American Chemical Society

National Awards Nomination Packet

E. V. Murphree Award in Industrial and Engineering Chemistry:2018
for: Avelino Corma

Received: 10/27/2015 *Cycle Year: 3*

"For pioneering contributions to the science of catalysis and for its prolific deployment as practical technology advances."

NOMINATOR:

Enrique Iglesia

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- Have you discussed this award nomination with the nominee? *Yes*

NOMINEE:

Avelino Corma

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ACS Current Member: Yes
Years of Service: 25
Date of birth: 01/01/1951
Present Position: Professor
Industry: Academia

- Does the nominee employ and require good safety protocols and practices in his/her laboratory? *Yes*
- What is the nominee's present position? *Professor*
- What professional discipline does the nominee work in? *Academia*

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October 27, 2015

Dear Award Committee:

The career of Professor Avelino Corma stands as the most elegant example of fundamental knowledge of chemistry and engineering translated into practical chemical processes with unprecedented energy and atom efficiency. His achievements and technologies span petroleum refining, renewable energy sources, petrochemicals, fine chemicals, and environmental protection. He is without doubt the academic with the most profound impact in the practice of catalysis.

His contributions extend well beyond those catalysts and processes that have been advanced and are being practiced specifically because of his work. He has developed seminal concepts in acid-base and oxidation/epoxidation catalysis, provided critical guidance for the synthesis of new zeolite structures, and advanced the coupling of chemistry and engineering concepts with unprecedented cleverness and insights. His scientific output has been remarkable in numbers (>1200 publications. > 100 patents, 10 in commercial practice), in rigor, and in their keen appreciation by others (nearly 70,000 citations; h-index of 120).

In refining and biomass conversion processes, his group has (i) developed processes to increase the octane of low-value streams, (ii) discovered and applied new and modified zeolite structures in hydrocarbon conversions, (iii) developed and implemented processes for heteroatom removal from streams, (iv) designed materials as selective and energy-efficient absorbers for olefin-paraffin and CO_2-methane separations, and (v) advanced efficient catalytic biomass pyrolysis, and upgrading strategies processes, selective catalytic oxidation and hydrogenation processes.

In petrochemicals and fine chemicals, his group has (i) developed a catalytic system to produce propylene oxide without concurrent formation of stoichiometric by-products, (ii) demonstrated catalysts and processes for the synthesis of diamine-diphenyl-methane at the commercial scale, (iii) developed and commercialized catalysts and more benign processes for the synthesis of lactones as precursors to fragrances and for multi-step production of families of fragrance compounds, (iv) and discovered chemoselectivity in nitroarene hydrogenation catalysis by metals, a breakthrough that eluded others for many decades.

His careful fundamental studies of the effects of leaching and hydrothermal treatments on secondary pore structures led to novel paraffin isomerization catalysts more active, selective, and stable than known materials. His mordenite-based hydroisomerization catalysts were commercialized by Süd-Chemie (>20 plants) as the Isopar process. His group has translated fundamental concepts about the role of extraframework Al on acid strength and on fluid catalytic cracking properties into a family of catalysts commercialized by Albemarle.

In the area of renewable resources, he has developed catalytic pyrolysis processes for the formation of bio-oils with reduced oxygen content from diverse sources of solid biomass and brought forth enabling discoveries in an extensive body of recent patents for the conversion of biomass-derived feedstocks into useful products. He has

exploited several new zeolite compositions discovered in his group to replace cryogenic distillation in separating hydrocarbon isomers in gaseous streams using ITQ-29 molecular sieves to affect separations of molecules of very similar sizes but subtly different shapes.

