# Letter of Intent for participation in the Advisory Board of the Moonshot research trajectory Biobased Chemistry

Undersigned, [Company], with registered seat located at [Address], duly represented by [Name of Legal Representative], confirms it is strongly interested in the technology development within the Moonshot research trajectory Biobased Chemistry (MOT1).

## Research trajectory ‘Biobased Chemistry’

The first Moonshot research trajectory (MOT1) will provide access to unique and added-value bio-based raw materials, materials and products via biomass. There is an urgent need to offer more sustainable alternatives to the current traditional molecules and materials based on fossil raw materials, in case the current materials will ultimately get burned and cause additional CO2 emissions. Renewable raw materials, combined with more energy-efficient processes, will reduce the CO2 footprint in Flanders. Both biomass waste streams and sustainable primary biomass streams will be converted into renewable basic building blocks in bio-refineries. Inventive new separation processes will make the difference by reducing energy requirements and production costs. The intrinsic functionalities and properties that are present in these natural products are retained and will lead to new, sustainable, safe and improved products that in turn make climate-friendly applications possible.

The following objectives will be pursued:

1. Develop at least 2 new bio-based chemical products up to TRL 6 in Flanders by 2025, followed by at least 2 new products to TRL 6 every 5 years. The new products have at least equivalent functionality/value and/or new functionality with a potential higher added value compared to similar products based on fossil raw materials.
2. The products and processes will be more sustainable (carbon footprint, environmental impact) than their fossil-based counterparts.

Within the following preconditions:

1. The products are based on stable, competitively priced supply chains/raw materials from the circular use of biomass and rational use of crops.
2. The end products must be able to play an important role in (future) Flemish industrial value chains and have considerable market potential on global scale.

[Company] is interested in this Moonshot research trajectory because …

*Please describe, as detailed as possible, the interest of your company in this Moonshot research trajectory.*

In addition, [Company] is interested in the following Moonshot cSBO project(s) within the Biobased Chemistry research trajectory:

*Please indicate below in which project(s) your company is interested by deleting or removing the project(s) that is/are not of interest to your company.*

* **AC2GEN:** **Acrylates from 2nd generation sugars: a powerful combination of fermentation, catalysis, and CO2 recycling**, full cSBO with a proposed starting date on 1 January 2022 and a proposed duration of 48 months, with research partners BBEPP, KU Leuven, UAntwerpen and VITO.
* **Bio-Acrylates: Bio-acrylates from biomass via polymeric 3-hydroxypropionic acid**, full cSBO with a proposed starting date on 1 January 2022 and a proposed duration of 48 months, with research partners UGent, BBEPP and KU Leuven.
* **WODCA: Waste oil to long-chain dicarboxylic acids**, full cSBO with a proposed starting date on 1 January 2022 and a proposed duration of 48 months, with research partners UAntwerpen, UGent and VITO.
* **PADDL-2: Polymer additives from lignin building blocks II**, full cSBO with a proposed starting date on 1 December 2021 and a proposed duration of 30 months, with research partners UAntwerpen, KU Leuven, Centexbel and VITO. Follow-up project of the currently running Moonshot sprint cSBO project PADDL (<https://moonshotflanders.be/mot1-paddl/>).

[Company] is interested in this/these Moonshot project(s) because …

*Please describe, as detailed as possible, and for each of the projects in which you are interested individually, how this project fits in your company’s innovation roadmap. Additionally, please describe how the project results could contribute to your company’s present and future activities.*

The next steps after this/these Moonshot project(s) are …

*Please describe step-by-step, as detailed as possible, and for each of the projects in which you are interested individually, how your company will organise follow-up activities for implementation and valorisation of the project results.*

[Company] engages to actively follow up on the Moonshot research trajectory and/or the project(s) of interest and to take part in Advisory Board meetings.

The Moonshot operational team can deliver information about and invitations for these Advisory Board meetings, as well as all other relevant communication related to this Letter of Intent, to [Name of company employee] ([employee email address]), who will act as [Company]’s main point of contact within the framework of this Letter of Intent.

