1. PUBLISHABLE SUMMARY

Summary of the context and overall objectives of the project (For the final period, include the conclusions of the action)

Biomass is frequently considered as an alternative feedstock for substitution to fossil oil, as this may allow to mitigate climate change and resources depletion. This biomass may be derived from agricultural residues, forest residues or agro industry residues whereas cellulose is the most abundant organic polymer on earth. However, direct substitution is not possible and processes are needed for a preliminary conversion of biomass into intermediate products: the industrial biology sector provides such processes. As a feedstock for these processes, ligno-cellulosic sugars represent an attractive alternative to traditional sugars as they can be made from widespread resources, and do not titrate or compete with food or feed production.

Technologies currently used to produce ligno-cellulosic sugars deliver complex syrups containing inhibitors which hamper the fermentation performances and impurities which make difficult the purification step for the desired molecule. Furthermore, biomass to building blocks technologies frequently propose to deliver molecules displaying characteristics that are significantly different from those of their fossil-based equivalents. Their use implies the need for heavy modifications and investments, taking place downstream in the value chain.

Isobutene is an important building block currently produced and used in the petrochemical industry for lubricants, rubbers, cosmetics, plastics, solvents, and fuels applications. Its global market is more than 15Mt a year and is growing 2.5% a year. At the same time, customers of fossil-based-isobutene derived goods are asking for more renewables.

The overall goal of OPTISOCHEM is to demonstrate the performance, the reliability and the environmental and socio-economic sustainability, of the entire value chains for the transformation of wheat straw, into bio-isobutene and derivatives. The project addresses two different isobutene derivatives families: oligomers and polyisobutylenes. These products are currently requested by the market for a wide array of applications. Presently these needs are satisfied by commercial processes designed to be fed with fossil-based isobutene. The project will demonstrate that these needs could be satisfied by the existing processes when fed with bio-based isobutene from sustainably extracted wheat straw. The outcome of the project will be to provide the backbone for a subsequent first of its kind 30kt per year flagship project and a series of numerous additional plants afterwards.

Work performed from the beginning of the project to the end of the period covered by the report and main results achieved so far (For the final period please include an overview of the results and their exploitation and dissemination)

As management activities, the Steering board and Executive committee met regularly, allowing for very good alignment and cohesion of the members as well as risk assessment updating.
Optimization activities focused on one hand on searching new process parameters for substrate preparation and handling in order to alleviate clogging issues initially observed with wheat straw hydrolysate, and on the second hand to create a series of matched strains with increased performances. Directed evolution in continuous culture techniques and rational metabolic engineering techniques were implemented in order to create and select new strains.

Upscaling activities consisted in producing more than 10 tons of wheat straw hydrolysate containing "ligno-cellulosic sugars ", in delivering these products to the pilot plant and the demo plant, and in performing fed batch at demo scale according to results obtained at pilot scale. Several bio-isobutene producing runs were executed at pilot and demo scales, with increasing performances at the pilot scale. First kilos of wheat-straw-based-bio-isobutene were delivered from the pilot for bio-based end-products validation activities, together with additional batches of traditional-sugar-based-bio-isobutene from the demo plant as a benchmark. First kilos of wheat-straw-based-isobutene were also produced at the demo scale. Samples of fermentation broth were analyzed and tested for recycling. Alternatives to classical sterilization of the sugars have been successfully tested at pilot scale.
End-product validation activities consisted in deep analysis of the bio-isobutene batches coming from upscaling activities in order to set a first set of specifications for the bio-isobutene to be accepted in conversion processes.
Process engineering and business plan activities just started at the end of the period and allowed preliminary work on economic analysis templates.
Dissemination activities provided communication materials (website, visual identity, slides, roll-up, flyers and twitter activity) and focused on presentation of the project at twelve conferences and delivered as well four articles, public reports and press releases.
Activities related to biomass supply, LCA, environmental and socio-economic performances, allowed to deliver an overview of straw availability in Europe, to complete a Life Cycle Inventory for fossil isobutene production and for traditional-sugars-bio-isobutene production.

Progress beyond the state of the art, expected results until the end of the project and potential impacts (including the socio-economic impact and the wider societal implications of the project so far)

OPTISOCHEM allowed so far to obtain matched strains which can consume glucose and xylose simultaneously, what was a crucial bottleneck identified at the beginning of the project and the impact of inhibitors on strain growth is largely alleviated what was part of another identified bottleneck. However, a residual inhibitory impact is still observed during the production phase and an undesired "flubber" phenotype impacting oxygen transfer (and therefore, scale-up) was observed on matched strains to start with. Thus, an adapted strain with no undesired associated phenotype was created, and is under characterization for bio-isobutene production.
Upscaling activities allowed to get several batches of bio-isobutene and to identify the nature and content of impurities which could not be so deeply characterized before the start of the project. As the effects of most detected poisons both on conversion of the isobutene to derivatives and on the quality of end-products are known, a first set of specifications could be proposed without need of conversion tests to end-products, thus allowing to prepare for experimental trials of conversion to be conducted during Q1 2019 at pilot scale.

So far, the benchmark traditional-sugars-bio-isobutene shows a significant better greenhouse gas performance than fossil isobutene. It has also been identified that important parameters for maximizing the greenhouse gas saving of bio- isobutene compared to fossil isobutene are sugar feedstock and process energy generation.

The project is on track for creating a new building block and at least 2 new bio-based materials with increased yield, reduced cost, reduced energy consumption and for delivering to the European and global markets this innovation which meets the needs of end-consumers. This paves the way for Strengthening the competitiveness and growth of companies and creating job in rural areas.

Address (URL) of the project's public website

http://optisochem.eu/


10 and 40L fermentation line, Evry, FR
500L pilot, Pomacle, FR
5000L fermenter and purification demonstrator, Leuna, DE