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NEWS

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BBVA Foundation Frontiers of Knowledge Award in Basic Sciences

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- Midway through the 1990s, the Professor of Chemistry at the University of California, Berkeley pioneered the development of MOFs and COFs; highly porous materials "of a diversity previously unknown in chemistry," in the words of the award jury.
- These materials have potential applications in confronting some of the world's biggest challenges, like the storage of the principal gas causing climate change or the development of clean fuels based on hydrogen.
- Yaghi's research also points to the future use of these materials to recover water from atmospheric air in desert climates; a technique he believes may become available in the next five years.

Madrid, January 23, 2018.- The BBVA Foundation Frontiers of Knowledge Award in the Basic Sciences category goes, in this tenth edition, to Jordanian-American chemist Omar Yaghi, "for his pioneering work in the conception and synthesis of new crystalline materials, MOFs and COFs, of major impact in science and engineering," with potential applications that extend to "the capture and storage of carbon dioxide (CO_2) and trapping water molecules in air to produce water for drinking."

Yaghi, Professor of Chemistry at the University of California, Berkeley (United States), created these materials using a chemistry based on "building bricks" – the jury explains – whose structure responds to a carefully controlled design. This strategy "has led to an exponential growth in the creation of new materials having a diversity previously unknown in chemistry."

Yaghi himself gave this new field the name of Reticular Chemistry, which he defines as "stitching molecular building blocks into extended structures by strong bonds." A strategy already being practiced, the jury remarks, "in numerous laboratories in academia and industry worldwide."

MOFs (metal organic frameworks) and COFs (covalent organic frameworks) can be thought of as crystalline sponges on a molecular scale: highly porous materials whose pores or cells, of pre-programmable size, form an organized structure. These frameworks unite many of the properties most prized by chemists, among them a considerable capacity to adsorb other compounds, which lodge within their pores, and exceptional versatility and selectivity, with the size of the pore tailored to the target or "guest" compound. In this sense, they operate like purpose-built "molecular sieves." As Yaghi explains it, if one gram of an MOF material was unfolded into a single atomic-scale sheet, it would extend across the equivalent of sixty tennis courts.

COFs are formed of organic materials, while MOFs combine organic and inorganic materials, specifically metal oxides. In this case, the metal oxides are the "anchors" – to which the molecule to be caught in the sieve adheres – and the organic compounds are the "struts" that join them together into large porous structures. The choice of metal oxide will depend on the molecule to be trapped, while the size of the pore will depend on the organic compound.

This ability to control the final product has long fascinated Yaghi, who created the first such compound in the mid-1990s: "When I was a student," – he explained on the phone after hearing of the award – "making new materials involved simply mixing stuff together and what you got at the end was what nature gave you, so there wasn't much control over what came out. But I realized there must be a lot of potential in being able to assemble units together like you would the components of an automobile. It was a dream for me to be able to make materials in that simple, rational way. To have control over what you are creating and being able to tweak it and modify it after you have made it is really quite powerful."

Yaghi's dream was the seed that produced the new chemistry now sweeping the world, with hundreds of laboratories eagerly pursuing fresh applications for these porous materials. The new laureate has to date, he says, counted "more than 60,000" varieties of developed MOFs.

He selects three from among the vast array of potential applications. One is carbon dioxide capture: "Carbon capture is very important, and I believe MOFs may be the best materials to do it," Yaghi affirms. "The difficulty here is to separate CO_2 from other gases, including water. MOFs allow us to seek out just CO_2 and separate it so that it does not reach the atmosphere."

The carbon capture techniques currently in use employ toxic compounds, and can consume over 20% of the fuel the plant produces. MOFs, which are synthesized in a simple, environmentally friendly process, are still not ready for industrial deployment for this application, but Yaghi is convinced that the day will come.

He sees as far more imminent the use of molecular sieves to trap water molecules in air – even in dry environments with less than 20% humidity – to deliver liquid water with no other energy input than ambient sunlight. “There is a lot of water in the atmosphere, and the possibility of trapping it would mark a tremendous transformation in arid regions of the world. We have designed MOFs that can collect water in the pores. Then, heated by sunlight, it comes out as liquid water. True water made from the air.” Yaghi recently published a paper in *Science* discussing just this application.

