

Biosketch Heinz Frei

Heinz Frei is a Senior Scientist at Lawrence Berkeley National Laboratory, now retired, who studied chemistry at the Swiss Federal Institute of Technology (ETH Zurich). He received his PhD in physical chemistry in 1977 (Hs.H. Guenthard), for which he was awarded the ETH Medal. Following postdoctoral research at the Chemistry Department of the University of California Berkeley under fellowship support from the Swiss National Science Foundation (1978-1980, supervisor G.C. Pimentel), he started a research group in solar photochemistry at LBNL with focus on chemistry with red and near infrared light, the spectral region that comprises the sun's most abundant photons. He discovered low energy pathways of chemical reactions accessed by red/near infrared photoexcitation of vibronic states that form when reactants are held in a state of collision inside nanosized cages, work for which he received the Werner Prize of the Swiss Chemical Society in 1990.

Expanding the concept of collisional pair photoreactivity to robust nanoporous zeolite hosts, Frei established new methods for utilizing visible and near infrared light for the environmentally friendly syntheses of major industrial chemicals, most notably partially oxidized small hydrocarbons with close to 100 percent selectivity. For the detailed mechanistic understanding of these and other heterogeneous catalysis, he introduced time-resolved nanosecond FT-infrared spectroscopy in zeolites and nanoporous silica hosts that enabled the discovery of short-lived intermediates including direct proof of their kinetic relevancy. Building on these advances, he took on the challenge of developing robust nanoscale integrated artificial photosynthetic systems, a design principle of natural photosynthesis. He pioneered all-inorganic atomically precise heterobinuclear photocatalytic units coupled to metal or metal oxide nanoclusters for the photoreduction of carbon dioxide and for oxygen evolution from water on high surface area nanoporous silica. Frei successfully coupled the two half reactions thereby accomplishing the direct conversion of carbon dioxide and water to carbon monoxide and oxygen at all-inorganic polynuclear clusters. For in-depth mechanistic understanding, time-resolved FT-infrared studies under photocatalytic conditions enabled the first detection of intermediates of water oxidation at earth abundant metal oxide clusters, and carbon dioxide one-electron intermediates at metal nanocatalysts. To block efficiency-degrading back and side reactions, he developed ultrathin electron and proton conducting amorphous silica membranes with embedded, energetically optimized molecular wires. These nanomembranes opened up complete nanoscale integrated artificial photosynthetic systems with built-in membrane separation, with Co oxide-silica core-shell nanotubes as part of macroscale nanotube arrays as a first example.

Frei served as a Deputy Director of LBNL's Physical Biosciences Division (1998-2007) and of LBNL's Helios Solar Energy Research Center (2008-2011). He was one of the founding scientists of the Joint Center for Artificial Photosynthesis (JCAP, the U.S. Dept. of Energy's first Innovation Hub for Fuels from Sunlight, a partnership with Caltech), Leader of its Interface Project 2010-2015, and Acting Head of JCAP at LBNL in 2012. A frequent plenary and invited speaker at international conferences and university departments, Frei has co-organized several symposia on solar photochemistry over the years including Joint-Chair of the 2016 Gordon Research Conference on Solar Fuels. He has regularly served on national and international research planning and review panels, advisory and editorial boards, and was Editor-in-Chief of the RSC Energy Environment Series 2016-2020.

He was elected a Fellow of the American Association for the Advancement of Science in 2014. H-index 63, > 15K citations.