In fine chemicals and intermediates, his group discovered that Au-based materials can act as chemoselective catalysts in hydrogenation of nitroarenes (>95% selectivity) via cascade reactions in which interfacial TiO_2 sites bind the organic substrate while Au clusters dissociate H_2 in rate-determining steps. His group has developed novel oxidation and epoxidation catalysts which significantly improve energy and atom efficiency for such processes (e.g., propylene oxide synthesis), for which previous processes led to costly reactors, separations, and waste disposal. This process uses cumene hydroperoxide as the oxygen-transfer agent and an internal recycle that re-oxidizes (using air) the cumene formed upon oxygen transfer, without forming undesired by-products. In one study, his group showed that peracids could be replaced by H_2O_2 in lactone synthesis using structured hierarchical Sn-containing molecular sieves invented in his group. The underlying mechanism was elegantly elucidated using kinetic, isotopic and spectroscopic techniques. These concepts were then extended to novel and more benign processes for the oxidation of aniline to azo-compounds with air and to solid catalysts for the oxidation of aromatic aldehydes and, in doing so, opened new opportunities based on the underlying concept of water-tolerant Lewis acid catalysts.

In summary, a remarkable record of practical breakthroughs and prolific contributions to the scientific and patent literature, and the academic with the most ground-breaking contributions to the practice of heterogeneous catalysis in the 100-year history of the discipline.

Regards,

Enrique Iglesia
Theodore Vermeulen Chair in Chemical Engineering
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University of California at Berkeley
Faculty Senior Scientist, E.O. Lawrence Berkeley National Laboratory
Director, Berkeley Catalysis Laboratory

SHORT CV

Avelino Corma

Avelino Corma was born in Moncófar (Castellón) Spain in 1951. He is research professor at the Instituto de Tecnología Química (CSIC-Polytechnical University of Valencia), centre which was founded by him in 1990, and where he was the scientific Director until 2010. He has been carrying out research in heterogeneous catalysis in academia and in collaboration with companies for nearly 30 years.

His academic career started with a Bachelor of chemistry degree from Valencia University in 1974, followed by PhD degree in Chemistry (*suma cum laude*)at Universidad Complutense de Madrid in 1976 under direction of Prof. Antonio Cortes. He spent two years postdoc at Queen´s University in Canada. Professor Corma then spent six years in research at the Instituto de catalisis y Petroleoquímica of CSIC in Madrid, after that he moves to Valencia where he found and directed the Instituto de Tecnología Química since 1990.

Professor Corma has worked on fundamental aspects of acid-base and redox catalysis with the aim of understanding the nature of the active sites, and reaction mechanisms. With these bases have developed catalysts that are being used commercially in several industrial processes. He is an internationally recognized expert in solid acid and bifunctional catalysts for oil refining, petrochemistry and chemical process, especially in the synthesis and application of zeolite catalysts. He has published more than 900 research papers, and inventor on more than 100 patents.

Prof. Corma works on the molecular design of solid catalysts by introducing well defined single or multiple active sites in micro and mesoporous structured materials. These together with metal and oxide nanoparticles allow him to catalyze reactions in the field of oil refining and petrochemistry, chemicals, fine chemicals, and biomass transformations into fuels and chemicals. The design of bi-and multi functional catalysts allow process intensification by performing one-pot multistep reactions.

His studies go from the fundamentals by introducing new catalytic concepts up to the industrial applications, as shown by the numerous industrial processes working today and which are directly based on his work.

Materials synthesised by Prof. Corma include, and have contributed to enlarge, the family of micro and mesoporous materials, in particular zeolites. Initially synthesised as crystalline tecto-aluminosilicates, zeolites may contain other tetrahedral atoms such as P, Ge, Mg, Be, Co, Ga, B, Zn; but its unique feature is the presence of microporosity, with channels and cavities characterised by their size, shape, dimensionality and intersections.

During his professional career, Professor Corma has served as Editorial Board of the most important journal in the field of catalysis, physical chemistry, and materials chemistry. He is the President of the European Federation of Catalysis Societies (EFCATS) and President of the Associations of Catalysis Societies (IACS). He is a member of The Royal Spanish Academy of Engineering, The Academia Europaea, the Royal Spanish Academy of Sciences, The National Academy of Engineering (USA) and Foreign member of The Royal Society (UK). Doctor Honoris Causa degree by Utrecht University (2006), UNED (2008), Technische Universität München (2008), Universidad Jaime I de Castellón (2008), Universidad de Valencia (2009), Bochum University (2010), Universidad de Alicante (2010), University of Ottawa (2012), Jilin University (2013) and Technological University Delft (2013).

