Acceptance speech

19 June 2025

Avelino Corma, awardee in the Basic Sciences category (17th edition)

It is an immense honor to receive the BBVA Foundation Frontiers of Knowledge Award in Basic Sciences, alongside my distinguished colleagues John Hartwig and Helmut Schwarz. I am deeply grateful to the Foundation for establishing these awards, which recognize not only individual careers, but also the importance of knowledge as an engine of human progress. My thanks also to the selection committee for considering catalysis a discipline worthy of this recognition.

Catalysts, whether they be molecular compounds or solid materials, have the capacity to accelerate chemical reactions and, above all, to steer them selectively towards a desired product. This selectivity is no mere technical detail: it is what makes life possible. In living beings, it is the action of enzymes, natural catalysts that evolution has perfected over millions of years, that governs the vast complexity of biochemical processes.

Enzymes have specific active sites, homogeneous and well-defined, that are capable of discriminating between competing molecules and guiding each reaction with precision. This working principle has been a constant inspiration in our research. Might we be able to emulate its efficiency in artificial catalytic systems?

Molecular catalysts, like the transition metal complexes or organocatalysts on which Professor Harwig has worked so successfully, can be made to function analogously to enzymes: their active metal centers are also well-defined, uniform, and can be electronically and geometrically modified depending on the choice of ligands. However in the realm of heterogeneous catalysis, which is the focus of our work, we have to deal with other kinds of problems. Solid catalysts tend to have irregular surfaces, with active sites that are difficult to pinpoint or evenly distribute. Further, their structural rigidity places constraints on the design of their electronic and geometric environment, making it harder to control the adsorption of reagents or the stabilization of the transition state. These constraints led us to explore new avenues which I will try to briefly describe here.

Our response to the above problems was to synthesize solid catalysts based on crystalline, nanoporous materials comprising a network of pores and

cavities of a size comparable to that of the reacting molecules. These materials allow us to insert specific catalytic sites and, at the same time, select which molecules can access them, based on their size and shape, giving us control not only over reactivity but selectivity as well. Also, with the right design of cavity size and geometry, it is possible to discriminate between transition states and thereby optimize process efficiency. Having this degree of control means we can advance towards a more sustainable chemistry, aligned with the energy and environmental goals of our time.

Advances in computational chemistry, nanomaterial synthesis and the characterization of reacting systems have been decisive enablers for our research. With their aid, we can now insert acid, basic or metallic active sites, be they single atoms or subnanometric clusters, at predefined positions within the zeolite's crystal structure. And we have also developed multifunctional catalysts able to perform cascade reactions, bringing us closer to the goal of an efficient, clean chemistry.

One major achievement has been the advances made in the ab initio design of zeolites tailored for a specific reaction. This is done by employing molecular self-assembly strategies that use transition state mimics as organizing agents. With this method, we have managed to synthesize over 70 novel zeolitic structures and develop catalysts that are now being applied in over 75 industrial plants worldwide.

All this work has been informed by a simple, but profound philosophy: "understand to design, and design to apply." Because we believe that knowledge should be useful, but also rigorous; that it should serve society without relinquishing the beauty of understanding.

I would like to express my sincerest thanks to the doctoral and postdoctoral students and the colleagues who have been an essential part of this scientific journey. This award is as much yours as it is mine. I am also grateful for the support of the Spanish National Research Council, the Universitat Politècnica de València, the European Union and the many companies who have believed in our proposals.

Finally, I wish to pay a personal and private tribute. None of this would have been possible without the patience, encouragement and unconditional love of my wife Brisa and our daughter Anaïs. My warmest appreciation and all my love to them both.

Thank you.