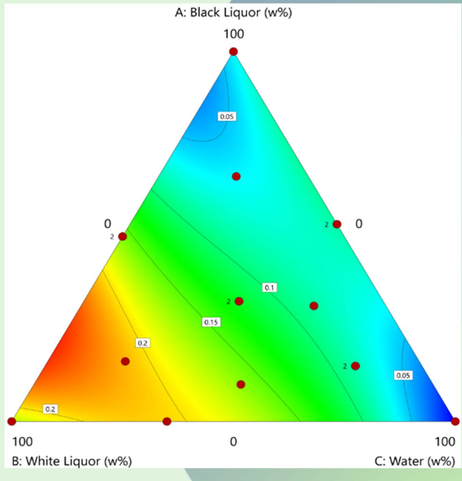

Figure 2: Ternary plot of obtained current at anode potential of 1V vs. SHE for BL: W: WL in different ratios with Ni electrodes.

The addition of alcohols as capping agents quantitatively prevents oxidative repolymerisation. Among the alcohols tested ethanol and 1-propanol show the highest current density and stability. Cathodic hydrogenolysis of the intermediate ethers of lignin fragments and alcohols results in aromatic hydrocarbons including toluene and xylene, identified by GC-MS.

Screening of electrode materials

Copper shows the highest current and formation of monomers but very unstable current. Lead shows low and unstable current. Stainless steel shows a more stable operation, but nickel performs best with respect to current stability (Figure 3), has the less deposit formation on the surface and is interesting due its low-cost.

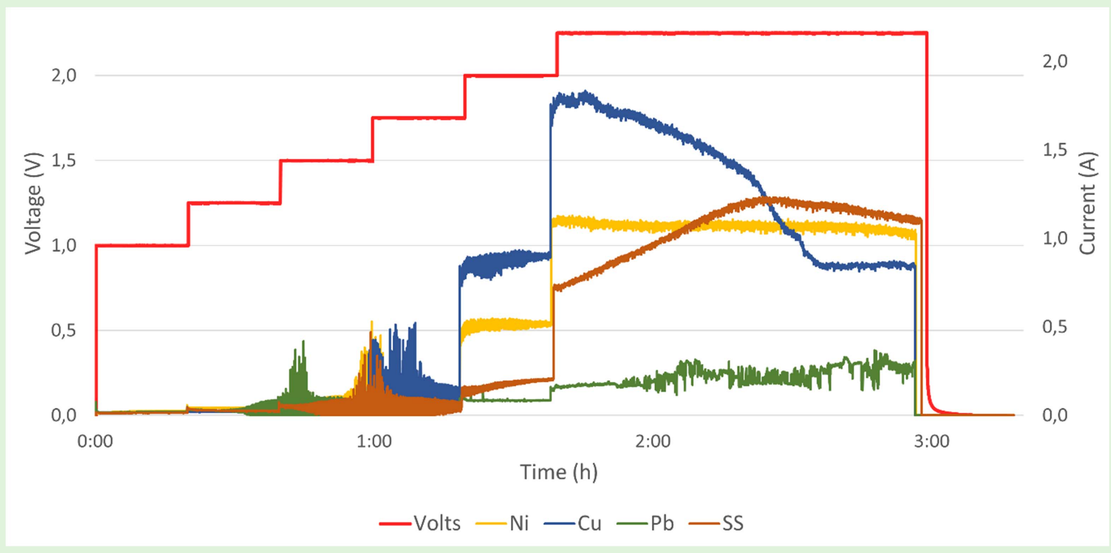

Figure 3: Chronoamperometry step test for different cathode materials with BL: W: WL (2: 1: 1) and Ni anode.

At optimised conditions nickel electrodes are employed and the electrolyte consists of a mix of intermediate black liquor, water, white liquor and alcohol in a volume ratio of 2: 0.75: 0:75: 0:5.

Project partners:

SINTEF · btg biomass technology group · Johannes Gutenberg Universität Mainz · University of Twente. · CONDIAS Conductive Diamond Products · Tüpraş · AFRY Åf Pöyry · etaflorence renewable energies · CSIC Consejo Superior de Investigaciones Científicas

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 101006612.