The outstanding level of his scientific research has been recognized by many awards. He has received the Ciapetta and Houdry Awards of the North American Catalysis Society, the F. Gault Award of the European Catalysis Society, the M. Boudart Award on Catalysis by the North American and European Catalysis Societies, the G. J. Somorjai ACS Award on Creative Catalysis, the Breck Award of the International Zeolite Association, the National Award of Science and technology of Spain, The king Jaime I prize, The National Award from Mexico, the ENI Award on Hydrocarbon Chemistry, The Alwin Mittash from Society for Chemical Engineering and Biotechnology (Germany), the Royal Society of Chemistry Centenary Prize, Rhodia Pierre-Gilles de Gennes Prize for Science and Industry and Gold Medal for the Chemistry Research Career 2001-2010 in Spain and La Grande Médaille de l'Académie des sciences de France. Prince of Asturias Award for Technical & Scientific Research (2014)

AVELINO CORMA SELECTED PUBLICATIONS

M. MIFSUD, S. GARGIULO, S. IBORRA, I. ARENDS, F. HOLLMAN, A. CORMA
“Photobiocatalytic chemistry of oxidoreductases using water as the electron donor”
Nature Commun. 5, 4145/1-4145/6 (2014)

R. MARTINEZ-FRANCO, M. MOLINER, Y. YIFENG, S. JULIANG, W. WEI, X. ZOU. A. CORMA
“Synthesis of an extra-large molecular sieve using proton sponges as organic structure-directing agents”
Proc. Nat. Acad. Sci. 110(10), 3749-54 (2013)

A. CORMA, P. CONCEPCION, M. BORONAT, M. J. SABATER, J. NAVAS, M. YACAMAN, E. LARIOS, A. POSADAS, A. M. LOPEZ-QUINTELA, D. BUCETA
“Exceptional oxidation activity with size-controlled supported gold clusters of low atomicity”
Nature Chemistry 5(9), 775-781 (2013)

OLIVER-MESEGUER, J.; CABRERO-ANTONINO, JOSE R.; DOMINGUEZ, I. LEYVA-PEREZ, ANTONIO, CORMA, A.
“Small Gold Clusters Formed in Solution Give Reaction Turnover Numbers of 107 at Room Temperature”
SCIENCE, 338 (6113), 1452-1455 (2012)

T. WILLHAMMAR, J. SUN, W. WAN, P. OLEYNIKOV, D. ZHANG, X. ZOU, M. MOLINER, J. GONZALEZ, C. MARTINEZ, F. REY
“Structure and catalytic properties of the most complex intergrown zeolite ITQ-39 determined by electron crystallography “
Nature Chem. 4(3), 188-194, (2012)

S. LAURSEN, D. COMBITA, A.B. HUNGRIA, M. BORONAT, A. CORMA
“First-principles design of highly active and selective catalysts for phosgene-free synthesis of aromatic polyurethanes”
Angew. Chem. Inter. Ed. 124, 1-5, (2012)

A. LEYVA-PEREZ, A. CORMA
“Similarities and Differences between the "Relativistic" Triad Gold, Platinum, and Mercury in Catalysis “
Angew. Chem. Int. Ed. 51(3), 614-635 (2012)

F. SASTRE, A. CORMA, H. GARCIA
“Nm Photoreduction of CO2 to methane by wáter. Influence of the Presence of a Basic catalyst”
J. Amer. Chem. Soc. 134(34), 14137-14141 (2012)

M. MOLINER, T. WILLHAMMAR, W. WAN, J. GONZALEZ, F. REY, J. JORDA, X. ZOU, A. CORMA
“Synthesis design and structure of a multipore zeolite with interconnected 12- and 10-MR Channels”
J. Am. Chem. Soc., 134 (14), 6473-6478, (2012)

J. JIANG, J.L. JORDA, J. YU, L.A. BAUMES, E. MUGNAIOLI, M.J. DIAZ-CABANAS, U. KOLB, A. CORMA
“Synthesis and Structure Determination of the Hierarchical Meso-Microporous Zeolite ITQ-43 “
SCIENCE, 333(6046), 1131-1134 (2011)

