Podcast Interview: Daniel Nocera

PN: I’m Prashant Nair and welcome again to Science Sessions. This week, you’ll be listening to MIT chemist Daniel Nocera, who has developed what could be a nifty solution to an unyielding problem tied to solar energy – its currently prohibitive cost. Nocera, a member of the National Academy of Sciences, has fashioned an artificial leaf out of relatively inexpensive, abundant materials. He has shown that the leaf can split water into oxygen and hydrogen using nothing but sunlight; the hydrogen can then be used as a fuel. That could make harnessing solar energy an economically viable option. Clean energy has now become part of a national conversation, thanks to the growing global demand for energy. Nocera estimates that by the turn of the century the global demand for energy will hover around a staggering 43 trillion watts. Fossil fuels, like coal, oil, and natural gas, can together meet that demand handily, but they come with a hefty price – climate change caused by the emission of planet-warming gases. Which is why, Nocera believes that to meet our energy demands and minimize our carbon footprint, we need cost-effective ways to harness solar energy.

DN: If you want to be carbon-neutral, the one big heavy hitter is solar energy. It has plenty of supply in terms of its capacity. The other nice thing because it is diffuse, it’s distributed. So you don’t need to worry about building a supply chain to distribute energy. The one disadvantage of solar is it’s too expensive to penetrate market. Solar energy needs to be stored; that’s what photosynthesis does. And the reason is it’s not there all the time. When the sun’s out, you have it. You could hook up your photovoltaic and power your house, but when the sun goes down, all of a sudden, you don’t have a 24/7 energy source. So you need to figure out ways to store solar energy when the sun is shining so that at night it’s available to you. There’s one super champ of energy storage and that’s fuels, and it’s because fuels have a 100 to a 1000 times more energy density. And so, in my opinion, the challenge of storing solar energy is to make a chemical fuel.

PN: And to make a fuel using solar energy Nocera developed an artificial leaf that contains silicon, which can harvest sunlight, and catalysts, which can split water into oxygen and hydrogen. When the leaf is immersed in water and exposed to sunlight, oxygen and hydrogen bubble up to the surface. Here, he explains how it works.

DN: These molecules split water to oxygen, and it leaves four protons behind which then can be combined at another catalyst to make hydrogen. And these catalysts, they’re composed of Earth-abundant materials, so they’re inexpensive. They form spontaneously, these are things that you can literally just put in water, and under the right conditions they just spontaneously lay down on a conducting surface and begin splitting water. They have self-healing properties. We designed that purposefully; we wanted the catalyst to be able to fix itself as it was working. It can use almost any type of water because it is self-healing. So these catalysts have lots of special properties with regard to simplicity, and if it’s simple then it means that it’s going to ultimately be inexpensive.
PN: Nocera’s inspiration for the catalyst came from nature. Plants split water whenever they perform photosynthesis. So Nocera modeled his catalyst on the plant’s water splitting machinery.

DN: The structure of the catalyst looks a lot like the catalyst that splits water that’s in a plant called the oxygen evolving complex. If you take the structure of the oxygen evolving complex in a plant and double it and substitute cobalt for manganese, you get the catalyst that we’ve invented. It looks like the oxygen evolving complex in a plant and then it operates like that – because a plant operates under simple conditions, benign atmospheric, environmental conditions, and the plant is self-healing, and our catalyst is self-healing.

PN: Nocera says the artificial leaf is at the heart of project of much larger scope. He believes that the ability to store solar energy could help personalize energy production. So instead of relying on power distributed from a centralized source along the grid, each home might become its own solar power station. Nocera’s device needs further technical refinements to be truly cost-effective, and there are many engineering hurdles to overcome, but he is optimistic that in the future electric bills might become a thing of the past for many of us.

DN: Personalized energy is saying you get energy where you live, where you’re standing, on the move. And I really believe that’s the energy future. I think with the dedicated effort of science and engineering under five years we could get very, very distributed energy systems for the poor that are inexpensive enough. That’s with a dedicated effort—meaning that there’s a moral imperative of society to fund and drive science and engineering to get there within five years. If there isn’t, it’s still going to happen, but it could happen in 20-30 years.