Econic: Summary of Lifecycle Assessment (LCA)

CCUS Innovation 2.0

Key Knowledge Deliverable 2.7

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Key Knowledge Deliverable Cover Sheet

This Key Knowledge Deliverable (KKD) has been produced by Econic Technologies as part of the Department for Energy Security and Net Zero £1bn Net Zero Innovation Portfolio (NZIP) - CCUS Innovation 2.0 programme. The document is reflective of the status of the project at the time of writing. The material presented could have been subject to change as the project matured. These documents should not be considered a full representation of the final project.

There is increasing imperative and demand for fast-moving consumer goods, like household cleaning products, to be made sustainably, at price. This project, in partnership with Unilever, will develop sustainable non-ionic surfactants, a component of such cleaning products, based on utilisation of waste CO2. The use of Econic's catalyst and process technology in the production of non-ionic surfactants allows captured waste CO2 to replace up to 40 wt% of traditional fossil fuel-based and palm oil-derived raw materials in a process that can be retrofitted onto existing production plants. The utilisation of waste CO2 as a raw material adds undeniable value to the surfactants industry.

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Introduction

Surfactants Industry

The majority of non-ionic surfactants are produced by an alkoxylation process, where alkoxylates (mostly ethoxylates) are produced from a combination of expensive, finite, carbon intensive petrochemical-based raw materials, and/or expensive oleochemicals of which there is a limited supply of sustainably sourced precursors. There has also recently been much outcry against deforestation in tropical climates to provide farming land to produce such oleochemicals. We need a solution that enables a renewable and green value chain, and we need it now.

Econic's Technology

Econic Technologies produces and sells a unique, patented catalyst and licenses the associated technology to enable polymer producers to turn waste CO2 into a feedstock for polymer production. Econic's renewable carbon technology makes everyday products better, and has applicability in a broad range of markets, including polyols for polyurethane - Econic's first market for commercialisation - and non-ionic surfactants – the second market of commercial interest.

Commercial benefits: Econic's technology operates at low pressures, which means that the process can be retrofitted onto existing manufacturing equipment. Adoption of the technology is therefore capital light, with return on investment expected within two years. Additional cost advantage is provided by partially replacing expensive, petroleum and oleochemical feedstocks with captured CO2, adding value to this otherwise waste gas – savings of 50% are possible. Further economic benefits are possible as these savings do not require CO2 subsidies or cheap renewable energy. Our process has been designed to fit into existing supply chains and infrastructure in surfactants manufacture.

Environmental benefits: The incorporation of CO2 into surfactants using our technology can produce products with substantially reduced carbon footprints. For every tonne of CO2 used in manufacture, a further three tonnes of emissions can be prevented as a result of both reduced reliance on carbon-intensive petrochemical and oleochemical raw materials and more sustainable manufacturing processes.

Performance benefits: Econic's technology allows the controlled incorporation of CO2 into the final product from 20-50 wt%, meaning that the properties and stability of the material can be tuned for the specific application it will be used in. What's more, incorporation of CO2 into ethoxylates has been shown to add value to the surfactants by enhancing performance, for example, in biodegradability of the material, a vital property of these materials.

Summary of LCA

Surfactants are high value products that can create significant value from waste CO2, which in turn can incentivise carbon capture technologies. Unlike many other CCUS technologies, the use of waste CO2 in surfactants and polyols can be cost competitive with incumbent technologies without incentives such as carbon credits or taxes, due to large raw material cost savings. Econic's carbon utilisation technology has first been developed to TRL7/8 for the polyols market, but the catalyst and process can be adapted to offer an innovative solution to surfactants producers and users that not only enables them to significantly reduce their raw material costs, but to also add value to their products through use of waste CO2 as a raw material, offering commercial, environmental and performance benefits across the value chain.

KKD Overview

Econic's process produces Carbonate Ethoxylate surfactants as a substitute for conventional ethoxylated surfactants. Econic has undertaken a detailed lifecycle assessment (LCA) with ERM.

Lifecycle Assessment

Lifecycle Assessment Definition

All products go through a relatively defined lifecycle, which comprises a number of phases:

1. Raw material extraction
2. Manufacturing and processing
3. Transportation
4. Usage and retail
5. Waste disposal or end of life.