Another potential application is the storage of hydrogen in far smaller vessels than are now required. Lodging hydrogen molecules in the pores of the material allows more gas to be contained in a smaller volume – counterintuitively, you can fit a lot more hydrogen into a tank full of MOFs than a tank that is empty. According to Yaghi, the technique is still at the preliminary research stage, but represents a direction of promise for developing a clean, hydrogen-based fuel for vehicles.

Yaghi declares himself increasingly convinced that “the design of new materials is one of the most important things we can do to solve the problems facing our planet, like, for instance, by developing clean energy sources.”

At the start of his career, however, his mind was not on applications, but rather on “the quest to create beautiful structures that I could also control.”

At the age of just 15, Omar M. Yaghi (Amman, Jordan, 1965) was sent by his family to study in the United States. He first fell in love with chemistry when looking at drawings of the structure of molecules: “I saw these molecular drawings at school and I was amazed, even though I didn’t know what they were. Later I learned that they were the components of things that we cannot see with our own eyes.”

Today, one of his main ambitions outside research is to fire young people with the same enthusiasm, including those from less advantaged countries: “Above all I am a teacher and a mentor, and I want to see more young people engage in science and in the business of solving the world’s problems. All over the world, in the developing countries too. That is why I am helping to build research centers in these countries, to help young scholars to get into science.”

Academic background

After obtaining a PhD in Inorganic Chemistry from the University of Illinois at Urbana-Champaign, he began his research and teaching career as an assistant professor at Arizona State University, then moved to the University of Michigan at Ann Arbor as Robert W. Parry Professor of Chemistry, and from there to the University of California, Los Angeles as Christopher S. Foote Professor of Chemistry and Irving and Jean Stone Chair Professor in Physical Science. Since 2012 he has been the James and Neeltje Tretter Chair Professor of Chemistry at the University of California, Berkeley, where he co-leads the Kavli Energy NanoSciences Institute, and the California Research Alliance by BASF.

He also heads the Center for Reticular Materials, at Japan's National Institute for Materials Science, and the Carbon Capture and Conversion Research Group at King Fahd University of Petroleum and Minerals in Saudi Arabia. From 2011 to 2016 he served as Co-Executive Director of the Molecular and Nanoarchitecture (MANAR) Research Center at the Vietnam National University. He holds 44 patents and has a further 25 patent applications published in the United States.

Basic Sciences jury and technical committee

The rigor, quality and independence of the judging process has earned these awards the attention of the international scientific community and a firm place among the world's foremost prize families.

The jury in this category was chaired by **Theodor Hänsch,** Head of the Division of Laser Spectroscopy at the Max Planck Institute of Quantum Optics (Germany), professor in the Faculty of Physics at the Ludwig Maximilian University of Munich and the 2005 Nobel Laureate in Physics. The secretary was **Avelino Corma**, a Research Professor at the Instituto de Tecnología Química (ITQ)-Universitat Politècnica de València (UPV). Remaining members were **Emmanuel Candés,** the Barnum-Simons Chair in Mathematics and Statistics at Stanford University (United States); **Nigel Hitchin**, Emeritus Savilian Professor of Geometry at the University of Oxford (United Kingdom), **Zakya H. Kafafi**, Adjunct Professor in the Department of Electrical and Computer Engineering at Lehigh University (United States), **Carmen Menoni**, University Distinguished Professor in Electrical and Computer Engineering at Colorado State University (United States), **Martin Quack**, a professor at ETH Zurich (Switzerland), where he heads the Molecular Kinetics and Spectroscopy Group, **Sandip Tiwari**, Charles N. Mellowes Professor in Engineering at Cornell University (United States); and **Xueming Yang**, Distinguished Fellow at the Dalian Institute of Chemical Physics (Chinese Academy of Sciences), a chair professor and Dean of Science at the Southern University of Science and Technology, and a professor and chairman of the Department of Chemical Physics at the University of Science and Technology of China.

