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Highlight

Q&A with Professor Javier Bilbao

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Energy & Fuels has announced the "Pioneers in Energy Research" (PIERs) program that honors prominent scientists who have made pioneering contributions to the field of energy research.[1] Professor Javier Bilbao (University of Basque Country, Spain) has been selected as the 2021 PIER in the field of bioenergy, biofuels, and biorefinery for his outstanding contribution to the area of biomass and waste conversion.[2] Below, Professor Bilbao answers questions about his research journey and gives advice to fellow researchers.

Professor Javier Bilbao. Credit: Javier Bilbao.

1. WHAT IS YOUR SIGNATURE RESEARCH (RELATED TO THE FIELD OF ENERGY AND FUELS) AND WHAT DO YOU SEE AS ITS BIGGEST IMPACT(S) ON SOCIETY?

I have carried out my research in a large group within a university framework (University of the Basque Country, Bilbao, Spain) with the following objectives: the training of researchers, excellence, and transfer of technology to the industrial sectors related to the field of energy and fuels. The priority has followed the indicated order, but the focus has always been on the quality of the results of the three targets. The long trajectory of the group over 40 years has focused on the development of new thermochemical processes (pyrolysis, gasification, and use of catalysts) for the production of fuel and raw materials from sources alternative to fossil fuels as well as the intensification of existing processes, especially those involving the oil industry. The research lines have been framed within the research and development (R&D) platform dealing with biorefinery and waste refinery. Our results have contributed to the progress of these platforms, which are key factors for the energy transition and environmental problems associated with CO_2 emissions and the inefficient management of wastes, such as plastics and tires. The development by the group of the conical spouted bed reactor is noteworthy. The design is based on solid fluid dynamic studies, modeling of the gas and solid flow, and its application (pilot plants) in the thermochemical processes of pyrolysis and gasification of different types of biomasses and wastes (plastics, tires, and sewage sludge). The contribution by the group to the co-feeding of biomass pyrolysis (bio-oil) and waste-derived oil into refinery units is also noteworthy. Concerning my personal contribution, my most valuable scientific contributions involve knowledge and control of catalyst deactivation. All features of multidisciplinary nature related to deactivation have had my attention. Thus, I have studied its origin, mechanisms, kinetics, and consideration in the design of reactors. The proposed methodologies have been successively incorporated into all of the catalytic or thermocatalytic processes studied by the group.

2. WHAT MADE YOU INTERESTED IN AND DECIDE TO MOVE INTO DEVELOPING CATALYSTS FOR OIL AND BIOMASS REFORMING?

The group began studying catalytic processes in the oil industry 40 years ago. We then focused our attention on the use of zeolites in catalytic processes, such as fluid catalytic cracking (FCC), for the production of fuels and olefins, with the deactivation and regeneration of the catalyst being our main attention subjects. The development of the methanol-to-gasoline (MTG) process on a zeolite involved a new challenge because it meant exploring sources alternative to oil. There was a large gap in the knowledge of the fundamental aspects of these processes, such as those involving the role of the acid sites of the catalyst, effect of the properties and modifications of the catalysts, reaction mechanism, kinetic modeling, and simulation of the reactors and reactor−regenerator systems. These studies have attracted the attention of Spanish and multinational companies in the oil industry, with which our research group continues to collaborate.

The advances in the knowledge have been used later in the study of other processes on acid catalysts, with ethanol and methane (via chloromethane) as reactants, for the production of fuels and raw chemicals (olefins and aromatics). The knowledge of acid catalysts was the basis for the development

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of bifunctional catalysts, which we initially used for the hydroprocessing of petroleum side streams (pyrolysis gasoline, residue, light cycle oil, etc.).

Two decades ago, the group started applying the knowledge acquired from studies of acid and bifunctional catalysts to sustainable processes aimed at valorizing lignocellulosic biomass and wastes from consumer society (plastics, tires, and sewage sludge) for the production of fuels, raw chemicals, and hydrogen and also valorizing CO_2.

We have studied several strategies for the integration of catalytic processes into thermochemical processes in pyrolysis and gasification of biomass and wastes for the production of fuels or raw materials (olefins and aromatics) or hydrogen. This is the case of catalyst incorporation into pyrolysis and gasification reactors and the provision of in-line catalytic reactors. Thus, the production of pyrolysis oils allows for their conversion *in situ* or their incorporation into a refinery unit (FCC and hydroprocessing).

The study of the strategies for the integration of thermochemical and catalytic reactors has been conducted at the same time as the development of new catalysts (acids, based on zeolites, and bifunctional catalysts prepared with noble and transition metals on acid supports). Besides, original kinetic models (especially those based on lumps) and reactor simulation programs have also been proposed. In addition, new reactors have been developed, especially the conical spouted bed and the fluidized bed system, with continuous operation units at pilot plant scale.

In the valorization of CO_2 by hydrogenation (alone and together with syngas), the contributions of our group to the direct synthesis of dimethyl ether are remarkable. Not only have new catalysts been designed and prepared, but original kinetic models and a hydrophilic zeolite membrane reactor have also been implemented.

