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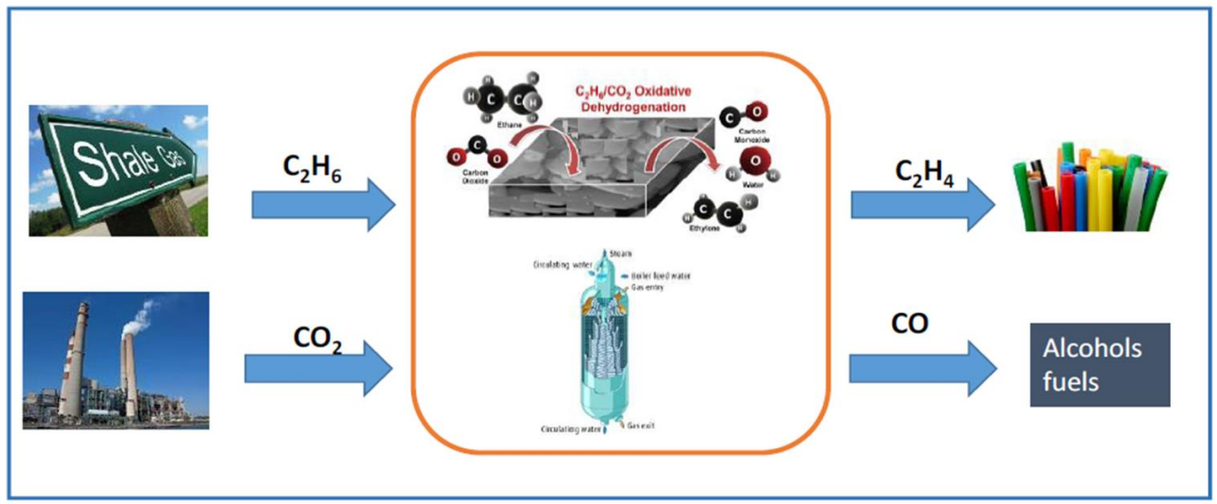
Hellenic Foundation for Research & Innovation

Description of the funded research project

1st Call for H.F.R.I. Research Projects to Support Faculty Members & Researchers and Procure High-Value Research Equipment

Title of the research project: **Exploring New Processes for CO_2 Utilization: CO_2-assisted Dehydrogenation of Ethane**



Principal Investigator: **Prof. Angeliki Lemonidou**

Reader-friendly title: **CUDET**

Scientific Area: **Engineering Sciences and Technology**

Institution and Country: **Aristotle University of Thessaloniki, Greece**

Host Institution: **Aristotle University of Thessaloniki**

Collaborating Institution(s): **CERTH, Technical University of Munich**

Project webpage: **http://lpt.cheng.auth.gr/en/node/37**
https://www.linkedin.com/in/cudet-project-auth-7178991a4/

PI

Post-Doc

PhD student

Budget: **187640,92 €**

Duration: **36 months**

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The use of fossil fuels in industry, transport and energy production releases huge amounts of carbon as CO_2 to the atmosphere. In order to achieve **global warming mitigation**, it is essential to capture CO_2 from large stationary emission sources, such as power plants and other energy intensive industries, and in the context of **circular economy** to re-use it as carbon feedstock.

The aim of the CUDET project, supported by **Hellenic Foundation Research & Innovation** (HFRI-FM17-1899), is to develop a new process for ethylene production via dehydrogenation of ethane assisted by **CO_2, acting as a mild oxidant.** By developing active and selective catalysts it will be possible to produce ethylene at relatively low temperatures and high yield and simultaneously convert CO_2 almost exclusively to high added value CO. The potential to employ two underutilized reactants to supply ethylene and CO, as well as to mitigate detrimental CO_2 emissions, can be highly rewarding though challenging.

The well-structured methodology of CUDET project is based on **three pillars** (catalyst synthesis, characterization/mechanism and reaction engineering) which are highly interrelated and integral part of the project constitute novel approach and will contribute to the fulfillment of scientific and technical objectives.

Key to the successful development of the new process is the **catalyst**. It should be able to activate the alkane, in our case **ethane**, by abstracting H from the C-H bonds and under the same conditions to abstract O from CO_2, a molecule which is highly stable. More specifically, catalysts should be reduced by the alkane forming selectively the olefin and re-oxidized by CO_2, performing as pure Oxidative Dehydrogenation (ODH) catalysts via Mars van Krevelen mechanism. Alternatively it can act as dehydrogenation catalyst and in a cascade mode activate CO_2 with H_2 via the reverse water gas shift reaction. Emphasis in our experimental plan put on the development of **novel catalytic materials** with tailor made properties. These efforts will be complemented by advanced characterization and mechanistic studies and engineering studies so to fully explore process characteristics at lab scale.

Rational design (**novel approach**) of the catalysts will target to i) increasing the turnover frequencies ii) increasing ethylene selectivity by suppressing the dry reforming and cracking reactions iii) minimising deactivation caused by sintering of the support and the active phases and completely avoiding coke formation. The above challenges will be tackled by using advanced synthesis techniques leading to nanostructured stable entities on the surface, adding dopant to stabilize the oxidation state of the active oxide and the structure of nanospecies on the surface to avoid sintering.

On successful completion of the project, the **major scientific and technical outcomes** will include (a) composition, texture, and preparation of stable catalysts for production of ethylene and CO (b) optimized reaction conditions for the developed catalysts (including a proof of principle), (c) know-how in reaction engineering and performance under realistic industrially relevant conditions. In addition to these, the following scientific advancements are expected i) understanding the principles of preparing nano-structured multi-element oxides ii) improved understanding of the reaction pathways and the surface reactions involved iii) understanding the potential and limitations of reactor engineering concepts to improve selectivity and activity of dehydrogenation reactions.

TRL level at the end of the project is expected to be at 4, the PI and senior members will seek to exploit the outcomes of the project mostly to scale up of catalytic materials and the envisaged process in a future pilot scale project with the involvement of both the academic and industrial partners at European level in the next EU programme (FP9 - Horizon Europe).

The development of a sustainable, integrated low-cost process, for the production of hydrocarbons utilizing highly available low-cost ethane as well as waste CO_2 will in general contribute in long-term to **both economic growth and improved competitiveness** and have a positive **social impact**. This growth concerns the use and exploitation of the innovative materials (catalyst) produced through the project and, in the long-term, the new catalytic process for the production of ethylene and CO. It is expected that the cost of the produced ethylene will be lowered as another one product of high value, CO, is also produced.

The implementation of **CUDET** project would significantly further enhance the scientific excellence of the senior group members (Prof. Angeliki Lemonidou, Dr Eleni Heracleous and Prof. Johannes Lercher). On top of that **H.F.R.I** funding will offer the involved scientists the chance to **strengthen their collaboration** and acquire expertise in an area of high interest. Young researchers, one research associate (postdoc) and one PhD student will be involved in the implementation of the project. Their participation will improve their qualifications and expertise in this hot topic area and facilitate them in career development and most importantly will **contribute to stop the brain drain.**

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