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# ERANET-LAC
# JOINT CALL 2015-2016

## Full Proposal Form

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|---|---|
| Project acronym: | **BIORESOL** |
| Project Coordinator: | **Dr Francesco Frusteri**<br>National Council of Research, Italy |
| Ref.: | **ELAC2015/T03-0493** |



## Funded by the following EU CELAC R&I funding agencies:

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- Peru: National Council of Science, Technology and Innovation, CONCYTEC
- Trinidad & Tobago: National Institute of Higher Education, Research, Science and Technology, NIHERST
- Uruguay: National Research and Innovation Agency of Uruguay, ANII

# Index

# INFORMATION RELATING TO THE COMPOSITION OF THE PROJECT CONSORTIUM

| | | | |
|---|---|---|---|
| Project acronym: | BIORESOL | | |
| Project full title: | Novel Catalytic Approaches for Olefin and Alcohols Production for Residual Biomass by CO2 Conversion | | |
| Topics: | Topic #03: Biorefinery - Fractionation and valorisation of residual biomass to intermediate and/or final high added value bioproducts | | |
| Keywords: | Chemical technologies<br>Materials, chemistry and life sciences | | |
| Total project costs: | 1.138.456,00 € | Total requested funding: | 810.750,00 € |
| Project duration (months): | 36 | Expected start date (mm/yyyy): | 11/2016 |
| Total Effort (Person Months): | 255,00 PM | | |

## 1. Project Coordinator Details

| | | | |
|---|---|---|---|
| First Name: | Francesco | Title: | Dr |
| Family Name: | Frusteri | e-mail: | francesco.frusteri@itae.cnr.it |
| Position held: | Senior Researcher | Telephone: | (39) 090624233 |
| Organisation Name: | National Council of Research | Organisation website: | http://www.itae.cnr.it |
| Address of the organisation: | Via S. Lucia ,5<br>98127 Messina | Country: | Italy |

## 2. Consortium: Details of the Organizations involved

| Organisation | Contact Person / e-mail | Activity type[1] | Applying for funding from |
|---|---|---|---|
| **National Council of Research *** | Dr Francesco Frusteri<br>francesco.frusteri@itae.cnr.it | RES | National Research Council (CNR) (Italy) |
| Åbo Akademi University | Prof. Dmitry Murzin<br>dmurzin@abo.fi | HE | Academy of Finland (AKA) (Finland) |
| Unapec, University | Dr. William Camilo Reynoso<br>wcamilo@unapec.edu.do | HE | Ministry of Higher Education, Science and Technology (MESCyT) (Dominican Republic) |
| Instituto de Investigaciones en Catálisis y Petroquímica | Prof Laura Cornaglia<br>lmcornag@fiq.unl.edu.ar | HE | Ministry for Science, Technology and Productive Innovation (MINCyT) (Argentina) |
| Universidad de Concepcion | PhD Alejandro Karelovic<br>akarelov@udec.cl | HE | National Council for Science and Technological Research (CONICYT) (Chile) |
| Federal University of Rio de Janeiro | Dr Donato Aranda<br>donato.aranda@gmail.com | HE | National Council for Scientific and Technological Development (CNPq) (Brazil) |

| Organisation | Contact Person / e-mail | Activity type[1] | Applying for funding from |
|---|---|---|---|
| Universidad Industrial de Santander | Prof Víctor Gabriel Baldovino Medrano vicbaldo@uis.edu.co | HE | Administrative Department of Science, Technology and Innovation (COLCIENCIAS) (Colombia) |

[1] HE – Higher Education, RES – Research, IND – Industry, SME, OTH - Others

## 3.1. Overall Project Costs

| Organisation | Person Months | Costs (€) | Partner Contribution (€) | Requested Funding (€) |
|---|---|---|---|---|
| **National Council of Research *** | 24,00 | 150.870,00 € | 50.870,00 € | 100.000,00 € |
| Åbo Akademi University | 39,00 | 285.621,00 € | 85.686,00 € | 199.935,00 € |
| Unapec, University | 72,00 | 300.000,00 € | 0,00 € | 300.000,00 € |
| Instituto de Investigaciones en Catálisis y Petroquímica | 12,00 | 52.000,00 € | 12.000,00 € | 40.000,00 € |
| Universidad de Concepcion | 36,00 | 90.815,00 € | 0,00 € | 90.815,00 € |
| Federal University of Rio de Janeiro | 36,00 | 104.000,00 € | 54.000,00 € | 50.000,00 € |
| Universidad Industrial de Santander | 36,00 | 155.150,00 € | 125.150,00 € | 30.000,00 € |
| TOTAL | 255,00 | 1.138.456,00 € | 327.706,00 € | 810.750,00 € |



## 3.2. Detailed Project Costs

## 3.2a. Personnel Costs

| Organisation | Average Monthly Salary (€) | Nº of Man-Months | Total Cost (€) | Requested Funding (€) |
|---|---|---|---|---|
| **National Council of Research *** | 4.000,00 € | 24,00 | 96.000,00 € | 46.000,00 € |
| Åbo Akademi University | 2.395,00 € | 39,00 | 143.876,00 € | 100.713,00 € |
| Unapec, University | 1.666,00 € | 72,00 | 120.000,00 € | 120.000,00 € |
| Instituto de Investigaciones en Catálisis y Petroquímica | 1.000,00 € | 12,00 | 12.000,00 € | 0,00 € |
| Universidad de Concepcion | 700,00 € | 36,00 | 25.080,00 € | 25.080,00 € |
| Federal University of Rio de Janeiro | 1.500,00 € | 36,00 | 54.000,00 € | 0,00 € |
| Universidad Industrial de Santander | 1.860,00 € | 36,00 | 66.960,00 € | 0,00 € |
| SUBTOTAL | 13.121,00 € | 255,00 | 517.916,00 € | 291.793,00 € |

## 3.2b. Equipment

| Organisation | Description | Total Cost (€) | Requested Funding (€) |
|---|---|---|---|
| **National Council of Research *** | Already available | 0,00 € | 0,00 € |
| Åbo Akademi University | Not applicable | 0,00 € | 0,00 € |
| Unapec, University | 680 mts3 Biogas Anaerobic Digestion Reactor | 80.000,00 € | 80.000,00 € |
| Instituto de Investigaciones en Catálisis y Petroquímica | Mass Flow Controllers + 6-way valves+oven | 13.000,00 € | 13.000,00 € |
| Universidad de Concepcion | Gas chromatograph for analysis of reactor effluents (first year) and mass flow controllers, pressure regulators (second year) | 42.239,00 € | 42.239,00 € |
| Federal University of Rio de Janeiro | N/A | 0,00 € | 0,00 € |
| Universidad Industrial de Santander | Equipment for catalysts preparation (extrusion machine). Equipment for catalysts characterization and testing (as provided by UIS) | 59.000,00 € | 15.000,00 € |
| SUBTOTAL | | 194.239,00 € | 150.239,00 € |



## 3.2c. Materials

| Organisation | Description | Total Cost (€) | Requested Funding (€) |
|---|---|---|---|
| **National Council of Research *** | Consumables for experiments | 30.000,00 € | 30.000,00 € |
| Åbo Akademi University | Chemicals, gases, | 17.000,00 € | 11.900,00 € |
| Unapec, University | *Device for Primary treatment: sieving, sieving, sedimentation for the separation of solids emulsified fats, degreasing * Device for Biological treatment in UASB and vermifilters digesters * Equipment for production of biogas and electric and heat energy * Device for Disinfection of effluent (UV rays) and treatment of sludge by vermi composting | 75.000,00 € | 75.000,00 € |
| Instituto de Investigaciones en Catálisis y Petroquímica | Precursor salts (Pd, Rh, Ru, Ni and Co), porous supports, gases (CH4, CO2 , O2 and Ar ) | 15.000,00 € | 15.000,00 € |
| Universidad de Concepcion | chemical reagents, materials for laboratory work, gas bottles, etc. | 17.160,00 € | 17.160,00 € |
| Federal University of Rio de Janeiro | Reagents, Glaziers, Laboratory Consumables e Filters | 25.000,00 € | 25.000,00 € |
| Universidad Industrial de Santander | Reactants and consumables for catalysts preparation and characterization | 8.000,00 € | 8.000,00 € |
| SUBTOTAL | | 187.160,00 € | 182.060,00 € |

## 3.2d. Sub-Contracting

| Organisation | Subcontractor | Description | Total Cost (€) | Requested Funding (€) |
|---|---|---|---|---|
| SUBTOTAL | | | 0,00 € | 0,00 € |

## 3.2e. Travel and Subsistence Costs

| Organisation | Description | Total Cost (€) | Requested Funding (€) |
|---|---|---|---|
| **National Council of Research *** | Meetings and visiting of researchers - Conferences | 15.000,00 € | 15.000,00 € |
| Åbo Akademi University | Travelling to project meetings and conferences | 12.000,00 € | 8.400,00 € |
| Unapec, University | travel and subsistence costs | 10.000,00 € | 10.000,00 € |
| Instituto de Investigaciones en Catálisis y Petroquímica | 2 researchers per each project year (Airplane tickets and travel expenses) | 12.000,00 € | 12.000,00 € |
| Universidad de Concepcion | travel to conferences and meetings with other members of the consortium | 6.336,00 € | 6.336,00 € |
| Federal University of Rio de Janeiro | Rio de Janeiro - Finlândia - Rio de Janeiro Rio de Janeiro - Itália - Rio de Janeiro | 5.000,00 € | 5.000,00 € |
| Universidad Industrial de Santander | Attending one conference + publishing fees for open access. | 4.000,00 € | 4.000,00 € |
| SUBTOTAL | | 64.336,00 € | 60.736,00 € |

