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HYBRID TANDEM CATALYTIC CONVERSION PROCESS TOWARDS HIGHER OXYGENATE EFUELS

E-TANDEM - Deliverable report

D4.2 – Water conditioning & recycling

Funded by
the European Union

Project summary

E-TANDEM aims to enable the efficient and direct production of a novel, oxygen-rich diesel-like e-fuel designed for use in the marine and heavy-duty transport sectors. This innovative fuel is generated directly from water and CO_2—used as the only carbon source—and powered solely by renewable energy. The process follows a one-pass, hybrid catalytic conversion route that brings together three key catalysis disciplines: (1) high-pressure electrocatalytic syngas production linked with tandem catalytic e-syngas conversion, incorporating (2) thermocatalysis using solid catalysts, and (3) chemocatalysis involving molecular complexes. The project will showcase the new e-fuel production method at bench scale and evaluate its ability to handle variable energy inputs.

Publishable summary

In an e-fuel production process like the one developed in the E-TANDEM project, the quality and quantity of the input and output mass flows play a key role in providing high quality fuel volumes at a competitive cost. The E-TANDEM process starts with a high-temperature solid-oxide electrolyte co-electrolysis (co-SOE), in which CO_2 and water are converted into e-syngas. This e-syngas serves as the feed for a subsequent, tandem conversion that yields the target higher oxygenate compounds as mildly oxygenated e-fuel components. The tandem system integrates two catalytic steps—Fischer-Tropsch synthesis, which converts e-syngas into olefins, with *in situ* reductive hydroformylation, through which the olefins are transformed into higher alcohols. A substantial amount of water is generated as a by-product of the Fischer-Tropsch reaction, which needs to be separated from the fuel product. The recycling of process water, e.g. as a makeup to the steam feed to the co-electrolysis step, is important for process intensification. However, the purification of said recycled water used is important as impurities may negatively affect the lifetime and efficiency of the co-electrolyser. In WP4, different purification methods have been investigated to define the concept for the E-TANDEM fuel production process. Extensive experimental analysis of the aqueous side-stream recovered after fuel synthesis was carried out to identify and quantity both organic as well as inorganic impurities. In collaboration with the project partners, a representative water sample was prepared to mimic the process water stream to be recycled, as applied in order to assess the capability of an EDI (Electrodionization) cleaning solution alone. The water sample was analysed, evaluated and compared with the capabilities of the EDI purification techniques. In previous work, these techniques have shown excellent performance to attain high water purity in continuous operation mode, without the need for acids or caustic reagents. Due to the significant concentration (up to 2.7 vol%) of organic compounds, primarily medium-chain ($C_{2\text{-}5}$) alcohols) in the process water, as well as the presence of other contaminants, EDI alone is concluded not be sufficient as a standalone purification method. Hence, a combination of different purification methods is recommended in this report. A three-stage purification concept has been developed for the E-TANDEM process (Figure 1), consisting of a filtration stage to remove entrained particles in suspension and optionally hydrocarbons, followed by a reverse osmosis stage to remove inorganic compounds such as metal cations leached out from catalysts and reaction vessels and other impurities. In the final stage, the water stream is treated by an electrical deionisation (EDI) process, which provides the high level of purity required for its recycling as a makeup feedstream into the co-electrolysis process step.

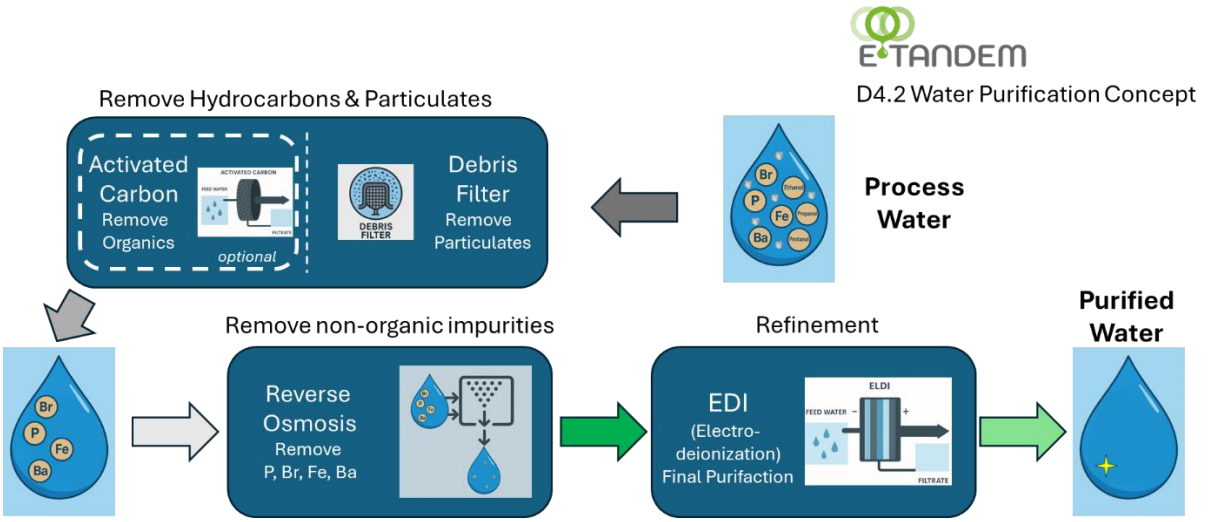

Figure 1: E-TANDEM Water Purification Concept.