New, innovative and sustainable transportation fuels

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Introduction

SusFuFlex project focuses on the converting of biomass (lignocellulose, starch) to sugars, which can further be converted by fermentation or catalytic conversion to higher bioalcohols and other compounds suitable as oxygenates (e.g. butanol, pentanol, mixed alcohols) and as biofuels.

1) Pretreatment of biomasses

In this study, a dried fibre sludge (ca. 90 vol-% of cellulose and ca. 10 vol-% hemicellulose or other components) was pretreated with ILs, i.e. 1-butyl-3-methylimidazolium chloride ([BMIM]Cl) or 1-allyl-3-methylimidazolium chloride ([AMIM]Cl). Fibre sludge, which is also known as a primary sludge, is a by-product from the pulping process.

The pretreatment in ILs was followed by either acid hydrolysis (sulfuric acid, organic acids) or enzymatic hydrolysis (cellulase enzyme ACCELLERASE®1500 or NOVOZYMES enzyme mix).

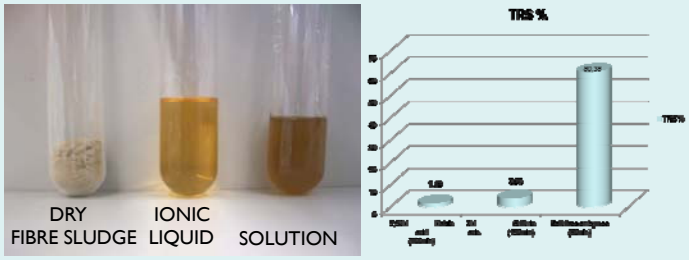

Figure 1a) Dissolution of dry fibre sludge in [BMIM]Cl · 1b) Relative results of fibre sludge hydrolysis (ref. Holm et al. 2011)

2) Fermentation

Fermentation experiments with the Multifermenter system Greta5 (Belach Bioteknik AB, Sweden) has been done by using a buffered glucose based medium. Without any further optimization, butanol concentrations of around 9-10 g/L have been obtained.

After the fermentation, cells have been separated from the fermentation broth by centrifugation and liquid products are stored for further downstream processing. First experiments for separation of butanol and other solvents by pervaporation technique have been done with model water-butanol and water-butanol-ethanol-acetone mixtures. Separation tests were done at temperatures of 40 °C and 60 °C and tested hydrophobic Poly-octylmethylsiloxane (POMS) membranes seems to be suitable for the process. Next step is to examine the membrane functionality with real fermentation mixtures.

Figure 2. Multifermenter system GRETA5

3) Characterisation of catalysts

Heterogeneous catalysts were analysed at University of Oulu, at Microelectronics and Materials Physics Laboratories using Transmission Electron Microscopy (TEM) and X-Ray Diffraction (XRD).

TEM image shows metallic sites and particle sizes of catalysts, XRD diffractogram shows oxidation states of catalytic metals.

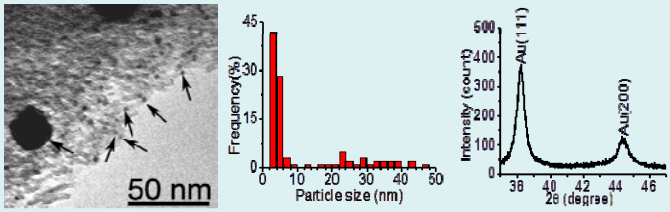

Figure 3a+b) TEM image: 8 % Au/Alumina. TEM: Bimodal distribution; ~3,5 nm and ~20-50 nm particles
Figure 3c) XRD diffractiogram: Au(111) 16,7±0,1 nm (Pictures, Anne-Riikka Leino)

4) Catalytic conversion of Ethanol to Butanol

Several chemical reaction pathways are studied in which butanol (and higher alcohols are produced catalytically. Continuous operation with selected catalyst series were tested in catalytic conversion of ethanol to butanol.

Test results indicate that catalysts should be in oxidized state. The chosen catalysts were tested in the reactor under different conditions after catalyst screening in mini-reactors has reached the goals.

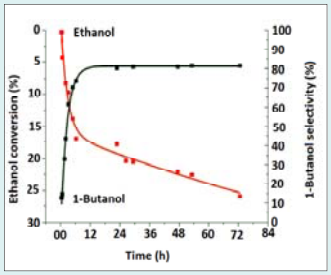

Figure 4. 1-Butanol selectivity for 80 % was reached at studies of catalytic conversion of ethanol to butanol.

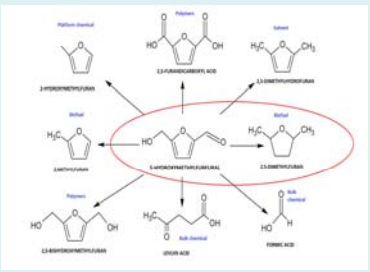

Figure 5. 5-Hydroxymethyl furfural (HMF) as a precursor for catalytic production of biofuels and chemicals.

5) Catalytic Conversion of C6 –sugars to 5-Hydroxymethyl furfural

The conversion of C_6 sugars to 5-hydroxymethyl furfural (HMF) was studied. 5-HMF is an intermediate for the production of biofuels, such as 2,5-dimethylfuran (DMF), and other chemicals. (Figure 5).

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