3. WHAT DO YOU SEE AS THE MAJOR CHALLENGES AND FUTURE DIRECTIONS OF RESEARCH ON REFORMING OIL AND BIOMASS?

The scientific and technological development of the catalytic processes for the conversion of biomass and its derivatives (bio-oil, syngas, and bioethanol) and wastes into fuels, raw chemicals, and hydrogen is worth mentioning. Thus, the challenges concerning the preparation of catalysts lie in the use of low-priced materials, the selection of simple and duplicable synthesis routes, and, especially, the manufacturing of stable and regenerable catalysts.

In line with the concepts of biorefinery and waste refinery, the incorporation of biomass and waste pyrolysis oils as alternative feeds to conventional refineries is attracting increasing attention. Thus, they may be fed into FCC units in the short term and to hydroprocessing units in the mid- and long terms, because these units are capable of treating these streams with small modifications in their operating conditions. Other initiatives concerning waste refinery are those that face the intensification in the valorization of secondary refinery streams by co-feeding them to FCC and hydroprocessing units. The research involving these initiatives has led to a variety of topics, such as the study of innovative catalysts, development of kinetic models, and reactor modifications.

The short-term viability of the sustainable production of hydrogen by the reforming of biomass, wastes, and their pyrolysis oils is also an aspect of special relevance. Indeed, it is a key process for making the concept of hydrogen economy come true during the transitional period until reaching the possibility of producing hydrogen via electrolysis from renewable electricity at a large scale.

A range of challenges also appear around the valorization of CO_2 for the production of fuels. Thus, the initiatives about new catalysts for the direct synthesis of fuels and raw chemicals from pure CO_2 and CO_2 mixed with syngas as well as the recent progress in membrane reactors are very promising. These recent routes, in which methanol or dimethyl ether are intermediate compounds, are capable of improving the results obtained with the conventional routes.

4. WHERE DID YOU GET ADVICE AND INSPIRATION THROUGHOUT YOUR CAREER?

At the time that I was a student at the University of the Basque Country, I discovered an exciting and vast area in the field of chemical reaction engineering. The academic books published at that time (those authored by Smith, Levenspiel, Satterfield, and Froment) showed me the variety of possibilities available for improving knowledge and optimizing catalytic processes. After having worked for 50 years in this field, I say that I have witnessed its richness and, especially, the capacity of catalytic processes for solving issues related to energy and the environment. Challenges that have motivated our research directions, which, in turn, are key aspects in the energy transition, include the intensification of crude oil valorization, the development of catalytic processes for the large-scale valorization of biomass and consumer society wastes, and the sustainable production of H_2 in the short term with the large-scale valorization of CO_2.

5. HOW DO YOU CHOOSE PEOPLE FOR YOUR LAB AND YOUR COLLABORATIONS?

The trademark of the research group that I lead is that the research is being carried out at the facilities of the University of the Basque Country (UPV/EHU) that pursue the training of researchers and involve students of chemical engineering, which stimulates their interest in research. Indeed, the fact that our research focuses on addressing the challenges of energy transition and climate change is crucial for attracting young students and encouraging them to join the Ph.D. program. Furthermore, the features of our publications also attract students from other universities, both national and international (especially from Ibero-America and Asia) to do Ph.D. studies with us.

Currently, international collaborations are vital for improving the quality and extent of the research work. In this context, our research group collaborates with universities from all over the world thanks to the programs funded by the European Union aimed to create collaborative networks between universities.

6. WHAT TRAINING DO YOU RECOMMEND FOR THOSE WHO WANT TO HAVE AN IMPACT IN THEIR RESEARCH FIELD? WHAT WOULD BE YOUR ADVICE TO YOUNG SCIENTISTS?

I would highlight originality, perseverance, collaboration, and consistency as the main attitudes to achieve high impact in the mid- and long terms. Originality in research is a consequence of a profound knowledge of the state of the art. Thus, detailed literature surveys will allow identifying challenges, which must be original and correctly chosen. The goals focused on the

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challenges of energy transition and climate change are key aspects to research with good funding perspectives. Within this context, chemical reaction engineering may efficiently contribute to developing processes for the valorization of biomass, wastes, and CO_2.

The main feature of any researcher lies in continuous learning and facing new challenges and tools to acquire the knowledge to design and conduct future studies. However, any issue related to chemical reaction engineering is multidisciplinary and must be approached from a global perspective. Thus, the collaboration with other research groups with complementary capacities is essential for successful studies. Nevertheless, collaboration must fulfill certain bases, including ethics and generosity, to be respectful of the intellectual property norms in different scientific cultures.

Although this is an effective way to achieving goals, the success will likely be partial and the results will have room for improvement. Therefore, continuous effort is required to revisit the initial hypothesis and improve the whole procedure or methodology. A consistent career in research being keeping active, looking for specialization, and opening new horizons. These will ensure results with long-lasting impact because they rely on the prestige and perseverance of the researcher.

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REFERENCES

(1) Wu, H. Celebrating 2021 Pioneers in Energy Research. *Energy Fuels* **2021**, DOI: 10.1021/acs.energyfuels.1c03260.
(2) Dufour, A. 2021 Pioneers in Energy Research: Javier Bilbao. *Energy Fuels* **2021**, DOI: 10.1021/acs.energyfuels.1c03309.

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