## 3.2f. Other Costs

| Organisation | Description | Total Cost (€) | Requested Funding (€) |
|---|---|---|---|
| **National Council of Research *** | not necessary | 0,00 € | 0,00 € |
| Åbo Akademi University | TEM and SEM analysis at Åbo Akademi | 3.400,00 € | 2.380,00 € |
| Unapec, University | publication, Supervising expenses, | 15.000,00 € | 15.000,00 € |
| Instituto de Investigaciones en Catálisis y Petroquímica | N/A | 0,00 € | 0,00 € |
| Universidad de Concepcion | N/A | 0,00 € | 0,00 € |
| Federal University of Rio de Janeiro | Third party services legal persons | 20.000,00 € | 20.000,00 € |
| Universidad Industrial de Santander | Bibliography, technical services from labs other than CICAT | 7.040,00 € | 3.000,00 € |
| SUBTOTAL | | 45.440,00 € | 40.380,00 € |

## 3.2g. Overheads (Please, check specific national requirements)

| Organisation | Percentage Overheads | Total Cost (€) | Requested Funding (€) |
|---|---|---|---|
| **National Council of Research *** | 7,00 % | 9.870,00 € | 9.000,00 € |
| Åbo Akademi University | 76,00 % | 109.345,00 € | 76.542,00 € |
| Unapec, University | 0,00 % | 0,00 € | 0,00 € |
| Instituto de Investigaciones en Catálisis y Petroquímica | 0,00 % | 0,00 € | 0,00 € |
| Universidad de Concepcion | 0,00 % | 0,00 € | 0,00 € |
| Federal University of Rio de Janeiro | 0,00 % | 0,00 € | 0,00 € |
| Universidad Industrial de Santander | 7,00 % | 10.150,00 € | 0,00 € |
| SUBTOTAL | | 129.365,00 € | 85.542,00 € |

## 4. Executive summary
(for internal ERANET-LAC use only)

This project focuses on developing essential step comprised in a biorefinery via novel catalytic approaches for olefins and alcohols production from residual biomass by CO2 conversion. The conversion of residual biomass to light olefins and alcohol is a key technology to achieve the target set for the chemical industry to reduce by 30% the use of fossil fuels for the year 2030. The project activity is centred on developing innovative catalysts, through a "knowledge-based" approach that integrates catalysts development and testing and their engineering to the understanding of the mechanistic aspects of reactions and correlation between the catalyst structure and catalytic behaviour. Furthermore, some aspects for the development of the so-called technical catalysts, i.e. those applied in a potential industrial process, will also be covered. The project encompasses three main lines of research, namely: the development of (A) a process for the production of syngas, from agro-industrial residual biomasses, by new catalytic processes alternative to the conventional ones (Aqueous Phase Reforming and Catalytic Supercritical Gasification); B) Production of olefins both from synthesis gas and DME streams; and, (C) production of fatty alcohols directly from syngas. In the overall process, the use of membrane systems for hydrogen separation is also considered for fine-tuning the syngas composition. Furthermore, the integration of an anaerobic digester is also considered aiming at producing methane as an energy source. In general, the integration of all of the components of the project account for all of the important processes needed to configure a modern clean tech biorefinery.

# TECHNICAL DESCRIPTION OF THE PROJECT

## 5. Publishable summary of the project

(this summary will be used solely for publication purposes)

This project aims to validate a biorefinery model based on the production of olefins and alcohols from residual biomass via catalytic conversion of CO2-rich syngas. The conversion of residual biomass to light olefins and alcohol is a key technology to achieve the target set for the chemical industry to reduce the use of fossil fuels. The project activity is centred on the development of innovative catalysts, through a "knowledge-based" approach devoted to the understanding of the mechanistic aspects of reactions and correlation between catalyst structure and catalytic behaviour. The project is divided into three main lines of research, namely: (A) Production of syngas from agro-industrial residual biomass, by new catalytic processes alternative to the conventional ones (Aqueous Phase Reforming and Catalytic Supercritical Gasification); B) Production of olefins via syngas and DME streams; (C) Production of fatty alcohols directly from syngas. In the overall process, the use of membrane systems for hydrogen separation is expected to allow the syngas composition to be tuned according the requirements of the different process targets. The integration of an anaerobic digester is also considered aiming at producing methane as an energy source. On the whole, the expertise from the different project partners will be helpful to configure a modern clean tech biorefinery.

## 6. Scientific and technological challenge

### Relation and relevance of the project to the topic

According to the requirements of Topic 3, the development of self-sustainable plants with minimum production of residues and fossil energy consumption represents the main challenge of the BIORESOL project.

Novel catalytic units for valorising agricultural or agro-industrial residues, as well as organic wastes with a good valorisation potential, are herewith proposed for the production of high-added value chemicals, such as olefins and alcohols. Particular attention is focused on the possibility to develop new catalytic processes, like Aqueous Phase Reforming (APR) and Catalytic Supercritical Gasification (CSG), effective to directly processing wet biomass, so to avoid preliminarily and costly drying operations. APR and CGS operate at low and high temperature respectively, both representing promising catalytic technologies, but still under investigation at basic or feasibility research levels. One of the main challenges deals with the use of feeds containing a wide variety of organic and inorganic compounds, each of which can drastically affects the catalytic performance. Therefore, the design of robust catalytic materials to be used in innovative processes represents the major goal of this research activity.

Considering that APR and CSG units give rise to a mixture of H2/CO/CO2 at various relative concentrations, different catalytic approaches for converting these mixtures into high value added products will be assessed. Firstly, hydrogen selective membranes for the fine tuning of the H2/CO/CO2 ratio will be used, so to satisfy the particular needs of the other downstream processes. Secondly, in presence of a CO2-rich syngas streams, several bifunctional catalysts will be prepared and tested for the production of MeOH/DME mixtures. Subsequently, this mixture will be fed to another catalytic stage process in which olefins will be produced via MTO process. Thirdly, in presence of CO2-lean syngas streams the selective transformation of CO-H2 streams into fatty alcohols will be realized over novel catalytic systems. Alternatively, the same type of stream will be converted into olefins via Fischer-Tropsch synthesis.

Finally, the possibility to integrate the overall process with an anaerobic digester for the production of bio-methane from the residual aqueous wastes will be also evaluated. So, biomethane can represent an additional energy source of heat suitable for sustaining the endothermic catalytic processes herein considered.

### International competitiveness, novelty and innovation potential of the proposal

The main purpose of this project is to propose a sustainable integrated process for valorising agro-industrial residues by obtaining chemicals with a high added value, such as olefins and alcohols. The idea is to use innovative catalytic technologies to treat flexible feedstock changing in composition. In this regard, reactions such as aqueous phase reforming (APR) and catalytic gasification under supercritical phase (CGS) will be investigated. These two catalytic technologies allow directly treating aqueous organic residues, but they are still under pre-industrial development. The synthesis gas obtained from such processes will be converted into useful products by novel catalytic technologies suitable to obtain olefins and DME directly.

Alternatively, it will evaluate the possibility of obtaining higher alcohols (Fatty Alcohols) from CO-rich syngas. Within the framework of the project an efficient anaerobic digester will be developed to produce methane from aqueous residues, so to furnish energy to the endothermic processes.

The development of such an integrated process would represent an opportunity to valorise agro-industrial residues with remarkable advantages from an environmental point of view, diminishing $CO_2$ emissions in the atmosphere and the release of soil pollutants, as well as from an economic viewpoint aiming at obtaining olefins and alcohols, which represent the basis for the production of polymers and many other industrial chemicals. In this sense, the project can be considered to be well placed within the context of the short-term market scenario, oriented towards the production of bio-chemicals.

## 7. Technical and scientific description of the project

***State-of-the-art***

**Residual Biomasses Treatment** *Aqueous Phase Reforming* - APR, introduced by Dumesic et al. [1] is a promising technology for the production of both hydrogen and/or liquid hydrocarbons from aqueous sustainable resources [2]. Group VIII metals generally show high activities in C-C bond breaking thus being effective catalysts for this type of reactions. [1] *Nature* 418 (2002) 964. [2] *Catal Rev* 51 (2009) 441.

*Gasification in supercritical phase* - *S*upercritical water gasification (SCWG) is promising to overcome the issues related to the commonly high water content in biomass feedstock [1-3]. SCWG benefits from the fact that supercritical water leads to the rapid degradation of the polymeric structure of the biomass producing a gas mixture mainly containing $CH_4$ at relatively low temperatures. [1] *Energies* 8 (2015) 859. [2] *Energy Convers. Manage.* 46 (2005) 615. [3] *Energy Environ. Sci.* 1 (2008**)** 32.

