



Physical Sciences

Karthish Manthiram

Professor, Chemical Engineering and Chemistry, California Institute of Technology, USA

Karthish Manthiram is Professor of Chemical Engineering and Chemistry at Caltech, where he is also the William H. Hurt Scholar. A graduate of Stanford (B.S. 2010) and UC Berkeley (Ph.D. 2015, with Paul Alivisatos), he trained as a postdoctoral fellow with Nobel laureate Robert Grubbs before joining MIT as faculty in 2017. He moved to a full professorship at Caltech in 2021.

Prof. Manthiram's honors include the Sloan Research Fellowship, DOE Early Career Award, NSF CAREER Award, Camille Dreyfus Teacher-Scholar Award, the ISE Elsevier Prize for Applied Electrochemistry, and recognition in *Forbes* "30 Under 30." He has delivered over 150 invited talks, mentored a new generation of leaders, and published over 50 high-impact papers and patents.

The arc of Karthish Manthiram's work embodies the convergence of fundamental chemistry, engineering insight, and societal urgency, forging electrified pathways to a sustainable chemical future.



The Infosys Prize 2025 in Physical Sciences is awarded to Prof. Karthish Manthiram, for pioneering sustainable electrochemical routes to essential chemicals. His breakthroughs in lithium-mediated ammonia synthesis and oxygen-atom transfer catalysis have transformed our understanding of electrified chemical manufacturing, demonstrating how renewable electricity can drive selective, efficient synthesis of chemicals that are fundamental to agriculture and industry.

Scope and Impact of Work

Prof. Karthish Manthiram's research spans the frontiers of electrochemistry, catalysis, and sustainability. His central theme is the electrification of chemical synthesis: developing methods to convert N_2 , CO_2 , and H_2O into essential products using renewable electricity, rather than fossil fuels.

Prof. Manthiram's most notable contribution is the creative coupling of the hydrogen oxidation reaction to lithium-mediated nitrogen reduction. By introducing novel gas-diffusion and metal-mesh electrodes, his group achieved ammonia synthesis rates under ambient conditions that were two orders of magnitude higher than prior art. This set a world record and provides the seed of an alternative to the Haber-Bosch process, which is among the most carbon-intensive industrial operations. His recent sodium-titanium tandem strategy further lowers cost and expands the scope of electrochemical nitrogen fixation.

Equally transformative is his vision for electrified oxygen-atom transfer. In *Science* (2024), Manthiram reported Pd-Pt oxide catalysts that directly epoxidize propylene using water as the oxygen source, achieving Faradaic efficiencies near 66%. This eliminates hazardous oxidants like chlorine and peroxides, showing how water-oxidation intermediates can serve as clean, versatile oxidants for organic synthesis. This work leads the field on selective oxidation, with significant implications for decarbonizing hydrocarbon upgrading.

Karthish Manthiram's other key innovations include electrochemical hydroformylation catalysts that operate faster than thermal analogues, CO_2 carboxylations of unactivated bonds, and lactonizations relevant to polymer synthesis. Each represents not just a new reaction, but a strategic leap toward electrified chemistry.

Manthiram's fearless pursuit of unconventional ideas, backed by deep mechanistic insight, is already shaping multiple areas of catalysis. His work exemplifies the Infosys Prize ideal: bold, original science with transformative potential for society.

Expanded Citation

Prof. Karthish Manthiram has redefined how electricity can be used to synthesize critical chemicals from abundant small molecules such as N_2 , CO_2 , and H_2O . In a landmark paper in *Nature Catalysis*, he demonstrated record-setting rates of ambient ammonia synthesis, overcoming diffusion bottlenecks by inventing metal-mesh electrodes for nitrogen reduction.

Prof. Manthiram then introduced palladium-platinum oxide alloy catalysts, in a paper in *Science*, to selectively epoxidize propylene from water, enabling efficient, chlorine-free production of propylene oxide.

Beyond these signature advances, his lab has electrified hydroformylation and devised sodium-titanium tandem systems that lower costs for nitrogen fixation. His creative use of the hydrogen oxidation reaction to power organic synthesis bridges electrochemistry, catalysis, and organic synthesis and is a bold new paradigm to replace fossil-based feedstocks with renewable electricity. The Infosys Prize recognizes his fearless creativity and transformative contributions to sustainable chemical manufacturing.

