BioMates

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Responsible author:	Stella Bezergianni
Co- author(s):	Ann-Christine Johansson, Leonard Raymakers, Vasiliki Dagonikou
Reviewer:	David Kubička
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Contents

1. Preface

This report presents the progress on validating the BioMates technology focusing on the infrastructure upgrading and operating characteristics and limitations associated with the overall production process, as part of the Task 3.1 "TRL5-AFP-plant adjustment", Task 3.2 "TRL5 AFP bio-oil production validation" and Task 3.3 "Lab- to pilot-scale mild-HDT incorporating RES-based make-up H_2 for BioMates production". This report is organized in the following sections: a) introduction (section 2), where the background corresponding actions are outlined, b) BioMates validation infrastructure, summarizing the technology adjustments and upgrading actions involved on all technological steps (section 3), c) Operating characteristics and limitations, outlining the operating characteristics and limitations associated with the overall production process (section 4), and finally d) conclusions.

2. Introducing BioMates

2.1. The BioMates Project

The BioMates project aspires in combining innovative 2nd generation biomass conversion technologies for the cost-effective production of *bio*-based inter*me*edi*ates* (BioMates) that can be further upgraded in existing oil refineries as renewable and reliable co-feedstocks. The resulting approach will allow minimisation of fossil energy requirements and therefore operating expense, minimization of capital expense as it will partially rely on underlying refinery conversion capacity, and increased bio-content of final transportation fuels.

The BioMates approach encompasses innovative non-food/non-feed biomass conversion technologies, including *ablative fast pyrolysis (AFP)* and single-stage *mild catalytic hydroprocessing (mild-HDT)* as main processes. Fast pyrolysis in-line-catalysis and fine-tuning of BioMates-properties are additional innovative steps that improve the conversion efficiency and cost of BioMates technology, as well as its quality, reliability and competitiveness. Incorporating *electrochemical H_2-compression* and the state-of-the-art *renewable H2-production* technology as well as *optimal energy integration* completes the sustainable technical approach leading to improved sustainability and decreased fossil energy dependency. The overall BioMates-Concept is illustrated in Figure 1.

The proposed technology aims to effectively convert residues and non-food/feed plants or commonly referred to as 2nd Generation (straw and short rotating coppice like miscanthus) biomass into high-quality bio-based intermediates (BioMates), of compatible characteristics with conventional refinery conversion units, allowing their direct and risk-free integration to any refinery towards the production of hybrid fuels.

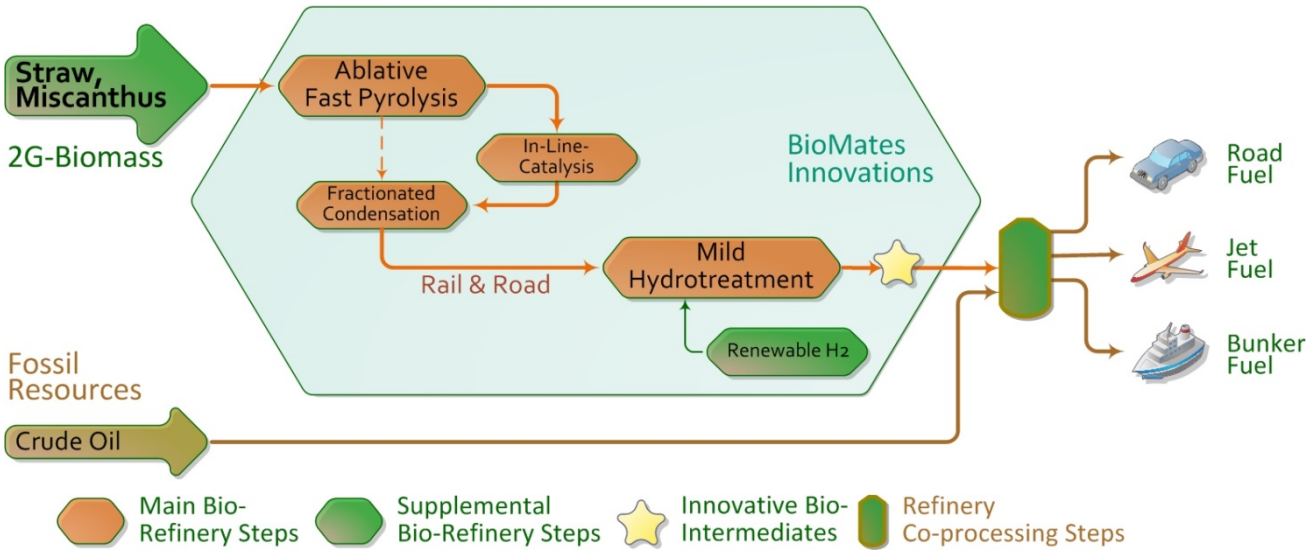

Figure 1: The BioMates-concept

2.2. European Commission support

The current framework strategy for a Resilient Energy European Union demands energy security and solidarity, a decarbonized economy and a fully-integrated and competitive pan-European energy market, intending to meet the ambitious 2020 and 2030 energy and climate targets [EC 2014a, EC 2014b]. Towards this goal, the European Commission is supporting the BioMates project for validating the proposed innovative technological pathway, in line with the objectives of the LCE-08-2016-2017 call [EC 2015]. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727463.

