Carbon Chain Building Reactions from Synthesis Gas to Hydrocarbons via a Three-Step Reaction Cycle with Increased Selectivity

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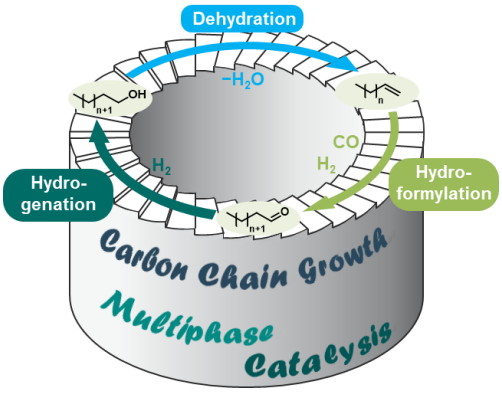
Abstract

The Fischer-Tropsch process for the conversion of synthesis gas to hydrocarbons currently exceeds a production volume of about 10 million metric tonnes per year as of 2013.[1-3] As several sectors and product lines such as aviation, heavy duty shipping and polymer production cannot be easily decarbonized, this number is only expected to grow as fossil resources are replaced by renewable feedstocks. The synthesis gas required for Fischer-Tropsch reactions can be derived from renewable and sustainable feed stocks such as biomass gasification and hydrogen produced with green energy.[4-6] So far, the Fischer-Tropsch reaction yields a broad spectrum of products all the way from methane to long-chain waxes, alcohols and olefins according to an Anderson-Schulz-Flory distribution.[7] Light gases such as methane in particular cannot be used in further chemical processes and are thus considered waste products.
In this work, we present a synthesis route that improves the carbon chain length selectivity of the hydrocarbons formed from synthesis gas and narrows down the product distribution to selective carbon chain lengths. By a combination of hydroformylation, hydrogenation and dehydration reactions, carbon chains can be elongated to specific value products. The cycle can be ended at one of the desired products: olefins, aldehydes or alcohols. If synthesis gas derived from biomass and bio-ethanol or bio-butanol are used as starting compounds for the cycle, this reaction can be based entirely on renewable resources. A key focus in the development of this system is the catalyst recycling in each of the three steps, reducing waste to a minimum.



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