**B) Syngas conversion and $H_2$ Separation** *Direct DME production from syngas containing $CO_2$* - The $CO_2$ hydrogenation reaction to obtain methanol or DME is of great interest both from the environmental and economical points of view [1-2]. Whereas the catalysts for methanol synthesis are not very active using only $CO_2$ and that the production of DME requires the presence of acid sites, the research is addressed towards the development of bi-functional hybrid catalysts. [1] *Appl. Catal. B: Environ*. 176 (2015) 522. [2] *Appl. Catal. B: Environ.* 162 (2015) 57.

*Membrane technology for hydrogen separation* - Membrane-related processes are considered to be one of the most promising routes for the separation of pure hydrogen which could be employed for fuel cell applications and as a raw material for several processes. Dense Pd membranes are attractive due to their perfect permselectivity to hydrogen. However, their thicknesses limit their use because of their low permeability and high cost. Thin Pd-based films supported on porous substrates constitute an economic option to overcome these limitations.

**C) Olefins and fatty alcohols production from syngas and oxygenates -** *Direct Olefins production* - Classic works concerning the preparation of technical catalysts for MTO deal mostly with ZSM-5 [1,2] and SAPO-34 extrudates [3]. These works show that using an inert matrix for the catalysts might be very important. However, very few details are normally provided on the shaping process. More recently, Lee et al [4] showed that also matrixes with a basic character could be advantageous to the MTO process. [1] App Catal A: Gen 328 (2007) 210. [2] App Catal A: Gen 391 (2011) 254). [3] ACS Catal. 2015, 5, 1922−1938. [4] Appl Catal A: Gen 502 (2015) 42.

*Olefins production by Fischer Tropsch process* **-** Bulk iron-based catalysts present high selectivity but are mechanically unstable due to the formation of carbon deposits that block the active sites and induce fragmentation of the particles. For that reason, supported catalysts are recommended [1]. Weakly interactive supports such as carbon nanofibers, β-SiC and α-$Al_2O_3$ favor the transformation of supported Fe particles into Fe carbide which is the active phase [1]. In order to make viable a future commercial implementation of FTO process new catalysts with carefully controlled properties are necessary. Fe nanoparticles in reverse microemulsions are proposed for this purpose [2]. [1] *Science* 335 (2012) 835-838. [2] *Colloids and Surf.* 5 (1982) 209-225.

*Fatty alcohols production* - Production of higher alcohols by the catalytic conversion of synthesis gas (CO + H2) derived from renewable biomass is one of the most promising approaches for biorefineries since it is desirable to use residual biomass as feedstock instead of lipids [1]. When compared to the high pressure commercial fatty acid hydrogenation, syngas to higher alcohols can be produced in milder conditions. This is possible with expensive rhodium supported catalysts but it can also be obtained with transition metals like Co-Cu supported catalyst, mainly when some promoters (Mn, Ce) are added [2]. Niobia is a very interesting support and catalytic promoter in the Fischer-Tropsch conditions [3]. [1] *Chem. Soc. Rev.* 36 (2007) 1514. [2] *Catal. Today* 147 (2009) 133. [3] U.S. Patent 6 362 239 Bl (2002).

*Anaerobic Digestion* - Biogas is a renewable energy source made up essentially of methane (CH4) and carbon dioxide (CO2). This occurs through the anaerobic decomposition of organic matter. It is a natural process that occurs in all areas where biomass in a humid environment and anoxic is decomposed through bacterial activity. In this project, we present an innovation for anaerobic biodigestion by aid heat to the manure mix, reaching 54º C by water thermosolar exchangers. This helps producing more and better biogas. The reason for the latter is the thermofilic phase in the biodigester where anaerobic bacteries may have better performance, thus improving the reactor efficiency.

# Technical milestones and expected results

**WP1 – Residual biomass treatment**

***Aqueous Phase Reforming* - Milestones:** -Catalyst development with respect to porosity, acidity, basicity, metal-support interaction - **Expected Results** - Novel catalyst with high activity and selective in APR condition.

***Catalytic Supercritial Gasification* - Milestones**: - Realization of continuous fixed bed reactor operating in supercritical phase - Preparation of novel structured (honeycomb) catalysts for syngas production - **Expected Results** - Measurement of catalytic activity of structured catalyst operating in supercritical phase - Optimization of operative conditions - Endurance test to evaluate the catalyst stability

***Anaerobic Digestion* - Milestones**: -Development of digester operating in continuous mode assisted by solar energy - **Expected Results** - Methane production with high efficiency

**WP2 – Syngas Conversion and H2 separation**

***CO2 hydrogenation to DME synyhesis* - Milestones:** - Optimization of procedure for catalyst preparation – characterization of catalysts – Tests in continuous fixed reactor - **Expected Results**: preparation of hybrid catalysts characterized by high activity in CO2 hydrogenation to DME – Optimization of operative conditions in terms of GHSV, temperature and pressure.

***Membrane technology* - Milestones:** *-Preparation of* Pd and Pd alloy films deposited by electroless plating on stainless steel substrate introducing oxides, NaA zeolite or ZrO - **Expected Results**: - Development of membranes that produce pure hydrogen or stream with higher H2/CO ratio.

**WP3 – Olefins and fatty alcohols production from syngas and oxygenates**

***Direct Syngas to olefins* - Milestones**: -Synthesis of technical catalysts using zeolites, clays, aluminosilicates and alkali metals. -Characterization and testing of catalysts in the MTO process at the laboratory scale - Correlation of physicochemical properties and catalytic performance. - ***Expected Results*** -To establish scientific bases for the shaping of MTO catalysts -To produce new highly active, selective and stable technical catalysts for the MTO process.

***Fischer-Tropsch (FT) Synthesis* - Milestones**: -Preparation of Fe nanoparticles inside reverse micelles. -Determination of the effect of microemulsion properties -Study of the effect of Fe nanoparticles size and promoter addition on the kinetics of olefin formation. **Expected Results:** Development of novel nanosized Fe based catalyst active and stable under FT conditions

***Fatty Alcohols production* - Milestones:** - Preparation of Cu-Co catalysts supported on niobia and Nb2O5/Al2O3 catalysts - Catalytic tests using CO/H2 feed- **Expected Results**: - Development of active, stable and selective to high alcohols niobia based Cu-Co catalysts.

# *Methodologies and technologies proposed to obtain goals*

**WP1 – Residual biomass treatment**

**Technology:** *Aqueous Phase Reforming* - ***Methodology***: synthesis of catalysts and testing technical feedstocks in APR. Supported catalysts based on Pt, Pt-Re, Ir-Re and Ru-Re will be prepared.

**Technology:** *Gasification in supercritical phase (SWG)* – ***Methodology**:* design, construction and implementation of a fixed bed reactor containing a honeycomb type monolithic catalyst. Measurements of the performance of this reactor.

**Technology:** *Anaerobic digestion* – ***Methodology:*** design, construction and implementation of an Anaerobic biogas reactor. Development of a protocol for handling, loading and mixing of waste biomass at different treatment stages. Development of an experimental protocol for sampling products and wastes at different stages of the process.

**WP2 – Syngas Conversion and H2 separation**

**Technology:** *Direct DME production from syngas containing CO2* - ***Methodology***: Synthesis of catalysts based on mixed oxide supported on bi-dimensional zeolite. Performing catalytic tests in a fixed bed reactor operating at high pressure (30-80 bar).

**Technology:** *Membrane separation of hydrogen* – ***Methodology:*** Synthesis of ternary Pd alloys supported on stainless steel porous tubes as composite membranes. Measurements of the activity and permeability of the synthesized composites.

**WP3 – Olefins and fatty alcohols production from syngas and oxygenates**

**Technology:** *Direct Olefins production* – ***Methodology:*** synthesis of technical catalysts by extrusion and by varying diverse synthesis parameters: nature of both the active phase and binder, etc. Characterization of catalysts by diverse techniques. Testing of catalysts in a fixed-bed reactor.

**Technology:** *Olefins production by Fischer-Tropsch*- ***Methodology:*** synthesis of Fe nanoparticles in reverse microemulsions. Testing of catalysts for their physicochemical properties and activity.

**Technology:** *Fatty alcohols production* – ***Methodology:*** Synthesis of catalysts with higher selectivity to alcohols larger than methanol and ethanol using renewable syngas as raw material. Testing of catalysts.

### Recent Research

The BIORESOL project aims at developing of new technologies suitable to use the diluted biomass as it is with the aim of obtaining high added value products. Specifically, gasification in supercritical phase and reforming in aqueous phase are proposed for syngas production from aqueous residual biomass; these technologies are to be considered as new approaches still at pre-industrial scale. The subsequent exploitation of the synthesis gas to obtain light olefins, to be used as bio-product in the biorefinery and higher alcohols, will be investigated focusing the attention on the development of new catalytic systems. The goal is the reduction of the production costs of the catalysts by using non-noble metals. Also new materials characterized by suitable morphology, structure, and specific surface and nanostructured properties will be investigated.

## BRIEF CV of each Partner

**Francesco Frusteri –** PhD in Catalytic Technology and Research leader at National Council of Research ITAE Institute. Prof. at Messina University and a winner of full professor position enablement in industrial chemistry. He is responsible and evaluator of several research International and national projects and leader of a research group. He published about 400 scientific papers. ***Expertise***: heterogeneous catalysis applied to energy and fuels production.

