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Progress in Development of Photocatalytic Processes for Synthesis of Fuels and Organic Compounds under Outdoor Solar Light

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ABSTRACT: With photovoltaics becoming a mature, commercially feasible technology, society is willing to allocate resources for developing and deploying new technologies based on using solar light. Analysis of projects supported by the European Commission in the past decade indicates exponential growth of funding to photocatalytic (PC) and photoelectrocatalytic (PEC) technologies that aim either at technology readiness levels (TRLs) TRL 1–3 or TRL > 3, with more than 75 M€ allocated from the year 2019 onward. This review provides a summary of PC and PEC processes for the synthesis of bulk commodities such as solvents and fuels, as well as chemicals for niche applications. An overview of photoreactors for photocatalysis on a larger scale is provided. The review rounds off with the summary of reactions performed at lab scale under natural outdoor solar light to illustrate conceptual opportunities offered by solar-driven chemistry beyond the reduction of CO₂ and water splitting. The authors offer their vision of the impact of this area of research on society and the economy.

1. INTRODUCTION

With the depletion of fossil fuel reserves,^{1,2} alternative sources, such as solar irradiation, grow more important not only for energy generation but also for the chemical industry, due to being essentially a cost-free and abundant power source to drive chemical transformations. A number of bulk products can be obtained by photocatalytic reaction under sunlight irradiation, such as hydrogen, syngas, methanol, formaldehyde, and formic acid.^{3,4} Nonbulk chemicals, such as pharmaceuticals, additives, and reagents, can also be obtained by means of sunlight irradiation, although the demand and economic impact for this kind of solar chemistry is much less.

Another important factor influencing the development of solar photocatalysis is the accumulation of carbon dioxide, which contributes more and more significantly to the overall carbon mass in the Earth's atmosphere. With a current average concentration in the air between 400 and 500 ppm and an overall atmospheric mass of around 3200 gigatons,⁵ CO₂ represents a growing threat to the biosphere but also an attractive carbon reservoir. Photocatalytic fixation of carbon dioxide in the form of bulk materials and solvents may contribute to the solution of this problem by decreasing the rate of production for corresponding petrochemical products, reducing the overall negative environmental impact of oil industry, and lowering atmospheric CO₂ concentration at the same time, once an efficient direct air capture (DAC) technology is developed.

Another alternative carbon source is biomass—around 146 billion metric tons are produced by plants each year,⁶ making it a widely available resource lower in price than fossil fuels and commercial carbon dioxide (liquefied CO₂ and dry ice). It also has some additional key advantages: much like products of the oil industry, it can be stored for a prolonged amount of time and provide a broad scope of chemical products.⁷ Fractionation of otherwise non-processable biomass, such as wastes of agriculture and wood processing, provides several products from cellulose and lignin decay (see Section 4.2.2 of the review for further discussion). These products can be utilized on their own as ready-to-use chemicals or may be converted into biocompatible and biodegradable polymers.

This review is focused on chemical, engineering, and economic aspects of bulk solar photocatalysis, i.e., CO₂ and biomass processing, including an overview of novel large-scale experimental and pilot-scale reactors reported in the past several years. Some proof-of-concept reports, namely, complex organic transformations under sunlight and experimental photocatalytic setups, are also covered with emphasis on more recent results and precious metal-free catalysts. The aim

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University of Galway has just published the first publication regarding NEFERTITI Project!

The article, ***“Progress in Development of Photocatalytic Processes for Synthesis of Fuels and Organic Compounds under Outdoor Solar Light”*** has been published at the “Energy & Fuels” Journal, by ACS Publications

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PARTNER: University of Galway



The project NEFERTITI has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No. 101022202



NEFERTITI participated in “Expoquimia” event



16 September 2021



Barcelona, Spain

Expoquimia is an international chemistry event with more than 15.000 visitors and 377 exhibitors which elaborates mainly on the axes of sustainability, digitalization and technology transfer.

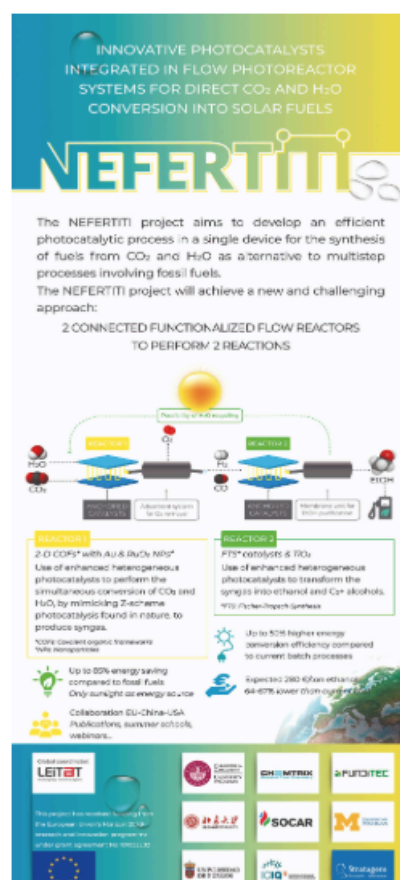
LEITAT, NEFERTITI Project's Coordinator, presented at Expoquimia the project's overview, main objectives and impact, in a presentation titled as **“Flow Chemistry Made True: Nefertiti”**.



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Communication materials are now available!



- **Communication materials developed for the NEFERTITI project, including a project leaflet and roll-up banner are now available on our website.**
- **Visit <https://projectnefertiti.eu/> to discover our communication materials and learn more about NEFERTITI's work and impact.**





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