Sincerely,

[Signature]

[Name, Function, Company]

[Date]

## Abstract AC2GEN

**Acrylates from 2nd generation sugars: a powerful combination of fermentation, catalysis, and CO2 recycling**

AC2GEN focuses on cost-effective production of acrylates from 2G biomass streams with maximal CO2 abatement.



**Acrylic acid and its alkyl esters** are one of the most versatile monomers in the chemical industry with a **global demand of over 6 Mtons** in 2020 and a market that is expected to reach **16 Bn EUR by 2022**. They are used for the production of various polymers with applications in a large variety of high-performance products such as coatings, paints, adhesives, resins, detergents, fibres, superabsorbent polymers (SAP), and dispersants. Currently, almost all acrylic acid is produced from petroleum-based propylene through a two-step gas-phase oxidation process showing a very large CO2 footprint. In the AC2GEN project, we aim for a more sustainable route starting from renewable acetic acid and CO2-sourced C1 building blocks.

In the recently started Moonshot project FUCATIL, fractionation and pretreatment of **2G waste streams** is being optimized to deliver abundantly available, low-cost **fermentation feedstocks**. In AC2GEN, these feedstocks will be used to generate a **continuous acetic acid stream**, serving as a renewable bulk platform intermediate. Here, an ingenious strategy involving acetogenic fermentation with CO2 recycling will be elaborated to **maximize carbon efficiency** and achieve a **50% increase in theoretical yield** as compared to conventional yeast fermentation processes. Furthermore, **process intensification** strategies will further boost productivity. Particularly, simultaneous saccharification and fermentation (SSF) and consolidated bioprocessing (CBP) will be investigated, while *in situ* product recovery (ISPR) technologies will be developed aiming at a concentrated acetic acid stream suitable for further catalytic conversion. Finally, advanced process monitoring and control during fermentation, followed by the development of chemometric models, will allow to define the optimal operation mode and process window at minimal (energy) cost.

Starting from the acetic acid product stream, two cutting-edge **chemo catalytical** concepts will be investigated with the aim of coupling acetic acid to sustainable **CO2-sourced C1 building blocks**. Two innovative pathways will be investigated with high potential towards acrylates from 2G acetic acid. T-While the first route proposes the condensation of biobased acetic acid with **dimethoxymethane (DMM)** as a safer, more sustainable C1 building block as compared to formaldehyde, the second route involves a novel cascade reaction with **overall 100% carbon efficiency**, using bio-derived acetic acid and CO2-sourced **methyl formate** to generate acrylic acid and derivatives.

Considering the threefold CO2 abatement targeted in AC2GEN, this ground-breaking strategy would result in a massive **6.4 tons of CO2 abated for every ton of acrylates** produced.

*For substantive questions about this project proposal, please contact MOT1 representative Isabelle Monnaie (**imonnaie@catalisti.be**; +32 471 506 833).*

## Abstract Bio-Acrylates

**Bio-acrylates from biomass via polymeric 3-hydroxypropionic acid**

Acrylic acid and its alkyl esters are commodity building blocks used for the production of various polymers with applications in a large variety of high-performance products such as coatings, paints, adhesives, ion-exchange resins, detergents, fibres, superabsorbent polymers (SAP), and dispersants. Acrylics are one of the most versatile monomers in the chemical industry with a worldwide demand of about 6.3 Mtons in 2020 and an expected growth of 4.7% CAGR in the coming years. Currently, almost all acrylic acid is produced from petroleum based propylene by a two-step gas-phase oxidation process with 95% propylene conversion and high acrylic acid selectivity. The CO2 footprint of this fossil-based process is estimated as 2.5 kg CO2 per kg of acrylic acid produced. In view of the large production and use of acrylic acid and derivatives in Flanders, more sustainable production routes for acrylic acid are a prime target for reducing the carbon footprint of Flanders.

The Bio-Acrylates project will develop a new production process for **biobased Acrylic Acid** (bio-AA) by fermentative conversion of waste biomass into **poly-3-hydroxypropionic acid**, followed by the hydrolysis of the polymer into **3-hydroxypropionic acid** that can be readily dehydrated to bio-AA with high yields and selectivity. By using waste biomass, a renewable resource obtained through the uptake of CO2 from the atmosphere, near zero carbon emission processes can be envisaged. Overall, this process offers many advantages compared to the direct production of 3-hydroxypropionic acid.