**Dmitry Murzin –** PhD in physical chemistry and full professor at Faculty of Chemical Engineering, Åbo Akademi University, Turku, Finland. Prof. Murzin has been a partner in 6 EU Framework projects, including project coordination.

He published more than 650 scientific papers and received several awards invited lecture and acted as chairman in several congresses. ***Expertise***: heterogeneous catalysis for the processing of bioderived materials.

***Laura Cornaglia -*** Member of the National Research Council – CONICET. Principal Researcher at *INCAPE (Institute of Research in Catalysis and Petrochemistry).* Associate Professor. School of Chemical Engineering, Universidad Nacional del Litoral. She p*ublished about* 80 *papers. Member of the Editorial Board. Applied Catalysis A General, 2009 -present.* ***Expertise.*** *Heterogeneous catalysis, Inorganic membranes, Surface characterization techniques. She published more than 80 scientific papers.*

***Víctor G. Baldovino-Medrano*** Prof. Universidad Industrial de Santander (UIS). Head of ***Centro de Investigaciones en Catálisis*** (CICAT), and of ***Laboratorio de Ciencia de Superficies*** (SurfLab). **Postdoctorate –Chargé de recherches, FSR-Marie Curie Fellow–** (2009-2014), Université catholique de Louvain. **Ph.D. & Chem. Eng.**, Universidad Industrial de Santander, Colombia. ***Expertise***: heterogeneous catalysis, surface characterization techniques. He published about 15 scientific papers.

**Alejandro Karelovic –** Obtained a PhD in Heterogeneous Catalysis (in 2013) from the Université catholique de Louvain (Belgium). He is currently assistant professor at the Chemical Engineering department of the Universidad de Concepcion (Chile). ***Expertise***: preparation of catalysts by innovative methods, characterization by ex-situ and in-situ techniques. He published about 14 scientific papers.

**Donato Aranda -** PhD in chemical engineering and full professor at Chemical Engineering Department, School of Chemistry, Federal University of Rio de Janeiro, Brazil. Director of catalyst laboratory and pilot plant, PROCAT. He published more than 115 scientific papers, 20 patents and received several awards, invited lecture and acted as chairman in several congresses. ***Expertise:*** heterogeneous catalysis for the processing of biofuels, microalgae and bioproducts.

**William Camilo** PhD in: Computer engineering concentration in systems (GIS) geographic information and geomatics, Universidad Pontificia de Salamanca, Spain. Robotics and educational technologies, University, AIU, U.S.A. Dean of engineering and computer science, Universidad APEC 2010-2015. • Coordinator at the Centre for research in high-tech Crea of the Instituto Tecnológico de Las Américas ITLA, systems for geomatics, mechatronic systems, and systems for renewable energy, 2008-2010. He publishd about 20 relevant scientific papers.

## 8. Work plan

Figure 1 ( see Annex) illustrates the project idea. Overall, the project aims to develop innovative technologies aimed to valorise the aqueous residual biomass, which also constitute a serious environmental problem, to achieve high added value products such as olefins and higher alcohols. The attention will be focused both on the development of innovative technologies such as gasification in supercritical phase and reforming in liquid phase and the development of new catalytic systems suitable of producing oxygen compounds, olefins and alcohols using synthesis gas also contains significant amounts of CO2 . A parallel activities will also be carried out in the area of anaerobic digestion using the same organic matrix. This activity will help to understand whether new technologies proposed constitute a viable alternative to propose a bio refinery concept that suitable to convert residual biomass getting chemicals with high added value biomass as an alternative to the production of energy from natural gas or synthesis gas.

The GANTT of BIORESOL project is reported as Figure 2 ( See Annex )

The work plane is structured as following:

**WP1 – Residual biomass treatment (Partners: ITAE-AAU-BIOTHEM)**

*WP 1.1 - Aqueous phase reforming (APR)*

*Milestones:* 1- Identification of a potentially active catalyst. 2 - Synthesis of the optimized catalyst

*Deliverables: Reports – Publications – solid catalysts*

*Time Schedule: See Fig. 2 in Annex*

*WP 1.2 - Gasification in supercritical phase (SWG)*

*Milestones:* Realization of continuous fixed bed reactor operating in supercritical phase - Preparation of novel structured (honeycomb) catalysts for syngas production

*Deliverables: Research reports – Scientific Papers – Catalyst preparation procedure – Reactor design*

*Time Schedule: See Fig. 2 in Annex*

*WP 1.3 - Anaerobic digestion*

*Milestones:* Development of digester operating in continuous mode assisted by solar energy

*Deliverables: Reports - Patent – Prototype*

*Time Schedule: See Fig. 2 in Annex*

**WP2 – Syngas Conversion and H2 separation (Partners: ITAE-INCAPE)**

*WP 2.1 - Direct DME production from syngas containing CO2*

*Milestones :* Optimization of procedure for catalyst preparation – characterization of catalysts – Tests in continuous fixed reactor.

*Deliverables: Research reports – Scientific Papers – Patent - Catalyst preparation procedure*

*Time Schedule: See Fig. 2 in Annex*

*WP 2.2 – Membrane technology for hydrogen separation*

*Milestones:* Preparation of Pd and Pd alloy films deposited by electroless plating on stainless steel substrate introducing oxides, NaA zeolite or ZrO.

*Deliverables: Reports – Scientific papers – membrane module*

*Time Schedule: See Fig. 2 in Annex.*



**WP3 – Olefins and fatty alcohols production from syngas and oxygenates (Partners involved ( Partners: UIS-UDEC-UFRJ)**

*WP3.1 - Direct Olefins production*

*Milestones:* Synthesis of technical catalysts for MTO/DMTO as based on ZSM-5 and SAPO zeolites and different binders. - characterization of catalysts and use in MTO/DMO -Incorporation of alkali metals and rare earths to selected catalysts - Selection of the more active and selective catalysts and stability tests

*Deliverables:* Research reports comprising the design of a synthesis process for technical catalysts and their corresponding catalytic performance - Publication of two research papers

*Time Schedule: See Fig. 2 in Annex*

*WP 3.2 - Olefins production by Fischer Tropsch process*

*Milestones* - Preparation of Fe nanoparticles inside reverse micelles - Study of the effect of microemulsion properties on the size of Fe nanoparticles - Study of the incorporation of the promoters (S and Na) on the Fe nanoparticles - Study of the effect of Fe nanoparticles size and promoter addition on the kinetics of olefin formation form ideal syngas feeds and also simulating feeds coming from aqueous phase reforming, which will be studied by other members of the consortium.

*Deliverables* - Research reports comprising the design of a synthesis process for technical catalysts and their corresponding catalytic performance

*Publication of 2 research paper*

Time Schedule: See Figure 2 in Annex

*WP 3.3 - Fatty alcohols production*

*Milestones:* Preparation of Cu-Co catalysts supported on niobia and $Nb_2O_5/Al_2O_3$ catalysts - Catalytic tests using $CO/H_2$ feed

*Deliverables:* Research reports comprising the design of a synthesis process for technical catalysts and their corresponding catalytic performance

Publication of 2 research paper

*Time Schedule: See Fig. 2 in Annex*

**Risk assessment (including scientific/technology, management and commercial risks)**

In the following table the risk assessment for each WP is evaluated.

| No. | Description of Risk | WP involved | Risk-mitigation measures | Risk Impact |
|---|---|---|---|---|
| 1 | Catalyst activity too low for efficient conversion of syngas in Aqueous phase reforming reaction | WP1.1 | Use of doped non-noble metal catalysts to enhance the catalyst performance | Medium |
| 2 | Difficulty in Structured catalyst preparation (honeycomb) | WP1.2 | Employment of new procedure to support the active phase | low |
| 3 | Supercritical Reactor Management | WP1.2 | Use of appropriate systems for continuous analysis of produts | medium |
| 4 | Anaerobic Reactor | WP1.3 | Technology already assessed | low |
| 5 | $CO_2$ hydrogenation take place with high rate at T>250°C | WP2.1 | Use of new hybrid catalysts to obtain high $CO_2$ conversion at lower temperature | Medium |
| 6 | Stability of membrane is too low and selectivity can decrease on time | WP2.2 | New preparation and stabilization procedure will be adopted | Medium |
| 7 | *Direct Olefins production from DME is a new process* | WP3.1 | Novel catalyst with appropriate structural an superficial proprieties will be investigated | low |
| 8 | *Fe based catalyst for olefins production by Fischer Tropsch process are not stable* | WP3.2 | Novel nano-sized catalysts will be developed to enhance the catalyst performance | Medium |
| 9 | *Fatty alcohols production is carried out using expensive noble metal based catalysts* | WP3.3 | New catalyst based on niobia will be developed | Low |



**Viability and feasibility of the proposal, emphasizing the relevant expertise of the partners, and the existing and requested resources (equipment, man power, etc.) - Monitoring and management of the project**

As can be deduced from the CV of the participants, the professional experience of each partner is to be considered relevant in terms of the positions held by each one in the field of national and international projects as well as quality and number of scientific papers produced.

The institutions involved are equipped with advanced instrumentation in the field of catalysis and therefore the regular performance of activity foreseen is certainly assured. Each partner participate involving researchers and technicians of high level with considerable number man-months close to 250.

