Profesor Omar Yaghi

*Dra. Margarita Viniegra**

El Profesor Omar M. Yaghi es mundialmente famoso por su trabajo en el diseño y producción de una nueva clase de compuestos conocidos como MOFs (Metal Organic Frameworks) y COFs (Covalent Organic Frameworks). Ha desarrollado con éxito estos materiales desde la ciencia básica hasta las aplicaciones en tecnologías de energía limpia como almacenamiento de hidrógeno y metano y captura de CO_2. Su estrategia de "bloques de construcción" ha originado un crecimiento explosivo en la creación de nuevos materiales con una diversidad de aplicaciones. El profesor Yaghi ha llamado a esta línea de investigación "Química reticular" y la define como "coser" bloques moleculares de construcción unos con otros, mediante enlaces fuertes, para formar estructuras extendidas.

El Profesor Yaghi nació en Jordania y emigró a los EUA a los 15 años de edad. Comenzó sus estudios de doctorado en La universidad de Illinois-Urbana bajo la asesoría del Profesor Walter G. Klemperer. Ha recibido un sinnúmero de reconocimientos como el premio de Química del estado sólido por la ACS y Exxon Co. en 1998, el premio Centenario de la Royal Society (2010) y el premio que otorga el Departamento de Energía de EUA en su Programa de Hidrógeno (2007). Su línea de investigación la comenzó en la Universidad de Arizona, continuó en la Universidad de Michigan y en la UCLA. Actualmente es Profesor en la Universidad de California, Berkeley, y ocupa la silla James and Neeltje Tretter. Es el Director fundador de Center for Global Science en Berkeley.

A continuación, se presenta la entrevista que se hizo al Profesor Yaghi con motivo de su participación en el 51° Congreso Mexicano de Química y 35° Congreso de Educación Química en la ciudad de Pachuca, Hidalgo.

About Chemistry. You have said that you are an explorer. In the analogy where some world explorers decide to take under the sea and others decide to climb up the mountains, where are you exploring chemistry? What is the chemical knowledge you are using to path your way? What are the areas in which chemistry has to strengthen its knowledge, which are the big questions of Chemistry these days?

Searching for new knowledge is a noble act and to me it is a privilege. It is an effective way to improve the world, elevate the way we think, and in the fullness of time help solve society's problems. I believe that Nature is rich and our understanding of the molecular world governing Nature is in many respects still primitive. We need to understand the natural world as well as

Foto: Profesor Omar Yaghi durante la Plenaria Inaugural del 51° Congreso Mexicano de Química y 35° Congreso Nacional de Educación Química en Pachuca, Hidalgo, 2016.

master the knowledge we have to make new materials, which will improve our lives and advance civilization. Exploration into new knowledge, or shall I say inquiry based research, depends not just on the questions we ask but also how we go about addressing these questions. In my research, we have endeavored to answer an intellectual question: how do we organize matter at the molecular level such that we can manipulate and modify it into new useful materials? Given how little we know about the interworking of molecules and how they interact, the idea of exploration and risk taking in chemistry comes into play. We might plan our experiments using sound science and use what we know to the full extent but in the end it is our observations into the results of those experiments that are paramount to making progress. The results are the closest we can get to the accessing the facts about how the molecular world works. The quality of the observations and analysis of those observations determine the quality of the knowledge we gain.

One of the dreams of chemists has always been how to control molecules and how to bring them together to make larger structures and frameworks. Historically, chemistry has been about controlling the bonding of molecules and the geometry and spatial arrangements of atoms within those molecules. The question of how molecules can be linked together to make frameworks is beginning to be addressed. We are developing the chemistry of the framework by making metal-organic frameworks (MOFs) and covalent organic frameworks (COFs). Simply said, the molecule to the atom is what the framework is

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to the molecule. In other words, molecules put atoms in specific geometry and spatial arrangement, while the framework puts the molecules in specific geometry and spatial arrangement. Except in the framework, molecules are exposed to space being encompassed by the framework and into which matter can be further manipulated and controlled. The fact that strong bonds hold these frameworks together has led to their architectural stability and robust chemical stability, allowing covalent chemistry to be carried out on their pore interior and made it possible to modify them nearly at will for specific applications.

