# Process Intensification at TNO for a Sustainable Chemical Industry

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Industry is responsible for one-third of all carbon emissions (in The Netherlands), thus the development of a carbon-neutral industry is an essential element of achieving climate goals and a sustainable future. TNO, the Netherlands Organisation for Applied Scientific Research, is facilitating the energy and materials transition to defossilised, renewable, circular value chains through the development of sustainable production processes. The heart of these processes is often chemistry: either catalysis, physical or electrochemical. These aspects are currently widely researched at universities, institutes and industry partners, but the first insight into the sustainability and applicability comes from the integration of reactor technology and downstream processing.

Within the Sustainable Process and Energy Systems group, a range of technological developments are being investigated, including energy storage, carbon capture, synthetic fuels, bio-based chemicals, plastics recycling, and electrochemical processing technologies. In this presentation, current developments in three of these areas will be communicated.

**Bio-Based Chemicals**: The development of an integrated process from residual hemi-cellulosic streams from a bio-refinery to a near-drop-in for phthalic anhydride (3-methylphthalic anhydride). Herein we will discuss the integration of furfural production from biomass with direct catalytic conversion into the key building block, 2-methylfuan.

**Electrochemical Processing**: The development of a pilot scale intensified electrolyser concepts for the production of bio-based molecules maleic anhydride and FDCA. The integration and scale-up challenges that face this emerging technology will be discussed. TNO has constructed an open-access, flexible PowerPlatform pilot plant within the PERFORM project (H2020 topic CE-SPIRE-02-2018) that allows for accelerated innovation and impact towards a sustainable chemical industry.

**Synthetic Fuels**: The use of $CO_2$ as feedstock, facilitating a shift away from petrochemical Carbon sources, and the use of $NH_3$, as an emerging hydrogen carrier. The challenges involved with the processing of equilibrium-based reactions will be discussed. TNO is developing novel 'Sienna' reactor technologies using combined catalysis, membrane and absorption technology to improve these processes.

**Plastics Recycling**: The application of solvent-based technologies for the physical recycling of polymers from waste plastics by dissolution and purification. The challenges associated with the processing of these complex materials will be communicated