As for the management of the project for each WP has appointed a responsible who regularly being held in contact with the other partners to check the progress of the work.

The coordinator will organize periodic meetings for the evaluation of results achieved. It expects to make at least 6 meetings over the 3 years.

## 9. Transnational/EU-CELAC related benefit & added value

BIORESOL will offer an extraordinary opportunity to share knowledge and experience of partners involved in the project. The recognized high scientific level of partners combined with the availability of instruments and devises of high quality is a strength point for a mutual professional growth. Certainly, attention will be focused on the exchange of researchers between laboratories and the possibility to use experimental techniques not currently available in some countries. The collaboration between partners will represent an opportunity for younger researcher to enhance the publication capacity.

The establishment of a strong partnership between the EU and ELAC partners will also represent a unique opportunity for future collaboration both for joint projects and educational activity.

## 10. Exploitation of results and -if applicable- economic impact

**Scientific and technological impact of the project, in terms of concrete applications.**

BIORESOL has as main objective the direct use of aqueous agro-industrial waste with the goal of obtaining high value added chemicals through gasification in supercritical phase and aqueous phase reforming. These are two catalytic technologies still in pre-industrialization step that require appropriate studies to overcome some technological and catalytic problems. The use of the synthesis gas, obtained from these processes, will be addressed towards the production of light olefins and higher alcohols. Olefins produced from biomass can be considered a bio-based product to reduce which will contribute to reduce the use of fossil sources. Furthermore the production of fatty alcohols, largely used in several industrial processes, will represent an interesting aspect that could have a positive impact on the economic sustainability of the global process.

As regard the catalytic processes proposed in BIORESOL, the industrial catalysts currently commercially available are not so active and selective for reactions proposed. Therefore, to achieve the goals foreseen new multifunctional and nano-structured catalytic systems should be developed.

Considering that the efficiency of the catalysts used in syngas conversion processes also depends on the gas composition, the use of a selective membrane system for hydrogen separation has been considered. In the overall management of the process it is important to have hydrogen to be used to modify the syngas composition to drive the catalytic reaction towards the formation of the desired products.

In order to supply energy to the different units also the possibility to integrate the process with a anaerobic digester has been also considered.

*In general, it is believed that the project can be considered innovative because aims to use residual biomass limiting the costs of their pre-treatment by employing both novel catalytic technologies and new multifunctional and nano-structured catalysts.*

**Publications**

All partners are interested in publication of results in scientific journals.

Al Partners expect to publish at least 2 papers for each WP.

**Management of intellectual property issues**

All partners involved in BIORESOL are public institutions therefore not particular intellectual property issues other than those stated by the Terms and Conditions document provided by each ones will be considered.

*Commercial exploitation and/or impact*

Potential commercial applications comprise possible patents related to the production of new catalysts and processes.

*Implementation of project results, future strategy etc*

New equipment for catalytic tests and methodologies for the different processes investigated will be developed. The possibility of developing further research projects in this area and providing services to the community are also envisaged.

**Other valorisation potential**

- Research works by master students

- Research works by undergraduate students

- Attending to scientific conferences

## 11. Experience of participants

**National Council of Research (ITAE) [coordinator]**

**CV of Dr Francesco FRUSTERI**

-Date of Bird : 7 August 1956, Longi (ME) - Italy - -PhD in “Catalytic Technologies” – Messina University – 1985

-Degree in Industrial Chemistry – Messina University - 1982 -Senior Researcher at CNR - 1988 - Professor at Messina University since 2000

**Organisational skills and Competences :** Since several years, in the within of work activities performed at Institute of Advanced Technologies for Energy - CNR-ITAE He acts as co-ordinator of work-group involved in research activities regarding Energy and Environmental fields. *He is Responsible of several International and National research projects*. He cares both the techno-scientific and economical aspects of such projects.

He acts as Scientific Evaluator of several National and International projects.

**Technical skills and competences**

His primary interest is in heterogeneous catalysis. In particular Dr. Frusteri showed interest in kinetics evaluation of several processes, catalysts development and reactor design. He is involved in the individualisation of innovative catalytic systems adequate to overcome several technological problems of different processes.

H2 production, Fuel Cell Systems, Biofuel production are some of the main research topics of the actual interest.

He is also an expert in the use of several techniques for the bulk and surface characterisation of materials useful for catalytic processes

**Additional information** -Dr. Frusteri is involved in teaching activity in different professional courses in the environmental field. In particular He held courses of: Chemical-physical treatment of waste water; Soil pollution; Industrial plants for waste water treatment.

- Dr Frusteri was also involved in teaching activity as contract professor at Messina University. He held the following courses: - Catalytic aspects of fuel cell technology; - Energy and Environmental - Industrial Physical Chemistry

-Dr Frusteri is Referee of several International Journals in the field of catalysis: J. of Catalysis, Appl. Catalysis; J.of Power Sources, Catalysis today, etc… -He is member of the American Chemical Society.

-**The research activity of Dr. Frusteri allowed the publication of 400 papers including**: **166** papers on international journals, 2 on national journals, 4 patents, more than 220 abstracts presented at International and National Congress, chapters of Book and several scientific reports. He attended several scientific meeting as speaker, invited speaker and chairman.

**Åbo Akademi University (AAU)**

Dmitry Yu. Murzin; Born 18.05.1963, Moscow

**Degrees:Dr.Sc.**, Physical chemistry, 26.4. 1999, Karpov Institute of Physical Chemistry, Moscow, Russia;

**Ph.D.**, Physical chemistry, 29.5. 1989, Karpov Institute of Physical Chemistry, Moscow, Russia (advisor Prof. M.I. Temkin); **Dipl. Eng.** (M.Sc. Chem. Eng.) 14.2.1986 (with honors, GPA 5.0/5.0), Faculty of Chemical Engineering (1980-1986) (major - Chemistry and Technology in Organic Synthesis) D.I. Mendeleev Moscow Institute of Chemical Technology, Moscow, Russia

**Appointments -** August 2000 - Professor in Chemical Technology, Laboratory of Industrial Chemistry and Reaction Engineering, Faculty of Chemical Engineering,Åbo Akademi University, Turku, Finland; 1999 – July 2000 Head, Chemicals Division, BASF Rus GmbH, Moscow, Russia; 1996-1998 Senior scientific researcher - technical expert, BASF Rus GmbH, Moscow, Russia; 1991-1996 (from 1992 on leave) Senior scientific researcher, Department of Catalysis, Karpov Institute of Physical Chemistry, Moscow, Russia; 1989-1991.

**Other activities/membership -** *Chairman* of the organizing committee of “Europacat VIII” congress (2007); Representative of Finland in European Federation of Catalysis Societies (2007-2011); Vice –president, European Federation of Catalysis Societies (2009-2013); *Editor*: Catalysis for Sustainable Energy; *Regional Editor for Europe*: Bulletin of Chemical Reaction Engineering and Catalysis; *Editorial board member*: Applied Catalysis. A. General (2007-2010); Bulletin of St. Petersburg State Institute of Technology

Catalysis in Industry (*Associate Editor*); Catalysis Letters (*Scientific Advisory Board*); Catalysis Today; Current Catalysis; International Journal of Chemical Engineering (*Editorial board member/Editor*); Journal of Engineering (*Editorial board member/Editor*); Kinetics and Catalysis; Russian Journal of Chemical Industry; The Open Catalysis Journal; Topics in Catalysis (*Scientific Advisory Board);* Honorary professorship, St. Petersburg State Technological Institute (technical university) (2015); Elected Member of Societas Scientiarum Fennica (2008-) Elected Member of Svenska Tekniska Vetenskapsakademien i Finland (2009-)

**Several Plenary and key-note lectures and Keynote;**

**Publications:** http://users.abo.fi/dmurzin/publications.htm

Publication statistics: https://scholar.google.com/citations?user=Apgk-ogAAAAJ&hl=en

**Relevant papers**

A. V. Kirilin, A. V. Tokarev, E. V. Murzina, L.M. Kustov, J.-P. Mikkola, D. Yu. Murzin, Reaction products and intermediates and their transformation in the aqueous phase reforming of sorbitol, *ChemSusChem* , **2010**, *3*, 708-718

A.V. Kirilin, A.V. Tokarev, L.M. Kustov, T. Salmi, J.-P. Mikkola, D.Yu. Murzin, Aqueous phase reforming of xylitol and sorbitol: comparison and influence of substrate structure, *Applied Catalysis. A. General*, **2012**, *435-436*, 172-180.'

A.V. Kirilin, B. Hasse, A.V. Tokarev, L.M. Kustov, G.N. Baeva, G.O. Bragina, A.Yu. Stakheev, A.-R. Rautio, T. Salmi, B.J.M. Etzold, J.-P. Mikkola, D.Yu. Murzin, Aqueous phase reforming of xylitol over Pt/C and Pt-CDC catalysts: catalyst characterization and catalytic performance, *Catalysis Science and Technology*, **2014**, *4*, 387-401.

A.V. Kirilin, J. Wärnå, A.V. Tokarev, D.Yu. Murzin, Kinetic modelling of sorbitol aqueous phase reforming over Pt/Al2O3, *Industrial and Engineering Chemistry Research*, **2014**, *53*, 4580-4588.