About MOFs (and COFs). What are the main impacts of MOFs on society? How green is its synthesis? How big is the problem of CO_2? How close are we getting to transform CO_2, closing the cycle?

A tank of gasoline in a typical family automobile will release into the atmosphere about 80 kilogram of carbon dioxide by the time it is fully utilized. Thus the problem of carbon dioxide is huge and it has detrimental impact on the environment, the atmosphere and acidity of oceans, to mention few. The pores of MOFs are being covalently modified to selectively remove carbon dioxide already in the atmosphere and from combustion sources before reaching the atmosphere. More recently, we also showed that COFs could trap carbon dioxide and convert it into high value stock materials including synthetic fuels. To close the cycle on carbon dioxide so that we have a carbon neutral cycle requires a lot more work. However, already there is evidence that this is within our reach. The issues of implementation, policy and cost have to be more closely examined but the basic science is progressing at a rapid pace towards a viable solution. These solutions involve solar energy use to convert carbon dioxide to hydrocarbons using harmless catalysts.

About mentoring and teaching. You have said that you are very fortunate to get the chance to helping young people to deal with difficulties, to think independently, and how to use the power of evidence in making their decisions every day. How do you do it? How much time do you spend with your students? How do you encourage them? Can you do the same in a classroom? You are fusing inorganic and organic chemistry in your lab, should we do the same in the chemistry curriculum?

Every person should be given the opportunity to improve and follow his or her dreams. Although we do not have equal abilities, we should have equal opportunity to find our abilities and improve ourselves. I am fortunate to have chosen my profession because I get to work side-by-side with students (fresh minds). The challenge is to convince them that even when there are chances that the experiment might not work, it is still worth trying it. As long as the experiment is grounded in sound science, it should be tried. The results may surprise you and it is at that point where one begins to think 'outside the box' and begins to believe in the power of the experiment. In my view, the experiment is our way of exploring the frontiers of our abilities and the frontiers of nature. So, in the undisturbed inquiry, we find new knowledge about nature and about our own selves and thus experiment, discovery and explorations have transformative affects on those pursuing science.

Accordingly, in my own lab I encourage students to explore without prejudging the experiment. Phrases such as "the experiment did not work", "I did the reaction and I got nothing", etc. do not exist in the lingo of my lab. If a student happens to say such a thing, I always respond, "It is not that the experiment did not work, it is the fact that you did not make it work". The point is that we need to make things work and not expect that things will work for us. That's how we make progress in transforming students into independent researchers. I must say, that I have been inspired by students because the rapidity of their progress and the agility of their mind. We just have to provide them with the environment to open their minds to the world around us.

In our research, we have fused organic chemistry and inorganic chemistry into one discipline. However, in the classroom, these topics are taught separately and often taught as separate intellectual endeavors. The science community needs to change that to reflect the reality: a student in my lab crosses boundaries of organic chemistry, inorganic chemistry, physical chemistry, crystallography, materials science, and engineering. We need to bring our teaching closer to the current reality. For example, science education has done very little to incorporate the Internet revolution into teaching. I don't blame entirely the educators for that but rather I would say that our focus as people is increasingly away from science and more onto fiction and feelings. The focus should be on facts and how we think rather than just about how we feel.

About our world. Can scientists tear down the (artificially made) human walls?

More than ever before, we as scientists have a chance to make fundamental positive impact on the world. Not only because of scientific advancements but also because of rapid communications and availability of information. The ability scientists have to communicate through the language of science is a powerful way to bring down barriers between people. Adversaries and friends alike can use the language of science to communicate also their needs, aspirations, hopes and the uniqueness of their culture. I am hopeful that the culture of science will have a chance to thrive in the world. In order to do this we must care about the well being of others as much as we care about ourselves. The easiest way to contribute here is by focusing on the individual and the quality of ones interaction with, and the care one gives to that individual through for example the mentoring we do routinely in science. This mentoring, when done properly, leads to independent thinkers committed to excellence, and in a way the planting a good seed in our world.