*For substantive questions about this project proposal, please contact MOT1 representative Isabelle Monnaie (**imonnaie@catalisti.be**; +32 471 506 833).*

## Abstract WODCA

**Waste oil to long-chain dicarboxylic acids**

Long-chain aliphatic dicarboxylic acids (LCDAs) are versatile, biodegradable, chemical intermediates of different chain lengths (≥C12) and saturation, usable as precursors for high-grade polymers (PE, PA, PU), lubricants, hydrophobic coatings, corrosion inhibitors, perfumes, adhesives and macrolide antibiotics. The current global LCDAs market was 201.36 M$ in 2019 with an increase in the last three years and a broadcasted compound annual growth rate (CAGR) of 5.9% (DataHorizzon Research 2020). The EU market share is about 20%.

Traditional fossil-based LCDAs are produced via expensive, harsh chemical processes that lead to unwanted side products and only short/medium-chain saturated DA products. Also, chemical processes to convert plant oils via metathesis into bio-based LCDAs have been implemented, with similar limitations or with the disadvantage of complex product mixtures in the case of the more recent self-metathesis. Biotechnological production proved to be a good alternative technology yielding a wider range of LCDA products with varying degrees of unsaturation, obtainable from fossil-based alkanes or plant-based fatty acids using microorganisms. However, biosynthesis of longer chains (≥C16) suffers from low performance (expensive substrates, low product concentrations, slow reaction rates, high viscosity, foaming), and costly downstream processing.

WODCA aims to tackle all limitations by applying **lipid waste streams** as a sustainable, low-cost feedstock for optimized biotransformation to **existing and new value-added LCDA building blocks, tailored to selected applications** (focus on C12, C16, C18). To this end, the project will apply robust **newly engineered non-pathogenic microbial strains**, **advanced conversion technologies** and **downstream processing at a competitive price**.

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## Abstract PADDL-2

**Polymer additives from lignin building blocks II**

The overarching goal of the cSBO PADDL project is to develop new polymer additives from lignin-derived platform molecules via the lignin-first biorefinery technology, employing reductive catalytic fractionation (RCF) on lignocellulose feedstock such as wood. These new polymer additives will hereby contribute to the reduction of CO2 emissions by using renewable carbon. Additionally, they need to provide safer alternatives for current petrochemical additives of which many have been included in the REACH Authorization List or placed on the Candidate List in recent years.

The PADDL project will follow a ‘safe by design’ approach for the discovery of new plastic additives to avoid regrettable substitutions of petrochemical additives. Based on market size, plasticizers and flame retardants have been selected as targets for PADDL-2. In addition, the potential to combine two properties in one additive molecule will be evaluated. The designed and synthesized candidate molecules will undergo a rapid preliminary performance tests and those with promising properties become “hit compounds”. Hit compounds are selected for the acute ecotoxicity screening and those which fulfil both the initial performance and acute ecotoxicity screening criteria become “lead compounds”. Lead compounds undergo advanced ecotoxicity studies (assessment of potential chronic and behavioural ecotoxicity as well as mode of action tests when appropriate), as well as more advanced standardized performance testing. For the latter, a limited number of polymer matrices is chosen (PP and PLA for flame retardants, PVC and PLA for plasticizers). Subsequently, on those lead compounds which successfully passed all these studies preliminary human toxicity tests will be performed. Finally, compatibility of the new plastic additives with the recycling process (mechanical recycling of polymer with additive and/or extractive removal of the additive to facilitate the recycling) will be evaluated as well as the feasibility of production from real-life feedstock. This approach will lead to the identification of at least one New Molecular Entity (NME) in each of the two targeted application areas: flame retardants and plasticizers.

Further development of these NMEs towards the market is not a part of PADDL-2 and will be the subject of further R&D in collaboration with interested companies. This will involve various other aspects such as the optimization of the synthesis suitable for scale up, optimization of dosing in function of the application, long-term performance studies taking into account stability of the material (both the additive and the polymer itself) under various conditions, full profiling of (eco)toxicity towards REACH registration, pilot production and finally, commercial scale production.

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