L.I. Godina, A.V. Kirilin, A.V. Tokarev, D.Yu. Murzin, Aqueous phase reforming of industrially relevant sugar alcohols with different chirality, *ACS Catalysis*, **2015,** *5*, 2989-3005.

**Unapec, University (Biotherm)**

**Dr. Engineer William Ernesto Camilo Reynoso, PhD.**

• Doctor in computer engineering concentration in systems (GIS) geographic information and geomatics, Universidad Pontificia de Salamanca (UPSA), Spain. • Dean of engineering and computer science, Universidad APEC 2010-2015.

• Chair / VP of the Council of Deans of the Caribbean, and Board member of LACCEI, 2012-2015. • Coordinator at the Centre for research in high-tech Crea of the Instituto Tecnológico de Las Américas ITLA, systems for geomatics, mechatronic systems, and systems for renewable energy, 2008-2010.

• Founder member and co-ordinator of the national group (GNEESER) and the International Consortium (CIEESEHR) for energy efficiency Solar, wind, hydro, biofuels, climate change and related. • Evaluator of projects ERANet-LAC for the European Union. • Researcher in Energia Termosolar, compressed air & fuel cells to Biogas.

ABOUT 20 INDEXED ARTICLES PUBLISHED AND FEATURED IN:

The magazine The American Scientific Research Journal for Engineering, Technology and Sciences (ASRJETS), ISSN 2313-4402, USA., 2015 - The magazine MAPPING, scientific publication specializing in geomatics and Geosciences, Spain., 2015

**Instituto de Investigaciones en Catálisis y Petroquímica (INCAPE)**

**LAURA CORNAGLIA**

Member of the National Research Council – CONICET. Principal Researcher. *2012 - present.* Associate Professor**.** School of Chemical Engineering, Universidad Nacional del Litoral. *1989 – present. Teaching the following courses:* Thermodynamics for Chemical Engineers. *Post graduate courses:* Statistic Thermodynamics; Surface Characterization Techniques for Solid Materials

**Coordinator.** Postgraduation courses in Chemistry**,** School of Chemical Engineering, UNL. *2003-2010.*

Visiting Scientist. Universidad Federal do Rio de Janeiro, Brasil. Université Catholique de Louvain. Belgium - Department of Chemical Engineering, Lehigh University, USA - Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh, USA.

Visiting Assistant Professor. Department of Chemistry, University of Pittsburgh, USA. October 1994–August 1995. Prof. David Hercules. Fellowship from the University of Pittsburgh. **Research Associate**. Department of Chemical Engineering, Carnegie Mellon University, Pittsburgh, USA. September 1995November1996. Prof. Andrew Gellman.

Chemical Engineer**.** School of Chemical Engineering, Universidad Nacional del Litoral, Santa Fe, Argentina.

CURRENT RESEARCH ACTIVITIES. Projects as Principal Investigator.

-Hydrogen recovery, capture and utilization of carbon dioxide employing membranes and sorbents. ANPCyT. PICT 2014 01948. 2015- 2018. CONICET. PIP 2011- 00955. 2012- 2015.

-Hydrogen Production and carbon dioxide capture for the generation of clean energy and decrease of environmental pollution. ANPCyT. PICT 2011- 01919. 2012- 2015. - Development of Pd membranes for High Purity Hydrogen production, CONICET- NSF, USA Prof. Andrew Gellman. Carnegie Mellon University. Pittsburgh. 2008- 2009. 2011- 2012.

Joint projects: MINCYT(Argentina)FNRS( Belgium) Prof. Patricio RuizProf. Eric Gaigneaux (2009-2015).

Supervisor of Undergraduate and Graduate Scholars - Total Undergraduate students: 21, Total Graduate students advised: 8, Doctoral theses completed: 5.

PUBLICATIONS LIST. 80 *international publications*.

PRESENTATION TO NATIONAL CONGRESS: Total 131. INTERNATIONAL MEETINGS: Total 90.

MEMBER OF THE EDITORIAL BOARD. Applied Catalysis A General, April 2009 present.

**Universidad de Concepcion (UdeC)**

**ALEJANDRO KARELOVIC**

The chilean partner is the Laboratory of Carbon and Catalysis (CarboCat) of the University of Concepción. The group leader is professor Alejandro Karelovic, PhD. Professor Karelovic obtained a PhD in Heterogeneous Catalysis at the Université catholique de Louvain (Belgium) in 2013 and later obtained an assistant professor post at the Chemical Engineering Department of the University of Concepción where currently works. Professor Karelovic research field correspond to gas phase heterogeneous catalysis focusing on hydrogenation reactions for solving energy and environmental problems and also on the tailored preparation of materials for these applications. He is the author of 14 peer-reviewed articles all in high-impact journals and 1 book chapter.

Some of the most relevant publications in the last five years are the following:

*Kinetic and in-situ FTIR study of CO methanation on a Rh/Al2O3 catalyst.* Mauricio Escobar, Francisco Gracia, Alejandro Karelovic and Romel Jiménez, **Catalysis Science & Technology** 5 (2015) 4532-4541.

*The role of copper particle size in low pressure methanol synthesis via CO2 hydrogenation over Cu/ZnO catalysts.* Alejandro Karelovic, Patricio Ruiz. **Catalysis Science & Technology** 5 (2015) 869-881.

*Improving the hydrogenation function of Pd/γ-Al2O3 catalyst by Rh/γ-Al2O3 addition in CO2 methanation at low temperature,* Alejandro Karelovic, Patricio Ruiz*,* **ACS Catalysis**, 3 (2013) 2799–2812.

*Mechanistic study of low temperature CO2 methanation over Rh/TiO2 catalysts*, Alejandro Karelovic, Patricio Ruiz, **Journal of Catalysis**, 301 (2013) 141-153.

*CO2 hydrogenation at low temperature over Rh/γ-Al2O3 catalysts: Effect of the metal particle size on catalytic performances and reaction mechanism,* Alejandro Karelovic, Patricio Ruiz, **Applied Catalysis B: Environmental**, 113-114 (2012) 237-249.



**Federal University of Rio de Janeiro (UFRJ)**

**DONATO ARANDA**

Donato Aranda; Born 05.03.1967, Rio de Janeiro

Degrees:Dr.Sc., Chemical Engineering, 1995 Federal University of Rio de Janeiro, Brazil; Dipl. Eng. (M.Sc. Chem. Eng.) 1992 Federal University of Rio de Janeiro, Brazil;, Faculty of Chemical Engineering (1985-1989) Federal University of Rio de Janeiro, Brazil.

Appointments 1997 - Professor in Chemical Engineering, Federal University of Rio de Janeiro, Coordinator of Green Technology Lab and PROCAT, Catalysis Pilot Plant , Brazil. 1995-1997 Professor at Physical Chemistry Department, Federal Fluminense University - Niteroi - Brazil.

Part- Time Jobs 2009-2016 Technical Consultant at UBRABIO - Brazilian Biodiesel and Biojet Association - Brasilia - Brazil

Postdoctoral experience: 1995-1996 Worcester Polytechnic Institute - USA.

Publications: http://buscatextual.cnpq.br/buscatextual/visualizacv.do?id=K4782979A3&idiomaExibicao=2

About 500 papers, 115 papers in international periodicals, 18 patents

**Publication statistics**: https://scholar.google.com/citations?user=tIUxs58AAAAJ&hl=en

**Relevant papers**:

Fuel (Guildford) v. 155, p. 144-154, 2015.

Renewable & Sustainable Energy Reviews, v. 50, p. 1013-1020, 2015.

Industrial & Engineering Chemistry Research, v. 50, p. 10176-10184, 2011.

Fuel (Guildford), v. 89, p. 685-690, 2010.

Fuel (Guildford), v. 87, p. 2286-2295, 2008.

**Universidad Industrial de Santander (UIS)**

**Víctor Gabriel Baldovino Medrano;** Born 24.04.1979, Sincelejo

**Degrees: Ph.D.**, Chemical Engineering, Oct/2009, (Laurate Research project) Universidad Industrial de Santander, Bucaramanga, Colombia; **Chem. Eng.** Dec/2003 (Laurate research project), Universidad Industrial de Santander, Bucaramanga, Colombia.

**Appointments -** February 2016 - Director of Laboratorio de Ciencia de Superficies (SurfLab), Universidad Industrial de Santander, Bucaramanga, Colombia; November 2015 - Director of Centro de Investigaciones en Catálisis (CICAT), Universidad Industrial de Santander, Bucaramanga, Colombia; September 2014 - Auxiliary Professor, Escuela de Ingeniería Química, Facultad de Ingenierías Fisicoquímicas, Universidad Industrial de Santander, Bucarmanga, Colombia; October 2013 - August 2014 Chargé de recherches, Molecules, Solids and Reactivity (MOST), Institute of Condensed Matter and Nanosciences (IMCN), Faculté d'Agronomie, Université catholique de Louvain, Louvain-la-Neuve, Belgium.

**Postdoctoral experience:** 2009-2014, Molecules, Solids and Reactivity (MOST), Institute of Condensed Matter and Nanosciences (IMCN), Faculté d'Agronomie, Université catholique de Louvain, Louvain-la-Neuve, Belgium.

