Carbon 2 Chem®

L-IV | Value-added fuels from alcohol mixtures

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Ethanol and Methanol are used to produce higher alcohols in a heterogeneous catalytic process employing a Guerbet reaction. The resulting mixture consists of mainly branched alcohols with a chain length distribution from C3 – C8. The mixture can be used as fuel blend or feedstock for further processes to produce jetfuel or synthetic naphtha.

SUSTAINABLE METHANOL AND ETHANOL: GREAT PERSPECTIVES, SOME DRAWBACKS

Sustainable methanol and ethanol will play major roles in a future economy as fuels and commodity chemicals. Methods for their sustainable production from CO_2/H_2 suited for large scale are investigated in Carbon2Chem® (L-II and L-IV). Methanol and ethanol offer excellent perspectives, since a sustainable production looks feasible, large growing markets are established and application areas are huge.

Next to the enormous market potential there are several drawbacks, in particular if methanol and ethanol are used as fuels. Both can only be used in internal combustion engines. Their blending limits into gasoline are, with app. 3 % and 10 % respectively, relatively small. These limits are mainly caused by their low energy density, good water miscibility and their relatively high oxygen content. Hence, their impact in CO_2 reduction is small compared to the big potential. To overcome the blending limits methanol and ethanol can be used as feedstock for production of higher alcohols via a catalytic gas-phase Guerbet reaction.

METHANOL AND ETHANOL AS FEEDSTOCK FOR HIGH QUALITY FUELS AND CHEMICALS

A Guerbet reaction implies a carbon chain elongation in which one mole of water is separated during each reaction step. The chain elongation stops when a branching at the β-carbon of the alcohol is formed. All primary alcohols can be used as feedstock. A typical conversion rate is 80 %. For a further carbon-chain elongation low amounts of acetone, isopropanol or cyclohexanone/-ol can be added. Main products – from ethanol and methanol – are methyl or ethyl branched alcohols with three to eight carbons.

The impact of co-feeding methanol is shown in the left and middle graphs in figure 1. Adding 30 mol-% methanol enables the synthesis of products with uneven carbon chains and improves the branching. Adjusting the process parameters (T, p) varies the chain length distribution and degree of branching. The character of the formed product mixture can be tailored. The middle and right graphs in figure 1 shows the impact of higher pressure. After the Guerbet reaction the energy density of the resulting product mixture is approximately 50 % higher and the oxygen content is reduced to less than 1/3 compared to the feedstock. This results in a much higher blending limit of about 30 % for gasoline. The product mixture itself can be processed further via alcohol to jet route or to green naphtha employing standard refinery catalysts.

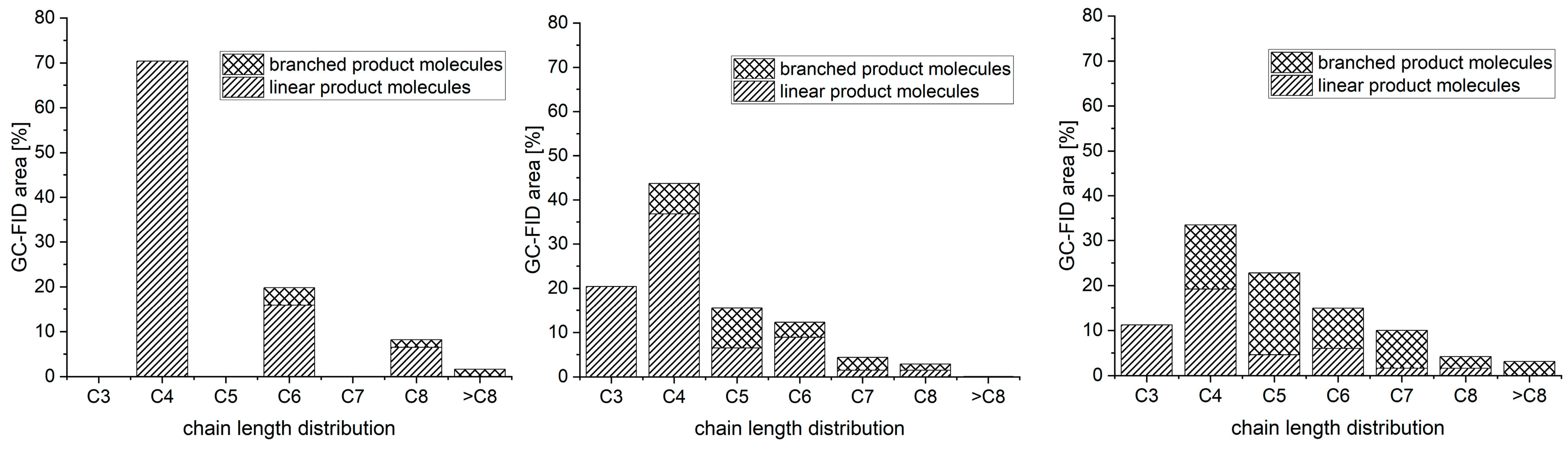

Fig. 1: Chain length distribution of linear and branched product molecules derived by catalytic condensation at 370 °C of ethanol (left), ethanol and methanol (middle) at atmospheric pressure and ethanol and methanol at 8 barg. The molar hourly space velocity was 6 mmol g^{-1} h^{-1}.

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CO_2 reduction through cross-industrial cooperation between the steel, chemical and energy industries