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Enhanced Biomass Valorisation to achieve 100% Carbon Efficiency by Effectively Supressing Ccarbon Dioxide Formation

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Abstract

The chemical industry of the future will have to move from the use of fossil resources, such as coal, oil and gas, to more sustainable organic resources. Biomass offers great substitution potential among the renewable energy sources. Consequently, the interest in cost-effective biomass conversion processes for producing valuable platform chemicals is growing in recent years.
Lignocellulosic biomass as the most abundant class of biogenic materials typically contains more than 50 wt% sugars that can be upgraded to valuable platform chemicals.
The reaction sequence for valorisation of lignocellulose starts with the fractionation of the main components followed by acid-catalysed hydrolysis of cellulose and hemicellulose into water-soluble monosaccharides and the subsequent oxidative cleavage of C-C bonds in monosaccharides into low-molecular carboxylic acids like formic acid (FA), acetic acid (AA) or lactic acid (LA). Overoxidation of the monosaccharides and intermediates results in the thermodynamically favoured complete combustion to carbon dioxide and water. Consequently, it is of critical importance that the applied catalyst systems prevent total oxidation leading to CO_2 but catalyse partial oxidation leading to the desired carboxylic acids.
In the last few years, it has been found that by using methanol as a (co-)solvent in small amounts below 10 vol%, Keggin-type polyoxometalate (POM) catalysts can completely suppress undesired total oxidation of biomass-derived feedstocks to CO_2 under oxidative conditions. This drastically enhances the carbon efficiency from biomass compared to the state-of-the-art technologies to close to 100% yield in formic acid methyl ester.
In this way, an oxidative route for sugar conversion to FA (derivatives) in ultimate selectivity is in reach. Biomass-derived FA is a highly relevant intermediate as it can be further converted to green H_2 or to green CO, making the described carbohydrate oxidation process a key step in producing green syngas under very mild conditions.
This strategy has the potential for paving the scientific route to novel, low-cost biomass utilisation technologies with unprecedented selectivity and great promise for decentralised valorisation of biogenic waste streams.