

Design and optimisation of model Co-Mn Fischer-Tropsch synthesis catalysts

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The mitigation of greenhouse gas emissions is a key objective of global energy plans, and governments across the world have aided in the growth of renewable energy sources and raised research funding for innovations such as carbon capture and utilisation, as well as energy storage methods [1]. Power-to-Liquids (PtL) concepts are frequently viewed as promising long-term energy storage alternatives as they incorporate fuel/chemical production and chemical energy storage *via* electrolysis in combination with carbon capture methods to produce “green” synthesis gas (*i.e.*, a combination of CO and H₂) [2,3]. This sustainable technology alleviates the use of fossil fuels in the chemicals and transportation sectors, and ultimately minimises greenhouse gas emissions [2]. In the early 20th century, the Fischer-Tropsch synthesis (FTS) was developed by Franz Fischer and Hans Tropsch to produce fuels and chemicals from synthesis gas [4]. Depending on the FT process conditions, the products formed typically compose of a wide range of hydrocarbons of different carbon chain lengths and functional groups.[1] Co-based catalysts are the most active and stable in the low-temperature Fischer-Tropsch synthesis (LTFTS) for the production of long-chain hydrocarbons (C₅₊) in the form of liquid and wax products. However, Mn has been added as a promoter to Co-based catalysts to enable their operation at optimum CO conversions (depending on the Mn loading and FTS conditions) and to improve CO adsorption/dissociation by facilitating oxygen removal, thus, improving the C₅₊ selectivity and minimising CH₄ formation.

As part of the Catalyst Research for Sustainable Kerosene (CARE-O-SENE) project (funded by the BMBF), which aims to de-fossilise the aviation sector through the utilisation of green sustainable aviation fuels (SAF), this study focuses on the development and optimisation of model catalysts with varied Mn_xCo_{3-x}O₄ crystallite sizes and Mn promoter contents (but at constant crystallite size, ~11 nm) that are supported on different three-dimensional mesoporous network supports. All catalysts were prepared *via* a surfactant-free synthesis method [5] to enable precise control of the Co crystallite size and the Mn addition process. These catalysts were characterised using TEM, STEM-EDX, and XRD to determine their physicochemical properties. It was found that the surfactant-free synthesis method was unique when compared to traditional impregnation techniques in that, the former gave supported catalysts with good Co-Mn interactions as opposed to the latter technique, which gave supported catalysts with the least Co-Mn interactions (Fig. 1) at a 1% Mn loading.

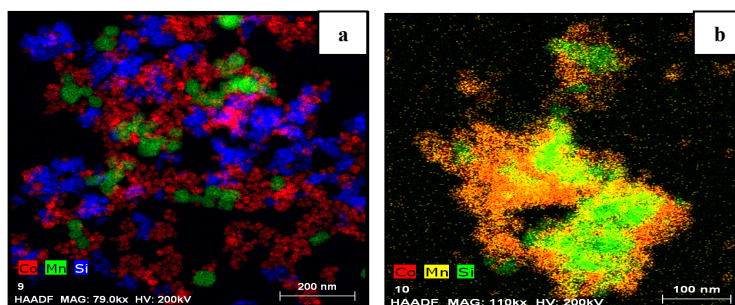


Figure 1: Effect of impregnation (a) vs the surfactant-free synthesis method (b) on the Co-Mn interaction.

- [1] Dieterich, V.; Buttlar, A.; Hanel, A.; Spliethoff, H. and Fendt, S. *Energy Environ. Sci.*, 2020, **13**, 3207-3252.
- [2] Ince, A.C.; Colpan, C.O.; Hagen, A. and Serincan, M.F. *Fuel.*, 2021, **304**, 121354.
- [3] Schnuelle, C.; Thoeming, J.; Wassermann, T.; Thier, P.; von Gleich, A. and Goessling-Reisemann, S. *Energy Res. Soc. Sci.*, 2019, **51**, 187-197.
- [4] Fischer, F. and Tropsch, H. *Brennstoff. Chem.*, 1923, **4**, 276-285.
- [5] Wolf, M.; Fischer, N.; Claeys, M.; Mater. Chem. Phys., 2018, 213, 305-312.

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