Hydroxymethylfurfural and advanced carbon materials: Two sides of the same coin

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Subcritical water is a reaction medium supporting hydrolysis of carbohydrates and water elimination. Has consequence Hydroxymethylfurfural (HMF) formed from hexoses and furfurals from pentose. Especially the reaction of fructose to HMF is rather fast, the reaction of glucose is very slow. HMF is a very interesting platform chemical, which can be transformed into other chemicals and consecutively to polymers. This way e.g. a bio-based substitute for PET, called PEF can be produced. PEF, basing on furanic dicarboxylic acid, has better barrier properties concerning carbon dioxide and oxygen and is therefore a better material for bottles, e.g. for soft drinks. In addition, Nylon 6 and Nylon 6, 6 can be produced from HMF, as well as many other products. HMF is further reacting by polymerization to humines or hydrochar. Here the challenge is to optimize the yield of this intermediate product. At one of the farms belonging to the University of Hohenheim a bench-scale plant will be built-up to convert a lignocellulose, here Miscanthus, to HMF. The Miscanthus grows also on one part of farm with marginal land. The idea is not to compete with food production; neither concerning the plant produced nor farm land. Side products are furfural from the hemicellulose part of the plant and lignin. The lignin could be split to phenols, than furfural and phenols together are the basis of a resin. This bench-scale plant is one a farm to demonstrate agriculture- near production and because of the biogas plant nearby, to process the process water.

Another on-farm concept bases on hydrothermal carbonization. The hydrothermal carbonization of agricultural residues or other biomass types and the consecutive activation leads to interesting carbon materials. These materials could be used to produce activated carbon, e.g. for hydrogen storage or the up-grading of biogas by carbon dioxide adsorption. In addition materials for the use as electrodes in batteries or fuels cells, as well as supercapacitors can be produced. Digestate is here a very good feedstock. As hydrothermal carbonization is a very useful process to recover phosphate, a challenge of some north German areas can be solved: Because of the high amounts of manure produced, being processed in biogas plant, and the use of this digestate as fertilizer, an over fertilization occurs. With the Hohenheim process, $MgNH_4PO_4$, a good fertilizer can be produced, in addition to carbon material. Now, the fertilizer can be used selectively, if needed and high value carbon material increase economics.