**Other activities/membership**

*Chairman* of the organizing committee of "1st Colombian Seminar on Surface Science (CSSS)" seminar (2015).

Publication list and statistics: https://scholar.google.com.co/citations?user=kHbLBHkAAAAJ&hl=en

Relevant papers

V.G. Baldovino-Medrano, G. Pollefeyt, V. Bliznuk, I. Van Driessche, E.M. Gaigneaux, P. Ruiz, R. Wojcieszak, Synergetic Behavior of TiO2-Supported Pd(z)Pt(1−z) Catalysts in the Green Synthesis of Methyl Formate, *ChemCatChem*, **2016**, DOI: 10.1002/cctc.201501211

J.R. Restrepo-Garcia, V.G. Baldovino-Medrano, S.A. Giraldo, Improving the selectivity in hydrocracking of phenanthrene over mesoporous Al-SBA-15 based Fe–W catalysts by enhancing mesoporosity and acidity, *Applied Catalysis A: General,* **2016**, 510, 98. DOI: 10.1016/j.apcata.2015.10.051

E.M. Morales-Valencia, V.G. Baldovino-Medrano, S.A. Giraldo, Reactivity of olefins and inhibition effect on the hydrodesulfurization of a model FCC naphtha, *Fuel*, **2015**, 153, 294. DOI: 10.1016/j.fuel.2015.03.003

V.G. Baldovino-Medrano, C. Alcázar, MT.. Colomer, R. Moreno,E.M. Gaigneaux, Understanding the molecular basics behind catalyst shaping: Preparation of suspensions of vanadium–aluminum mixed (hydr)oxides, *Applied Catalysis A: General,* **2013**, 468, 190. DOI: 10.1016/j.apcata.2013.08.041.

V.G. Baldovino-Medrano, B. Farin, E.M. Gaigneaux, Establishing the Role of Graphite as a Shaping Agent of Vanadium–Aluminum Mixed (Hydr)oxides and Their Physicochemical Properties and Catalytic Functionalities, *ACS Catalysis* **2012**, 3, 322.DOI: 10.1021/cs200465h

## 12. Main facilities and Equipment

**ITAE – Italy -** ITAE is provided with several devises both for testing and characterization of materials. In this project lab plants suitable for catalytic testing in gas and liquid phase will be used. In particular fixed bed and batch reactors operating at high temperature and pressure will be used. Characterization of material will be performed by TEM-EDAX, SEM-EDAX, XRD, XPS, BET, TGA-DSC, TPR, TPO, TPD, FTIR and others.

**AAU - Finland** AAU provides discontinuous and continuous experimental rigs for the aqueous phase reforming as well as knowledge on biomass pretreatment, fractionation, analysis and analytical infrastructure related to APR (GC, HPLC, GC-MS procedures). Micro GC, GCMS and HPLC with sugar and acid columns will be available for the project.

**INCAPE – Argentina -** XPS, ISS, Auger Electron Spectroscopy (AES), FTIR, XRD, TPR, DSC-TGA and Operando Raman-FTIR spectroscopies. SEM, AFM and TEM are also available in other centers. Reaction and gas permeation flow systems are installed in the labs. They are connected to GC and also to mass spectrometers to analyze gas compositions.

**BIOTHEM – Rep. Dom.** Anaerobic Digester – Analitical instruments **CICAT-UIS – Colombia -** CICAT-UIS has direct access to the following equipments. -XPS/ISS/UVS surface characterization platform. -3Flex machine for measuring adsorption isotherms (chemi-and physisorption). -FTIR instrument provided with ATR. -Catatests for reaction experiments.

**UDEC- Chile - R**eactor setups, adsorption equipment, in situ FTIR/DRIFTS, TGA-MS - (TEM and SEM) and X-ray diffraction.

**UFRJ – Brasil -** Our facilities include 20 high pressure reactors, ovens, spray dryer (400 kg/h) and advanced heterogeneous catalyst characterization equipments like surface area, XRD, FRX, TEM, GC, GC-MS, powder size distribution. We have also a complete biofuel characterization laboratory.

## 13. Status of Consortium Agreement

**State of Consortium**

The consortium is composed by 7 partners, 2 from European part and 5 from LAC. Dr Frusteri from ITAE institute will coordinate the project. In the Figure 3 ( see Annex) is shown the structure of Consortium. Essentially the project is built along 3 main research lines. For each research line there is a person in charge that will follow the scientific activity of single WP having care to establish a collaborative network with other person in charge.

In general, the experience of the partners is primarily in industrial catalysis, and each of them has a strong expertise in the specific area where they are involved, as demonstrated by the scientific publications reported in their CV.

The consortium is well balanced and qualified and each institution is provided with instruments and devices of high level that will constitute a solid bases to achieve the goals foreseen.