A.CORMA, O. DE LA TORRE, M. RENZ, N. VILLANDIER
“Production of High-Quality Diesel from Biomass Waste Products “
Angew. Chem. Int. Edit. 50(10), 2375-2378 (2011)

L. ALVES, B. BALLESTEROS, M. BORONAT, J.R. CABRERO-ANTONINO, P. CONCEPCION, A. CORMA, M.A. CORREA-DUARTE, E. MENDOZA
“Synthesis and Stabilization of Subnanometric Gold Oxide Nanoparticles on Multiwalled Carbon Nanotubes and Their Catalytic Activity “
J. Am. Chem. Soc. 133(26), 10251-10261 (2011)

M. MOLINER, J. GONZALEZ, M.T. PORTILLA, T. WILLHAMMAR, F. REY, F.J. LLOPIS, X. ZOU, A. CORMA
“A New Aluminosilicate Molecular Sieve with a System of Pores between Those of ZSM-5 and Beta Zeolite”
J. Am. Chem. Soc. 133(24), 9497-9505 (2011)

A. PRIMO, T. MARINO, A. CORMA, R. MOLINARI, H. GARCIA
“Efficient Visible-Light Photocatalytic Water Splitting by Minute Amounts of Gold Supported on Nanoparticulate CeO2 Obtained by a Biopolymer Templating Method “
J. Am. Chem. Soc. 133(18), 6930-6933 (2011)

R. SIMANCAS, D. DARI, N. VELAMAZAN, M.T. NAVARRO, A. CANTIN, J.L. JORDA, G. SASTRE, A. CORMA, F. REY
“Modular Organic Structure-Directing Agents for the Synthesis of Zeolites “
SCIENCE (Washington, DC, USA) 330(6008), 1219-1222. (2010)

J. SUN, C, BONNEAU, A. CANTIN, A. CORMA, M. DIAZ-CABANAS, M. MOLINER, D. ZHANG, M. LI, X. ZOU
“The ITQ-37 mesoporous chiral zeolite”
Nature (London, UK). 458(7242), 1154-1157 (2009)

RUBIO-MARQUES, PAULA; RIVERO-CRESPO, MIGUEL A.; LEYVA-PEREZ, ANTONIO; CORMA, AVELINO
“Well-Defined Noble Metal Single Sites in Zeolites as an Alternative to Catalysis by Insoluble Metal Salts”
Journal of the American Chemical Society (2015), 137(36), 11832-11837.

MARTIN, NURIA; BORUNTEA, CRISTIAN R.; MOLINER, MANUEL; CORMA, AVELINO
“Efficient synthesis of the Cu-SSZ-39 catalyst for DeNOx applications”
Chemical Communications (Cambridge, United Kingdom) (2015), 51(55), 11030-11033.

MARTIN, NURIA; MOLINER, MANUEL; CORMA, AVELINO
“High yield synthesis of high-silica chabazite by combining the role of zeolite precursors and tetraethylammonium: SCR of NOx”

Chemical Communications (Cambridge, United Kingdom) (2015), 51(49), 9965-9968.

MARGARIT, VICENTE J.; MARTINEZ-ARMERO, MARTA E.; NAVARRO, M. TERESA; MARTINEZ, CRISTINA; CORMA, AVELINO
“Direct Dual-Template Synthesis of MWW Zeolite Monolayers”
Angewandte Chemie, International Edition (2015), Ahead of Print.

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September 28, 2015

Dear members of the evaluation committee,

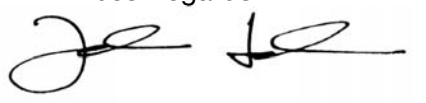
With this letter I express my strong support for the nomination of Avelino Corma for the E. V. Murphree Award in Industrial and Engineering Chemistry. Professor Corma has made unique contributions to a wide variety of catalysts and catalytic processes of which an unusually high number has been industrially realized. He is the most prolific and versatile contributor to the science and technology of heterogeneous catalysis today, having published over 1100 papers and over 100 patents. Two specific examples are described below to highlight the breadth and depth of his contributions.