2.3. The BioMates team

The BioMates team comprises nine partners from industry, academia and research centres:

- Centre for Research & Technology Hellas / CERTH - Chemical Process & Energy Resources Institute / CPERI, Greece (Project Coordination) - http://www.cperi.certh.gr/
- Fraunhofer Institute for Environmental, Safety, and Energy Technology UMSICHT, Germany - www.umsicht.fraunhofer.de
- University of Chemistry and Technology Prague, Czech Republic - http://www.vscht.cz
- Imperial College London, United Kingdom - www.imperial.ac.uk
- Institut für Energie und Umweltforschung Heidelberg gGmbH / ifeu, Germany - www.ifeu.de
- HyET Hydrogen B.V. / HyET, The Netherlands - www.hyet.nl
- RANIDO, s.r.o., Czech Republic - http://www.ranido.cz/
- BP Europa SE, Germany - www.bp.com/en/bp-europa-se.html
- Research Institutes of Sweden AB, Sweden - https://www.ri.se/en

For additional information and contact details, please visit *www.biomates.eu*.

3. BioMates validation infrastructure

The existing TRL5 AFP-plant at RISE was adjusted to enable the production of the targeted amounts of bio-oil fractions from straw and Miscantus, as presented in detail in D3.1/D18 "1st batch of bio-oil for mild-HDT produced".

The existing TRL5 hydroprocessing pilot plant HDS1 of CERTH [Bezergianni-2011] was employed as a basis for the TRL5 validation of the AFP bio-oil upgrading via mild-HDT. The HDS1 pilot-plant is a once-through continuous hydroprocessing system with similar configuration with the TRL3 hydroprocessing plant employed in WP2, including a feed subsystem, a reactor subsystem and a product separation system. The TRL5 plant's reactor subsystem includes two reactors in series (while the TRL3 plant had only one reactor), and allowed higher capacity (maximum 600 ml/h throughput) and operating flexibility (max 180 barg system pressure, and max 550 °C reactor temperature). In order to ensure uninterrupted and reliable operation, several revamps were necessary on the underlying plant, primarily on the feed and production separation subsystems.

The integration of the TRL5 hydroprocessing plant at CERTH with HyET's Electrochemical Hydrogen Compression (EHC) and Electrochemical Hydrogen Purification (EHP) system was also performed, upon the provision of several connecting hardware that enable the connection of the EHC/EHP system with the TRL5 pilot plant. Additionally, a custom-made system that enables CO and H_2S removal from the HDT off-gas production prior to the EHC/EHP system was also installed. The recycling gas cleaning system connection with the EHC/EHP system required the effective communication of the EHC/EHP with the recycling gas system's SCADA (Supervisory Control and Data Acquisition) as well the installation of an alarm notification to enable the envisioned 24/7 operation.

The H_2 consumed for the mild-HDT reactions has to be substitute by RES-based make-up H_2 that is produced by the existing solar-powered water electrolysis TRL5 system installed and operated at CERTH, to increase the sustainability of the proposed conversion pathway. For this reason, the BioMates approach employs an existing operational prototype system of CERTH for the production of renewable hydrogen. The renewable H_2 is produced via RES-powered electrolysis, involving the electrical splitting of water ($2\ H_2O \rightarrow 2\ H_2 + O_2$) into its elemental precursors oxygen and hydrogen. The electrical energy for the electrolysis is renewable as it is solely provided by photovoltaic solar panels. CERTH's solar H_2 TRL 5 prototype system is presented in [Ziogou-2013].

4. Operating characteristics and limitations

The BioMates technology validation in TRL5 employed the upgraded/revamped infrastructure described in section 2, in order to enable the validation in an industrial relevant environment. The infrastructure upgrading and modification allowed the TRL5 validation of the overall BioMates production pathway, leading to the production of a total of 180 l of BioMates.

The scaling up of the technology in TRL5 has identified some key operating characteristics and limitations that have been addressed by the highly skilled personnel of RISE, CERTH, HyET, which were instrumental in the TRL5 validation. The modifications enabled the extended continuous operation of both the AFP and hydroprocessing pilot plants at RISE and CERTH respectively, the effective integration of the hydroprocessing pilot plant with the EHC/EHP system of HyET, and validation of the BioMates production pathway in TRL5 industrially relevant environment.

5. Disclaimer

This Deliverable report reflects only the authors' view; the European Commission and its responsible executive agency INEA are not responsible for any use that may be made of the information it contains.

6. Literature

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