**The Consortium Agreement is in progress and it will be signed within 6 months from the submission of project**

**The Partner from Chile asked to attach a documet (see Fig.4 - Annex section)**

## 14. Related proposals submitted to other funding agencies

No proposals

## Annex

**Title: Novel Catalytic Approaches for Olefin and Alcohols Production from Residual Biomass by CO2 Conversion**

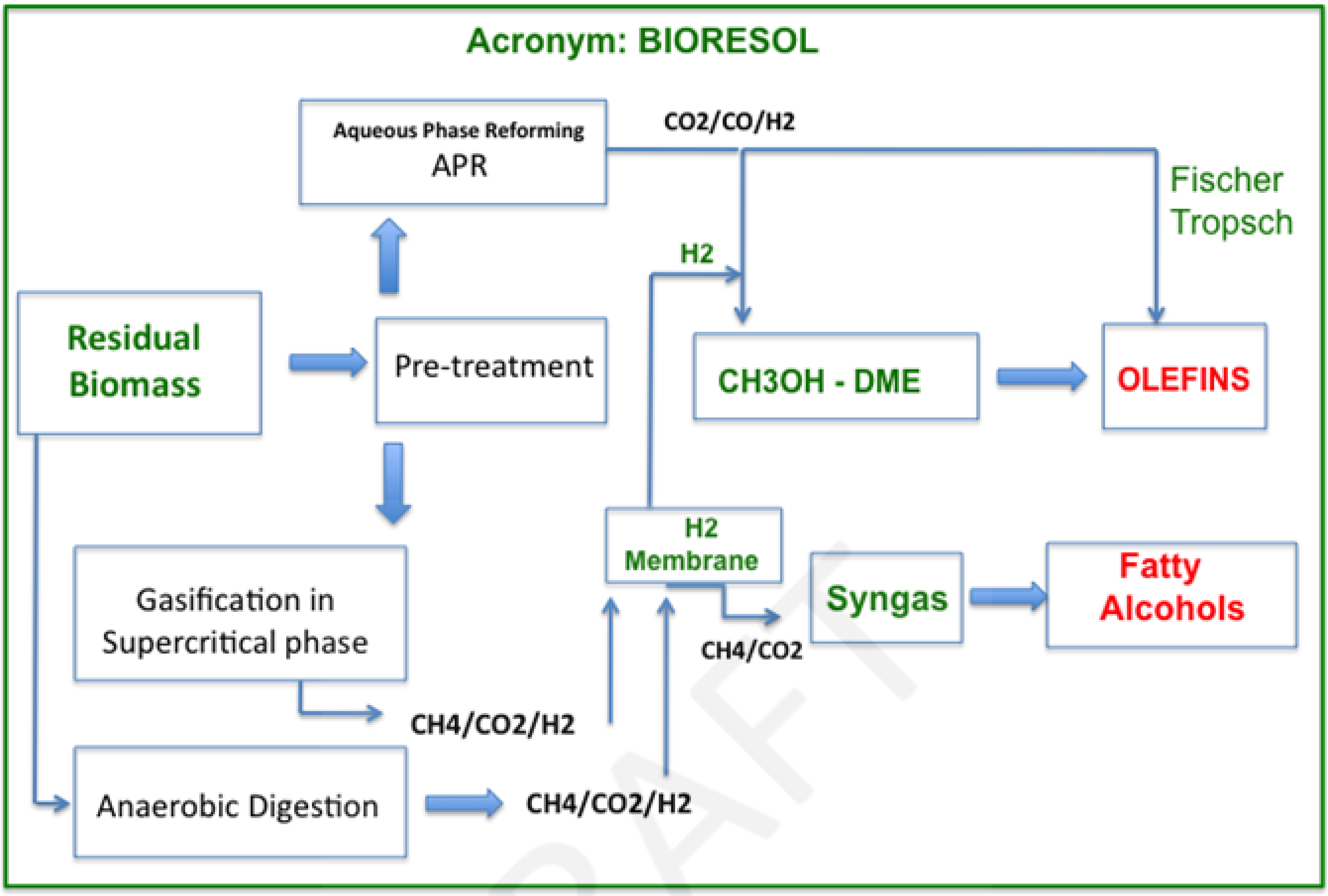


**Fig. 1. BIORESOL flowsheet.**

| ACRONYM: BIORESOL / PROJECT CALL: ERANET-LaC2 | TOTAL EFFORT | CNR-ITAE - ITALY | AAU - FINLAND | UdeC - CHILE | INCAPE - ARGENTINA | UFRJ - BRASILE | UIS - COLOMBIA | BIOTHERM - DOMINICAN REP. |
|---|---|---|---|---|---|---|---|---|
| | 255 | 24 | 39 | 36 | 12 | 36 | 36 | 72 |
| **Workpackage 1: Residual biomass treatment** | 125 | 14 | 39 | 0 | 0 | 0 | 0 | 72 |
| ***WP 1.1: Aqueous Phase Reforming (APR)*** | 39 | | 39 | | | | | |
| *T1.1.1 Catalyst preparation and characterization* | | | 13 | | | | | |
| *T1.1.2 Catalytic testing & effect of experimental conditions* | | | 13 | | | | | |
| *T1.1.3 Catalyst optimization* | | | 13 | | | | | |
| ***WP 1.2: Gasification in supercritical phase (SWG)*** | 14 | 14 | | | | | | |
| *T1.2.1 Preparation of novel structured catalysts* | | 6 | | | | | | |
| *T1.2.2 Realization of a continuous PFR for SWG* | | 3 | | | | | | |
| *T1.2.3 Characterization and testing of catalysts* | | 5 | | | | | | |
| ***WP 1.3: Anaerobic digestion*** | 72 | | | | | | | 72 |
| *T1.3.1 Design of a digester operating in continuous mode* | | | | | | | | 36 |
| *T1.3.2 Study of operative parameters on the outlet stream* | | | | | | | | 36 |
| **Workpackage 2: Syngas Conversion and $H_2$ separation** | 22 | 10 | 0 | 0 | 12 | 0 | 0 | 0 |
| ***WP 2.1: Direct DME production from $CO_2$-rich syngas*** | 10 | 10 | | | | | | |
| *T2.1.1 Development of multifunctional catalysts* | | 4 | | | | | | |
| *T2.1.2 Characterization and testing in PFR conditions* | | 4 | | | | | | |
| *T2.1.3 Influence of dopants on DME productivity* | | 2 | | | | | | |
| ***WP 2.2: Membrane technology for hydrogen separation*** | 12 | | | | 12 | | | |
| *T2.2.1 Preparation of Pt and Pd alloy based films* | | | | | 7 | | | |
| *T2.2.2 Permeability study in real conditions* | | | | | 5 | | | |
| **Workpackage 3: Olefins and fatty alcohols production from syngas and oxygenates** | 108 | 0 | 0 | 36 | 0 | 36 | 36 | 0 |
| ***WP 3.1: Direct Olefins production*** | 36 | | | | | | 36 | |
| *T3.1.1 Synthesis of ZSM-5 or SAPO based catalysts* | | | | | | | 12 | |
| *T3.1.2 Characterization and testing in MTO/DMO* | | | | | | | 18 | |
| *T3.1.3 Doping with alkali and rare earths* | | | | | | | 6 | |
| ***WP 3.2: Olefins production by Fischer-Tropsch process*** | 36 | | | 36 | | | | |
| *T3.2.1 Preparation of Fe nanoparticles* | | | | 12 | | | | |
| *T3.2.2 Effect of the preparation method on particle size* | | | | 12 | | | | |
| *T3.2.3 Influence of promoters on kinetics* | | | | 12 | | | | |
| ***WP 3.3: Fatty alcohols production*** | 36 | | | | | 36 | | |
| *T3.3.1 Synthesis of catalysts supported on mixed oxides* | | | | | | 18 | | |
| *T3.3.2 Catalytic test using $CO/H_2$ feed* | | | | | | 18 | | |

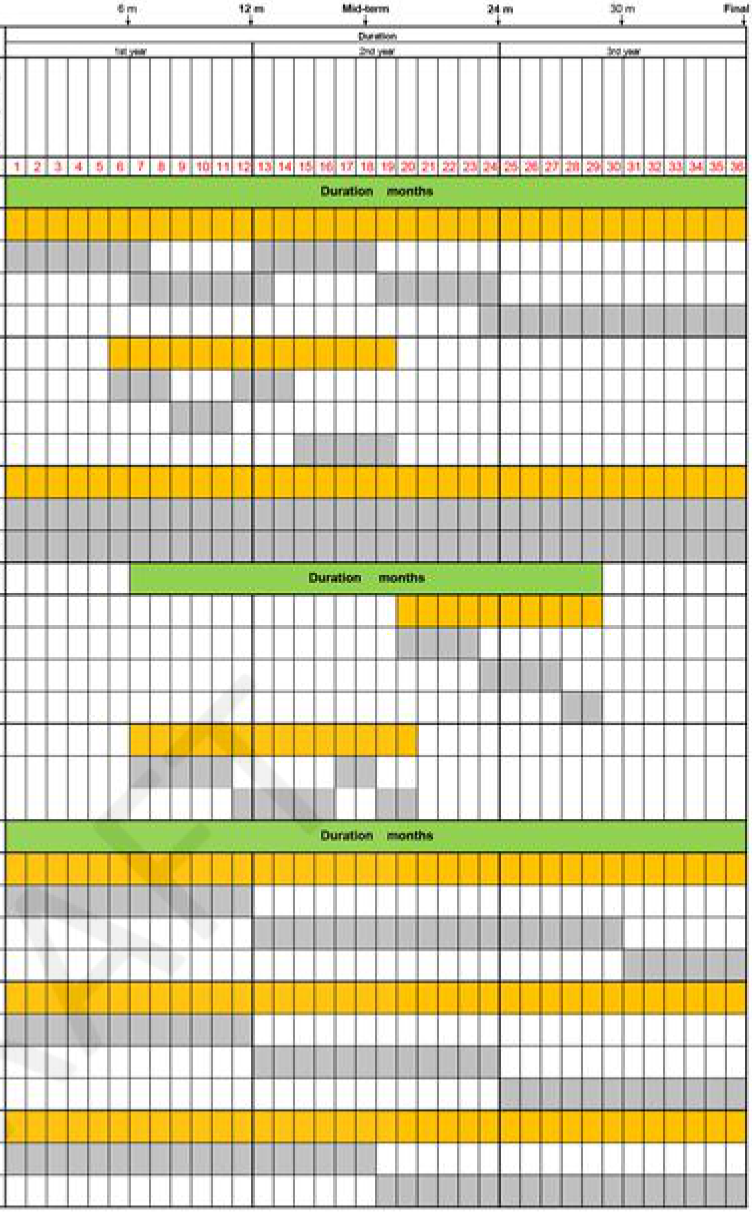


**Fig. 2. GANTT of the project.**

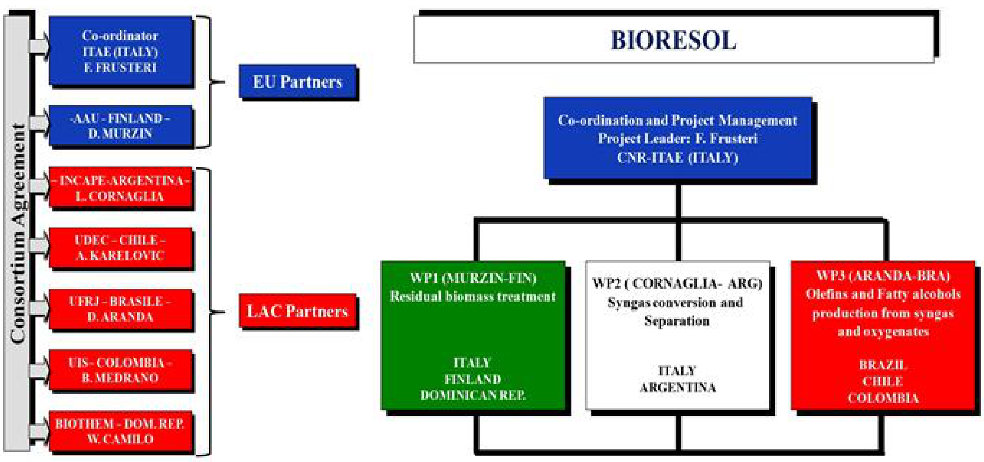


**Fig. 3. Consortium and WPs leaders.**

UNIVERSIDAD DE CONCEPCION

COMPROMISO INSTITUCIONAL

UNIVERSIDAD DE CONCEPCION en el marco del Segundo Concurso ERANET LAC para investigación conjunta e Innovación-Conicyt, se compromete a apoyar en calidad de institución socia en Chile el proyecto, cuyo acrónimo es BIORESOL, que se titula **"Novel catalytic approaches for olefin and alcohols production from residual biomass by $CO_2$ conversion"** y cuyo investigador responsable institucional es el Dr. Alejandro Karelovic Burotto, profesor del Departamento de Ingeniería Química de la Facultad de ingeniería.

El alcance de este compromiso cubre aquellos aspectos de destinación temporal de académicos y otro personal; el empleo y acceso a equipos, instrumentos e instalaciones; el uso de la infraestructura física y otras instalaciones de las que dispone la Institución, de acuerdo con las especificaciones detalladas en el presente proyecto.

Asimismo, la Institución brindará las facilidades que sean necesarias para el cabal cumplimiento de los objetivos del presente proyecto y tomará todas las medidas necesarias para el fiel uso de los recursos que en razón de este proyecto le serán asignados.

SERGIO LAVANCHY M.
RECTOR

Marzo 2016

**Fig. 4. Commitment letter from UdeC to CONICYT (Chile).**