The first area is related to cracking of alkanes in zeolites. The combination of theoretical, kinetic and spectroscopic studies led him to demonstrate already in 1983, simultaneously with, and independently from Haag and Dessau, the existence and relevance of a protolytic cracking mechanism of hydrocarbons within the pores of the zeolites, a concept much used today. Understanding the formation and reaction mechanisms of carbocations in zeolites was the basis for developing catalytic cracking and short chain alkane isomerization catalysts, which were industrially applied towards the end of the eighties, and which, nowadays, still operate in more than 20 plants worldwide.

The second area to emphasize relates to the alkylation of aromatic molecules by zeolitic catalysts. Prof. Corma showed that the spatial confinement of electrons when the molecule sorbed in a micropore results in an increase of its energy levels compared to those of the catalyst acid sites, especially visible in frontier orbitals. Theory of electronic confinement and its effect on the HOMO orbital of aromatic molecules was experimentally probed by monitoring toluene and naphthalene using photoluminescence and Raman spectroscopy. Decreasing zeolite pore size leads to a lower HOMO-LUMO gap of the aromatic molecule, enabling a larger capacity to donate electrons. Introducing so zeolite hardness and softness and its impact on the orbital control in product selectivity for toluene and m-xylene alkylation had a major impact on the field.

The fact that many of the developments were achieved through detailed methodological studies highlights the importance of combining fundamental and applied research for achieving stable results. Prof. Corma's seminal contributions to industrial catalysis have benefited markedly from his pragmatic and elegant use of theory and high throughput methods to enhance the efficiency of research. I cannot see a better candidate for the Murphree award and hope the selection committee shares this view.

With best regards



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Mülheim, 26.10.2015

Letter of Endorsement for the nomination of Prof. Dr. Dr.h.c.mult. A. Corma for the E.V. Murphree Award of the ACS

Dear Madam or Sir,

I have recently learned that Avelino Corma will be nominated for the 2016 E.V. Murphree Award. With this letter I enthusiastically support this nomination. I could not think of a worthier candidate.

I have followed Avelino Corma's work with the highest admiration for almost 30 years. The work has always been a combination of catalytic chemistry – mainly focused on hydrocarbon conversion -, materials science and chemical engineering. Especially remarkable is the wide scope of Avelino Corma's activities, as demonstrated in his numerous publications in the highest ranking journals.

The hallmark of Corma's work is the detailed understanding of the requirements, which are posed on the catalyst by a specific target reaction, the analysis of the properties which catalysts for such a reaction should have, and finally the fine-tuning of the catalyst's features to meet the requirements. This has led to several breakthroughs in the conversion of hydrocarbons. Catalysts for the isomerization of naphtha (U.S. 5,057,471 (1989)) are in current use in ten commercial units. Another significant contribution of the Corma group was the discovery and use of Al- containing sepiolite materials ([U.S. Patents 4,542,002 (1985); 5,492,874 (1992)) as additives for bottoms upgrading in fluid catalytic cracking (FCC) units. A collaboration between Corma and Sumitomo has led to a commercial process for the selective epoxidation of propene to propylene oxide (U.S. Patents 5,783, 167; 6,211,399 (1998)).

Possibly even more important are the developments of Avelino in the synthesis of catalytic materials. His innovative use of germanium in zeolite synthesis has led to a wealth of materials with extremely large pores, while his concepts for the synthesis of

delaminated zeolites approach the problem of accessibility of active sites for large hydrocarbons from an alternative angle. These breakthrough discoveries will show their true importance probably in the future, when crude oil qualities decrease further.

Avelino Corma is one of the most prominent figures in contemporary catalysis, who has worked and works in the core of the fields covered by the Murphree-Award: he carries out fundamental research in industrial and engineering chemistry, and his findings have been widely applied in industrial practice. There are few – if any – contemporary catalysis researchers, whose influence on catalytic scienc and practice is at a comparable level. He would be an ideal recipient of the Murphree-Award. I wholeheartedly and most enthusiastically endorse his nomination.

Kind regards

Ferdi Schüth