The **CSIC Technical Committee** was coordinated by **María Victoria Moreno**, the Council's Deputy Vice President for Scientific and Technical Areas, and formed by: **Paloma Adeva**, Coordinator of the Material Sciences and Technology Area and Research Professor at the National Center for Metallurgical Research (CENIM); **Marta Fernández**, Scientific Researcher in the Institute for Polymer Science and Technology (ICTP); **Asunción Fernández**, Research Professor in the Institute of Materials Science of Seville (ICMS); **Oscar García**, Research Professor in the Institute of Mathematical Sciences (ICMAT); and **Alberto Casas**, Research Professor in the Institute for Theoretical Physics (IFT).

Previous awardees in this category

The **Basic Sciences** award in last year's edition went to mathematicians **David Cox and Bradley Efron** for revolutionizing statistics and making it into an indispensable tool for other sciences through their "pioneering and hugely influential contributions."

Five of the 83 winners in earlier editions of the BBVA Foundation Frontiers of Knowledge Awards have gone on to win the Nobel Prize. Shinya Yamanaka, the 2010 Biomedicine laureate, won the Nobel Prize in Medicine in 2012; **Robert J. Lefkowitz**, awardee in the same Frontiers category in 2009, won the Chemistry Nobel in 2012. In Economics, Finance and Management, three Frontiers laureates were later honored with the Nobel: **Lars Peter Hansen**, winner of the Frontiers Award in 2010 and the Nobel Prize in 2013; **Jean Tirole**, Frontiers laureate in 2008 and Nobel laureate in 2014; and **Angus Deaton**, 2011 Frontiers laureate and Nobel laureate in 2015.

About the BBVA Foundation Frontiers of Knowledge Awards

The promotion of knowledge based on research and artistic and cultural creation, and the interaction of these domains, forms a core strand of **the BBVA Foundation**'s action program, along with the recognition of talent and excellence across a broad spectrum of disciplines, from science to the arts and humanities.

In line with these objectives, the **BBVA Foundation Frontiers of Knowledge Awards** were established in 2008 to recognize outstanding contributions in a range of scientific, technological and artistic areas, together with knowledge-based responses to the central challenges of our times. The areas covered by the Frontiers Awards are congruent with the knowledge map of the 21st century, in terms of the disciplines they address and their assertion of the value of cross-disciplinary interaction.

Their **eight categories** span classical areas like Basic Sciences (Physics, Chemistry and Mathematics), Biomedicine and other areas characteristic of our time, like Biomedicine, Information and Communication Technologies, Ecology and Conservation Biology, Climate Change, Economics, Finance and Management and Development Cooperation, and the particularly innovative realm that is Contemporary Music.

The BBVA Foundation is aided in the evaluation process by the **Spanish National Research Council (CSIC)**, the country's premier public research organization. As well as designating each jury chair, the CSIC is responsible for appointing the technical evaluation committees that undertake an initial assessment of candidates put forward by numerous institutions across the world and draw up a reasoned shortlist for the consideration of the juries.

CALENDAR OF UPCOMING AWARD ANNOUNCEMENTS

Biomedicine	Tuesday, January 30, 2018

Ecology and Conservation Biology	Tuesday, February 6, 2018
Contemporary Music	Tuesday, February 13, 2018
Economics, Finance and Management	Tuesday, February 20, 2018
Development Cooperation	Tuesday, February 27, 2018

LAUREATE'S FIRST DECLARATIONS AND IMAGES

A video recording of the new laureate's first interview on receiving news of the award is available from the Atlas FTP with the following coordinates:

Server: **5.40.40.61**

Username: **AgenciaAtlas4**

Password: **mediaset17**

The name of the video is:

"PREMIO CIENCIAS BÁSICAS"

In the event of connection difficulties, please contact **Miguel Gil** at production company Atlas:

Mobile: +34 619 30 87 74

E-mail: mgil@mediaset.es