A lifecycle assessment (LCA) determines the environmental footprint of some, or all, of these phases. The phases assessed define the scope, or system boundaries, of the LCA. Assessment of the full lifecycle of a product, that is from raw material extraction to end of life would be considered a cradle-to-grave assessment, with any phases in between these two points considered gates. Assessment of any number of a product's lifecycle phases can be considered.

To build a lifecycle model, a range of data is collated for each phase of the product lifecycle, including:

- Energy carriers
- Utilities
- Process emissions
- Production waste
- Transport

- Raw materials in the form of a bill of materials (BOM)
- Average use and maintenance of the product by consumers, e.g. electricity, cleaning, etc.
- The waste-disposal method used and emissions connected to the method.

These data are input into a model, which allows for a number of output factors to be determined. These factors can range from the greenhouse gas emissions (kg CO2 per kg product), land use impact, water use, eutrophication, human toxicity, ozone depletion and depletion of abiotic resources, to name but a few.

As well as assessing the environmental impact of your own process and product, it can also be equally as important to compare the results against an incumbent process to determine whether there is a sustainability advantage against what is currently used in the industry.

LCA Results

Conventional fatty alcohol ethoxylates comprise fatty alcohols from either fossil (via ethylene) or oleo/bio (typically palm kernel oil) sources with ethylene oxide. The Econic process utilises captured CO2 to replace a portion of the traditional feedstocks, which drives the environmental benefit.

A cradle-to-gate assessment was performed, which considers a partial product life cycle from resource extraction (cradle) to the factory gate, i.e. before it is transported to the consumer. In this way, the environmental impact of the Econic process – from raw material extraction, upstream chemical processing to prepare the chemicals required, and the manufacturing process itself – could be assessed, and compared against the analogous processes required in production of the incumbent non-ionic surfactants.

A number of different scenarios were assessed in order to comprehensively compare the impact of Econic's process and quantify improvements that our customers will benefit from. A full fossil-derived comparison was made first, where an incumbent alcohol ethoxylate surfactant prepared from a fossil-derived fatty alcohol and fossil-derived ethylene oxide was compared with a CO2 surfactant prepared from emissions-sourced CO2 (e.g. captured from an industrial process) and fossil-derived ethylene oxide. A global warming potential (GWP) reduction of >40% can be achieved when fossil-derived raw materials are used in combination with captured CO2 (Figure 1).

In the second scenario, an alternative incumbent alcohol ethoxylate prepared from oleochemicals and biogenic ethylene oxide was compared against a CO2 surfactant prepared from biogenic-sourced CO2 (e.g. from direct air capture or fermentation processes) and biogenic ethylene oxide. These examples allow for comparison of the two most sustainable options for surfactants production, and show that the Econic process brings even greater GWP reductions of >50% (Figure 1).