Jury Chair
Shrinivas Kulkarni



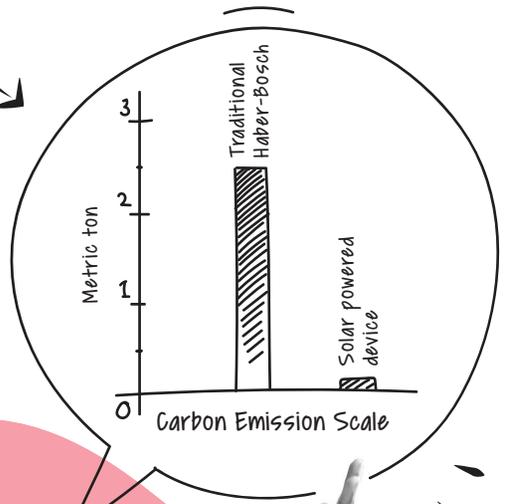
On behalf of the jury, I warmly congratulate Prof. Karthish Manthiram on receiving the Infosys Prize 2025 in Physical Sciences. His fearless creativity in electrifying the synthesis of vital chemicals—spanning ammonia, propylene oxide, and beyond—exemplifies transformative science at the interface of chemistry, energy, and sustainability. He is a brilliant role model for the next generation of physical scientists.



All you need is a little sun

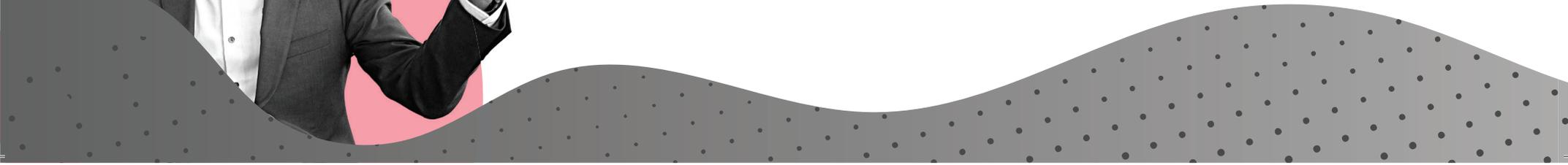
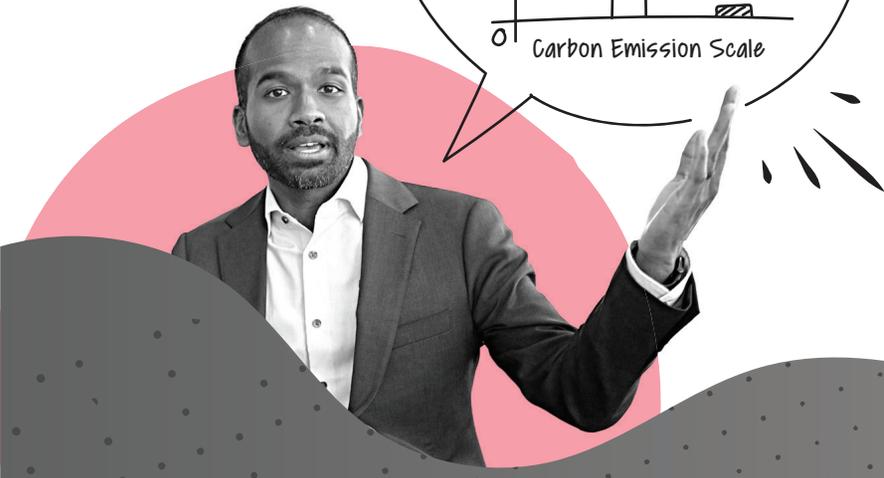
*Ammonia
and its carbon
footprint*

Ammonia is a vital ingredient for fertilizer production since nitrogen is the key nutrient for plant growth. However, the production of ammonia is a primary contributor of carbon dioxide emissions leading to climate change. As the production process involves fossil fuels, the emissions are sizeable. 70 percent of global ammonia is used in the production of fertilizer. Between 1.9 and 2.6 metric tons of carbon dioxide are generated for every ton of ammonia produced. Furthermore, in places like Africa that need to step up agricultural production to meet demand, current centralized methods of production are not feasible.



*Feeding a
burgeoning
population*

At the turn of the 20th century, as the global population grew, food production needed to be stepped up. The demand for fertilizer in agriculture increased exponentially. Industrial production of ammonia needed to produce fertilizer had to be scaled up. The German physicists Fritz Haber and Carl Bosch came up with the Haber-Bosch process of synthesizing the ammonia using water, natural gas and atmospheric nitrogen. There has been little change or innovation in this space since that time.



*Solar
powered devices
for cleaner
ammonia*

*Modular
ammonia*

Now, more than one hundred years later after the discovery of the Haber-Bosch process, Karthish Manthiram's lab has come up with a process for producing ammonia using renewable energy sources. Manthiram has developed a device that can produce ammonia from just air, water and sunlight. The process developed by Manthiram would significantly reduce carbon emissions.

The Manthiram Lab's research could revolutionize fertilizer production by making ammonia close to where it is needed. The devices are modular, meaning that they can be assembled in the areas that they are needed, so that the ammonia is made where it is demanded, thereby reducing emissions and carbon footprints further. This would help countries in Africa which have traditionally struggled with ammonia cost and distribution, affecting agricultural production.

