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News & Views

Let the sun shine into a brighter future: an interview with Prof. Aldo Steinfeld

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Aldo Steinfeld, professor at the Department of Mechanical and Process Engineering of ETH Zurich

Aldo Steinfeld (Ph.D., University of Minnesota, 1989) is a professor at the Department of Mechanical and Process Engineering of ETH Zurich, where he holds the Chair of Renewable Energy Carriers. He has pioneered the development of solar thermochemical reactor technologies for producing clean transportation fuels using concentrated solar energy. From 1995 to 2014, he directed the Solar Technology Laboratory at the Paul Scherrer Institute. At ETH Zurich, he was the Head of the Institute of Energy Technology from 2005 to 2007 and Associate Head of the Department of Mechanical and Process Engineering from 2007 to 2009. He served on several editorial boards of international journals and as the Editor of the *Journal of Solar Energy Engineering* (2005–2009) and co-Editor of the *CRC Handbook of Hydrogen Energy* (2014). His contributions to science and education have been recognized with the ASME Rice Award (2006), the Yellott Award (2008), the European Research Council Advanced Grant (2012), the ISES Farrington Daniels Award (2013), the ASME Heat Transfer Memorial Award (2013), and the ASME Kreith Energy Award (2016). Prof. Steinfeld is member of the Swiss Academy of Engineering Sciences, the Pan-American Academy of Engineering, and the International Solar Energy Society's Board of Directors.

This April, in the framework of the Chinese Academy of Sciences President's International Fellowship for Distinguished Scientists, Prof. Steinfeld made an academic visit to the Institute of Engineering Thermophysics, Chinese Academy of Sciences. *Science Bulletin* was given the opportunity to interview him.

Science Bulletin: Can you comment generally about the development of your field, say solar thermochemistry or solar fuels in general and also the development of the whole area of solar energy? What does the future hold?

Prof. Steinfeld: Let me first answer the second part of the question – the future. The potential of solar energy is enormous, as only 1% of the solar radiation reaching the arid regions of the earth would be enough to cover the global energy consumption. It is up to scientists and engineers to develop energy-efficient and cost-effective technologies to convert solar energy into useful forms, namely: heat, power, and fuels. Most of us are familiar with solar water collectors, photovoltaics, and concentrated solar power. These technologies continue to improve and become cheaper, but they are already mature and implemented commercially. However, the solar fuel technologies are not as developed. There is a need for further R&D in advance materials and solar reactor engineering. The ultimate goal is to develop solar fuel technologies for the efficient conversion of H_2O and CO_2 into fuels, as they offer a sustainable path to the production of renewable drop-in hydrocarbons for the transportation sector, especially aviation, without the need to replace the existing massive global infrastructure for their storage, distribution and consumption.

Science Bulletin: The energy crisis is a problem of worldwide concern. Renewable energy resources, such as solar energy, water power, wind energy, and biomass energy, will be the main energy sources of the future. Of these renewable energy resources, which do you think will have the greatest technological breakthrough in the near future?

Prof. Steinfeld: Solar energy certainly!

Science Bulletin: As solar energy can provide a source of clean, non-polluting, high-temperature heat for power and fuel production, related research on the materials and processes of

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solar energy technologies has developed quickly in recent years. Can you comment on the developing trends of this research field?

Prof. Steinfeld: Materials play a pivotal role in the conversion of solar energy into fuels with high selectivity, stability, and rates. Specifically, novel metal oxides, e.g. doped-ceria and perovskites, can significantly improve the redox performance of thermochemical cycles for splitting H_2O and CO_2.

Science Bulletin: Developing solar technologies for converting CO_2 into fuels has become a great energy challenge. In one of your recent papers published in *Energy & Environmental Science*, your research group has reported the development of a new thermochemical approach of splitting CO_2 into separate streams of CO and O_2 by the use of concentrated solar radiation. Can you talk about the advantages of this approach, whether there remain some aspects to be improved, and if you plan to address these issues in upcoming research work?

Prof. Steinfeld: Solar thermochemical approaches using concentrated solar radiation inherently operate at high temperatures and utilize the entire solar spectrum, and as such provide a favorable thermodynamic path to solar fuel production with potentially high efficiency. We experimentally demonstrated the solar-driven thermochemical splitting of CO_2 using a redox cycle with total selectivity, long-term stability, high mass conversion, and a solar-to-fuel energy efficiency comparable to the highest value reported to date. This benchmark performance was accomplished using a robust and scalable solar reactor featuring a reticulated porous structure, made of ceria, directly exposed to 3000 suns irradiation. The experimental results obtained under realistic operational conditions provide compelling evidence of the viability of the solar thermochemical technology for converting CO_2 to fuels. Higher efficiencies are readily possible by superior redox materials, partial heat recovery, scaling up, and integration with the large-scale solar concentrating infrastructure already established for commercial concentrated solar power (CSP) plants.

Science Bulletin: As an outstanding researcher, you have published more than 300 journal papers. You must know impact factor is an important index of each academic journal and most researchers refer to this index when choosing a journal to publish their work. What are your thoughts in this regard?

Prof. Steinfeld: Indeed, the impact factor is a controversial topic these days. It is only one indicator, but it does not tell the whole story about the scientific quality of a publication. An excellent paper will be recognized worldwide, regardless of the journal. Moreover, different disciplines have different level sorting. For example, in the engineering field, a journal with an impact factor above 2 is already considered respectful. In contrast, in the natural sciences, the top journals have much higher values of impact factors. In any case, researchers in each discipline know which the top journals are, so that the discussion about the impact factor becomes secondary. Perhaps we are putting too much emphasis on that and creating unnecessary stress on young researchers.

Science Bulletin: However, many researchers continue to care more about the impact factor.

Prof. Steinfeld: I know, we do care as well in my university when recruiting young faculty. But again, this is only one indicator among many; it does not tell the whole story about the scientific quality of research.

Science Bulletin: Currently, the level of scientific research in China is increasing rapidly, but the development of academic journals remains relatively slow. As a board member of many international journals, can you offer some suggestions on the development of Chinese academic journals?

Prof. Steinfeld: There are several ways of promoting a journal. One example is association with a conference series and publication of selected papers from the proceedings. More importantly is to have a rigorous and rapid peer-review process.

Science Bulletin: Have you ever organized a special issue in a journal?

Prof. Steinfeld: Yes, I did it during my tenure as Editor-in-Chief of the *Journal of Solar Energy Engineering*. We published annually a special issue dedicated to selected papers of the ASME Solar Engineering Conference. When you have a multidisciplinary journal such as *Science Bulletin* it is more difficult to do it because you will be competing with specialized journals.

Science Bulletin: Finally, a question about the international research collaboration. As you may know, this is playing an increasingly important role in science outcomes and in the global advancement of science. Do you have experience in international collaboration, especially with Chinese scientists?

Prof. Steinfeld: Over the years I have developed a very strong international network in my research field. Especially in Europe, as the European Union is an important funding source for inter-European academic and industrial partners. I have also strong collaborations with partners in the US. I hope very much to do it as well with Chinese partners. In fact, my visit to CAS this week is already being fruitful. We have concrete plans for a joint project with the group of Prof. Hao that includes a sabbatical visit of Prof. Hao to ETH Zurich and exchange of graduate students.