Biolas Project

A project financed by:

EEA Grants

ICELAND
LIECHTENSTEIN
NORWAY

Ministerio de Economía y Competitividad

CDTI Centro para el Desarrollo Tecnológico Industrial

CEPSA
Title: Synthesis of BIO-surfactants obtained from vegetable oil using more efficient processes. (IDI – 20140104)

Objective: Alternative production of Linear Alkylbenzene Sulfonate (LAS) from vegetable oil and improvement of the energy efficiency of the process.

Partnerships:
- CEPSA (Coordinator of the project)
- CIPR Bergen
- University of Oslo
- ICP-CSIC

Financed by:
- EEA Grants

BioLAS Project
A.1. BIOPARAFFINS PRODUCTION

A.2. BIOSURFACTANTS PRODUCTION

A.3. SYNTHESIS of NEW CATALYSTS

A.4. PERFORMANCE OF BIOLAS

A.5. ENVIRONMENTAL IMPACT ASSESSMENT

Conclusion

Divulgation & Dissemination
A1. BIOPARAFFINS PRODUCTION

1. Selection of vegetable oil
2. Pilot plant testing
3. Production

Vegetable oil + diluent + H₂ → T, P → Hydro treatment → Bioparaffins

Source: www.palmoilindia.com

Catalyst NiMo and CoMo
A2. BIOSURFACTANTS PRODUCTION

Bio n-paraffins → Production Process → Bio LAS (Linear Alkylbenzene sulphonate)

CEPSA
A2. BIOSURFACTANTS PRODUCTION

Bio n-paraffins → PACOL® → DEFINE® → DETAL® → DISTILLATION → Bio LAB

Bio LAB → SULPHONATION → Bio LAS
A2. BIOSURFACTANTS PRODUCTION

PACOL®: Paraffins dehydrogenation

\[ \text{n-paraffins} \xrightarrow{-H_2} \text{n-mono-olefins} \]

The PACOL process (Paraffin Conversion to Olefins) is a catalytic dehydrogenation Process which produces a mix of olefins and a non dehydrogenated paraffins.
A2. BIOSURFACTANTS PRODUCTION

**DEFINE®**: Di-olefins hydrogenation

\[ n\text{-diolefin} + H_2 \rightarrow n\text{-mono-olefin} \]

The DeFine process is a liquid phase, selective hydrogenation of di-olefins (impurities formed in PACOL® reactor) to their corresponding mono-olefins.
A2. BIOSURFACTANTS PRODUCTION

The DETAL® process is a heterogeneous reaction that involves the alkylation of benzene with mono-olefins over a zeolitic catalyst. The product obtained are the linear alkylbenzenes (LAB).
A2. BIOSURFACTANTS PRODUCTION

Bio n-paraffins → PACOL® → DEFINE® → DETAL® → DISTILLATION → Bio LAB

Bio LAB → SULPHONATION → Bio LAS

Distillation (Purification process)

Crude LAB → BENZENE → Paraffins

LAB

Heavy alkylate
Sulphonation is an electrophilic aromatic substitution reaction. After this reaction, the molecules formed are neutralized and the linear alkylbenzene sulphonate (LAS) is obtained.
SCOPE: Development of a new optimized catalysts. Improvement of the energy efficiency of the process by increasing the catalyst stability.
Preparation of new catalysts to improve their catalytic performance:

ACHIEVEMENTS:
✓ Enhance of the stability of zeolitic catalysts.
✓ Slight modulation of selectivity to the desired LABs isomer.
✓ Slight inhibition of production of non-desired products.

Activities and Partners

Activity 3.1.: Preparation of new catalysts to improve their catalytic performance:

Activity 3.2.: Control of coke production to avoid frequent regenerations in the industrial process. Study of new regeneration procedures:

BioLAS Project
A4. PERFORMANCE OF BIOLAS

SURFACTANT

Detergency (Laundry)  Enhanced Oil Recovery (EOR)

European collaboration:
CIPR (Bergen)
**Surfactant**: amphiphilic substances that lower the interfacial tension

*Tail Group*  
Lipophilic  
Hydrophobic

*Head Group*  
Hydrophilic  
Lipophilic

**Affinity for oil**

**Affinity for water**
A4. PERFORMANCE OF BIOLAS

Detergency: washing clothes

Evaluation of BioLAS in terms of:

- Critical micelle concentration
- Krafft Temperature
- Foam formation
- Efficiency versus different stains
A4. PERFORMANCE OF BIOLAS

Detergency: washing clothes

Evaluation of BioLAS in terms of:

Critical micelle concentration

Minimum concentration of surfactant required to form micelles and remove the stains
A4. PERFORMANCE OF BIOLAS

Detergency: washing clothes

Evaluation of BioLAS in terms of:

Krafft Temperature

Minimum temperature required to provide a proper efficiency of the surfactant and avoid its precipitation
A4. PERFORMANCE OF BIOLAS

Detergency: washing clothes

Evaluation of BioLAS in terms of:

Foam formation

Height of formed foam in both static and dynamic washing systems
A4. PERFORMANCE OF BIOLAS

Detergency: washing clothes

Evaluation of BioLAS in terms of:

**Efficiency in different stains**

The biosurfactant is tested against different types of stains: grass, soil, wine, oil, lipstick...
A4. PERFORMANCE OF BIOLAS

EOR: washing rocks

Evaluation of BioLAS in terms of:

- Formulation’s compatibility
- Interfacial tension
- Phase behavior
- Core flooding

European collaboration: CIPR (Bergen)
EOR: washing rocks

Evaluation of BioLAS in terms of:

Formulation’s compatibility

BioLAS is the main ingredient of a specific-task formulation to improve oil recovery. The selected formulation must be compatible and stable under the field conditions.
A4. PERFORMANCE OF BIOLAS

EOR: washing rocks

Evaluation of BioLAS in terms of:

- Interfacial tension

European collaboration: CIPR (Bergen)

The interfacial tension between the BioLAS formulation and the crude oil is measured, looking for a minimum value that will ensure an efficient oil recovery.

