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Selective bio-aromatics production from genetically modified biomass by fast pyrolysis

Aim

Develop a more detailed intrinsic kinetic model for biomass fast pyrolysis that can provide guidelines for genetic modification of biomass in order to increase the yield of aromatics in bio-oil.

Justification

Fast pyrolysis is a promising thermochemical biomass conversion technology that provides high yields of bio-oil (of up to 75 wt%). Lignocellulosic bio-oils which consist of water and hundreds of organic compounds are strong candidates to be used as renewable and sustainable feedstocks for the production of specialty chemicals, in particular because they are rich in aromatics originating from lignin and some sugars. For this reason, there is recently a growing interest to increase the yield of aromatics in bio-oil.

In the last decades, major breakthroughs in genetic modification of lignocellulosic biomass have made it possible to modify the composition of the lignocellulosic material, and hence to optimize biomass composition for a targeted application. Recently, in-house studies have shown that genetic engineering can be a promising strategy to alter the biomass composition for the production of high value-added chemicals. However, the lack of fundamental understanding of the biomass fast pyrolysis process make it quasi impossible to guide the optimization of genetic biomass.

Model compounds representative for cellulose, hemicellulose and lignin are often used in providing kinetic and mechanistic insights on the pyrolysis process for the production of bio-oil, since the composition of biomass is complex and highly depends on the type of biomass. Ideally, studying model compounds and developing a detailed intrinsic kinetic model comprising in-depth chemical understanding of fast pyrolysis, would be the perfect tool for biomass selection and on the long run genetic modification in order to gain better control over the bio-oil composition and yield.

Program

- Obtain experimental pyrolysis data of model compounds that are abundant in genetically modified biomass, such as hydroxycinnamaldehydes in plants downregulating the enzyme activity of cinnamyl alcohol dehydrogenase (*CAD*), using the micro-pyrolysis setup with GC×GC/TOF-MS/FID, in different pyrolysis temperatures.
- Develop detailed intrinsic kinetic models by identifying all the possible reaction steps for the formation of the experimentally observed products, and calculating the potential energy surface of pyrolysis pathways of the primary products.
- Validate and refine the model using the quantitative data obtained from the micro-pyrolysis setup. Model refinement will re-evaluate already identified reaction pathways and search for new ones.
- Pyrolyze genetically modified biomass such as *CAD* transgenic poplar, and investigate the influence of lignin composition on the composition of pyrolysis-derived bio-oil from model-compound level by comparing with the pyrolysis products of wild-type biomass.
- Provide guidelines to genetically modify biomass and for scale-up of the fast pyrolysis process.

Once developed for model compounds, kinetic models will be combined and validated for more complex mixtures of molecules, and eventually for both wild and genetically modified biomass.