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Technology Offer

Direct conversion of synthesis gas to higher alcohols via tandem integration of Fischer-Tropsch synthesis and olefin reductive hydroformylation

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Abstract

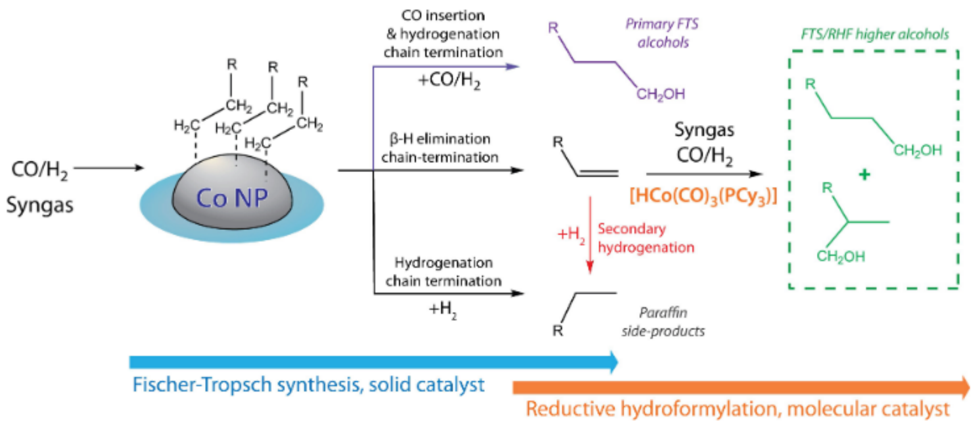
The invention outlines a novel process for converting synthesis gas (syngas), comprising carbon monoxide and hydrogen, into higher alcohols (C_{3+}), using a combination of Fischer-Tropsch and olefin hydroformylation catalysts. This innovative approach improves selectivity towards valuable terminal alcohols, including higher alcohols that can serve as fatty alcohols (C_{6+}). Higher alcohols produced through this method are crucial in industries such as solvents, plasticizers, and detergents. The process is especially efficient due to its integration of two catalytic reactions in a single reactor, minimizing by-products like CO_2. The method simplifies the overall production process, enhancing both economic and environmental efficiency.

Background

Higher alcohols are essential chemicals used across various industries, such as solvents, plasticizers, and precursors for detergents. Traditionally, higher alcohol production involves multi-step processes with intermediate separation and conditioning. These methods are energy-intensive and yield significant amounts of CO_2 by-products, which negatively impact both efficiency and the environment. The Fischer-Tropsch process, though effective for hydrocarbon production, is limited in its alcohol selectivity. This invention addresses these limitations by combining Fischer-Tropsch synthesis with hydroformylation in a single reactor, enabling high selectivity for C_{3+} alcohols with minimal CO_2 emissions.

Technology

This process involves the simultaneous operation of Fischer-Tropsch and hydroformylation catalysts in a single reactor to convert syngas into higher alcohols, exemplarily shown in scheme 1.



Scheme 1: Production of higher alcohols from syngas via the integration of Fischer-Tropsch synthesis (FTS) and reductive hydroformulation (RHF).

The Fischer-Tropsch catalyst, typically cobalt- or ruthenium-based on a porous carrier, is designed to suppress CO_2 formation and produce C_{2+} olefins, while remaining inactive for the water-gas-shift reaction. The hydroformylation catalyst, containing cobalt, ruthenium, rhodium and/or iridium combined with at least one organic ligand, selectively converts these olefins into terminal alcohols. Operating within a controlled temperature range of 298 K to 533 K and pressures between 1 to 300 bar, this

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integrated approach eliminates the need for intermediate steps. As depicted in scheme 1, the Fischer-Tropsch catalyst (depicted by cobalt nanoparticles) initiates the conversion of syngas into olefins through a chain-growth mechanism. These olefins are subsequently transformed into higher alcohols by the hydroformulation catalyst, showcasing the seamless integration of both catalytic processes within the same reactor. The process is highly selective for C_{3+} alcohols with a chain-growth probability greater than 0.60, maximizing yield while minimizing by-products. Fatty alcohols (C_{6+}) are possible products, which are valuable for their use in detergents and personal care industries, and beyond.

Advantages

- Auto-tandem catalysis for real-time catalyst recycling and improved effiency.
- Single-step conversion of syngas to C_{3+} alcohols.
- High selectivity for terminal alcohols with minimal CO_2 formation.
- Simplified process reduces the need for intermediate separation and purification.
- High alcohol yields with significant chain growth probabilities (>0.60).
- Energy-efficient, reducing overall carbon footprint.

Potential applications

- Alcohols having 8-12 carbon atoms are valuable as precursors for plasticizers.
- Hydrocarbon chains containing at least 12 carbon atoms are valuable as raw materials for detergent and textile industries.
- Higher alcohols (C_{8+}) can be used for clean energy applications such as the production of fuels.

Patent Information

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