![Graph showing interfacial tension (IFT) vs. NaCl concentration (g/L)]
A4. PERFORMANCE OF BIOLAS

EOR: washing rocks

Evaluation of BioLAS in terms of:

European collaboration: CIPR (Bergen)

Phase behavior

The behavior of the different phases involved in the thermodynamic equilibrium is analysed in order to obtain the best EOR performance.
A4. PERFORMANCE OF BIOLAS

EOR: washing rocks

Evaluation of BioLAS in terms of:

- Core flooding experiments

European collaboration: CIPR (Bergen)

The designed formulation containing BioLAS is tested for the recovery of oil in real cores under pressure and temperature conditions.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)
A5. BIOLAS' ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

- Life Cycle
- Life Cycle Assessment
- Life Cycle Inventory
- Life Cycle Impact Assessment
A unit operations view of consecutive and linked stages of a product system, from raw material acquisition (or generation from natural resources) to final disposal. This includes all materials and energy input as well as waste generated to air, land and water.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

Life Cycle Assessment: Environmental Impacts

- Global Warming Potential (GWP)
- Acidification Potential (AP)
- Ozone Depletion Potential (ODP)
- Eutrophication Potential (EP)
- Photochemical Ozone Creation Potential (POCP)
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

**Global Warming Potential (GWP)**

**GWP**: A measure of greenhouse gas emissions, such as CO2 and methane. These emissions are causing an increase in the absorption of radiation emitted, increasing the natural greenhouse effect. This may in turn have adverse impacts on ecosystem health, human health and material welfare.
Eutrophication covers all potential impacts of excessively high levels of macronutrients, the most important of which nitrogen (N) and phosphorus (P). Nutrient enrichment may cause an undesirable shift in species composition and elevated biomass production in both aquatic and terrestrial ecosystems.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

Life Cycle Assessment: Environmental Impacts

**Acidification Potential (AP)**

**AP**: A measure of emissions that cause acidifying effects to the environment. The acidification potential is a measure of a molecule’s capacity to increase the hydrogen ion (H+) concentration in the presence of water, thus decreasing the pH value. Potential effects include fish mortality, forest decline and the deterioration of building.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

**Life Cycle Analysis (LCA)**

**Photochemical Ozone Creation Potential (POCP)**

**POCP**: A measure of the emissions of precursors that contribute to increase the formation of smog at ground level (mainly ozone, O3), produced by the reaction of VOC and carbon monoxide in the presence of nitrogen oxides under the influence of UV light. Ground level ozone may be injurious to human health and ecosystems and may also damage crops.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

Life Cycle Assessment: Environmental Impacts

Ozone Depletion Potential (ODP): A measure of air emissions that contribute to the depletion of the stratospheric ozone layer. Depletion of the ozone leads to higher levels of UVB ultraviolet rays reaching the earth’s surface with detrimental effects on humans and plants.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

Life Cycle Inventory

Phase of Life Cycle Assessment involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.
A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION

Life Cycle Analysis (LCA)

Life Cycle Impact assessment

Phase of Life Cycle Assessment aimed at understanding and evaluating the magnitude and significance of the potential environmental impacts for a product system throughout the life cycle of the product.
CONCLUSIONS

A1. BIOPARAFFINS PRODUCTION
- Oil selection
- Process variables study & optimization
- Products characterization
- Paraffins production

A2. BIOSURFACTANTS PRODUCTION
- Distillation study
- Olefins production & purification
- Olefins alkylation. BioLAB obtaining
- Sulfonation. BioLAS obtaining
- Commercial zeolites evaluation
- Synthesis of zeolites
- Catalysts screening
- Laboratory & pilot plant scale tests
- Catalyst optimization
- BioLAS detergency range evaluation
- BioLAS EOR range static evaluation
- BioLAS EOR range dynamic evaluation

A3. SYNTHESIS OF NEW CATALYSTS
- BioLAS Life Cycle Assessment
- BioLAS Life Cycle Inventory
- BioLAS Life Cycle Impact assessment

A5. BIOLAS’ ENVIRONMENTAL IMPACT EVALUATION
Divulgation & Dissemination

Publications

SECAT’15
Barcelona, 13-15 Julio 2015

Catálisis, confluencia interdisciplinar:
modelos, catalizadores y reactores

ESTUDIO DE CATALIZADORES PARA LA REACCIÓN DE
ALQUILACIÓN DE BENCENO

MODIFICATION OF COMMERCIAL ZEOLITES TO IMPROVE THEIR
CATALYTIC PERFORMANCE IN THE ALKYLYATION OF BENZENE