Summary of LCA

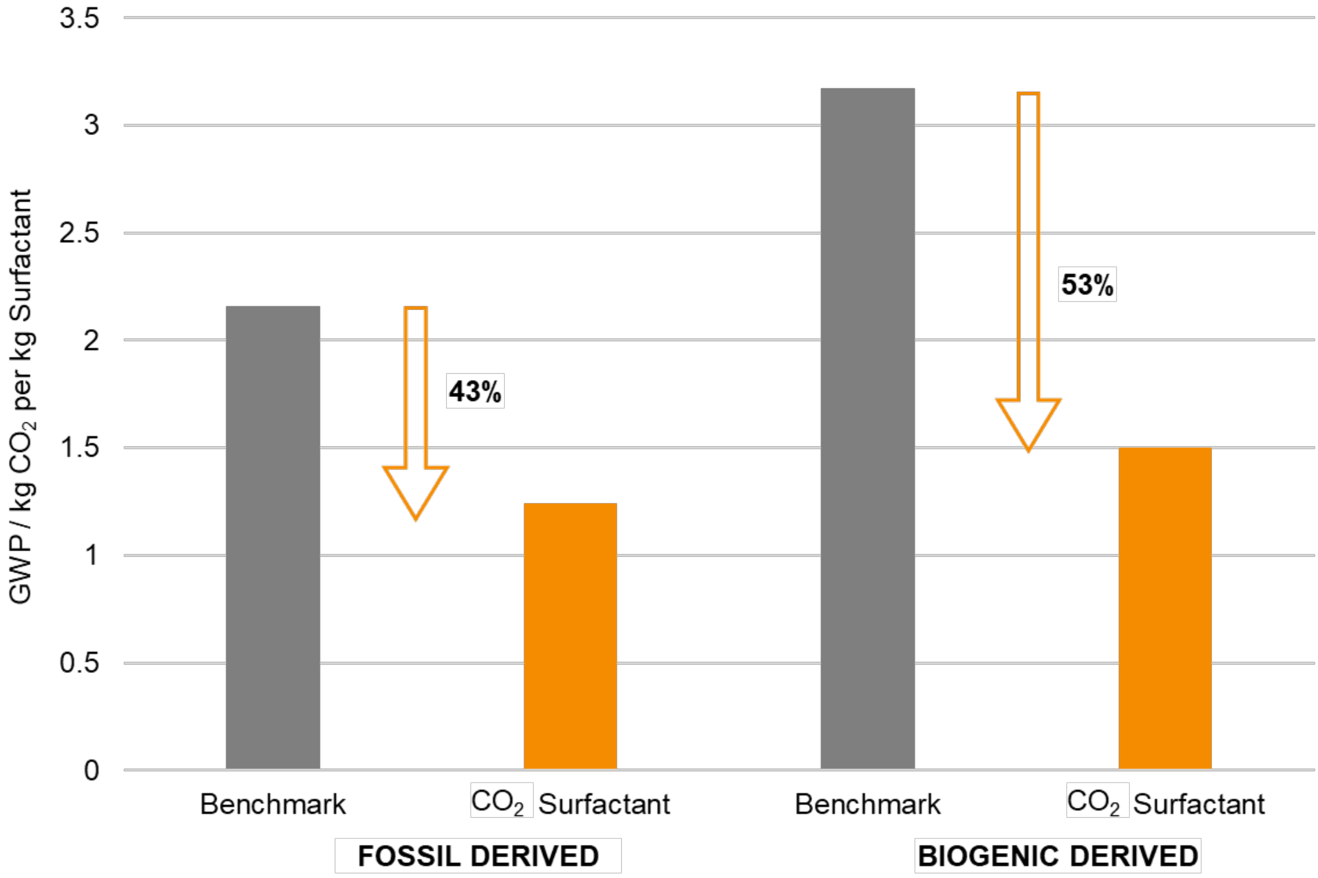

Figure 1: GWP reductions possible through use of Econic's process to prepare CO2 surfactants.

It is evident from this quantitative assessment that surfactants made from captured CO2 as a raw material in surfactant production brings significant environmental benefit through reduced greenhouse gas emissions in their manufacture.

Methodology

The LCA provides a cradle-to-gate analysis of Econic's carbonate ethoxylate surfactant compared to a conventional fatty alcohol ethoxylate surfactants. Data is provided by Econic for the carbonate ethoxylate manufacturing steps. The EcoInvent database and literature provided information on the upstream inputs to the Econic process (including production of ethylene oxide and capture of CO2) and for the conventional fatty alcohol ethoxylate processes.

A multi-scenario approach was modelled to establish the impacts of conventional fossil process inputs against biogenic inputs. Full fossil feedstock and full biogenic conventional and carbonate ethoxylate surfactants were modelled.

A sensitivity analysis was performed in the LCA to address the impact of feedstock source and plant location, particularly in the production of biogenic EO where the use of maize from the US versus sugarcane in Brazil can have a significant impact on the environmental impact. It should also be noted that the technology available for biogenic EO, and therefore the process data available, is immature when compared to fossil EO. Accounting of captured fossil and biogenic

CO_2 varies between different LCA methodologies, and this was considered as part of the assessment. In this assessment, the benefit of carbon is accounted for at the cradle as it is used as a feedstock.

Next steps

Considering the typically short lifecycle of surfactants in consumer goods, it is critical to consider the full lifecycle of these materials including incorporation into formulations, consumer use and end of life. These analyses will be conducted in the future.

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