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MIT researchers have now designed a battery material that could offer a more sustainable way to power electric cars. The new lithium-ion battery includes a cathode based on organic materials, instead of cobalt or nickel (another metal often used in lithium-ion batteries).

In a new study, the researchers showed that this material, which could be produced at much lower cost than cobalt-containing batteries, can conduct electricity at similar rates as cobalt batteries. The new battery also has comparable storage capacity and can be charged up faster than cobalt batteries, the researchers report.

"I think this material could have a big impact because it works really well," says Mircea Dinc?, the W.M. Keck Professor of Energy at MIT. "It is already competitive with incumbent technologies, and it can save a lot of the cost and pain and environmental issues related to mining the metals that currently go into batteries."

Dinc? is the senior author of the study, which appears today in the journal ACS Central Science. Tianyang Chen PhD "23 and Harish Banda, a former MIT postdoc, are the lead authors of the paper. Other authors include Jiande Wang, an MIT postdoc; Julius Oppenheim, an MIT graduate student; and Alessandro Franceschi, a research fellow at the University of Bologna.

Most electric cars are powered by lithium-ion batteries, a type of battery that is recharged when lithium ions flow from a positively charged electrode, called a cathode, to a negatively electrode, called an anode. In most lithium-ion batteries, the cathode contains cobalt, a metal that offers high stability and energy density.

However, cobalt has significant downsides. A scarce metal, its price can fluctuate dramatically, and much of the world"s cobalt deposits are located in politically unstable countries. Cobalt extraction creates hazardous working conditions and generates toxic waste that contaminates land, air, and water surrounding the mines.

"Cobalt batteries can store a lot of energy, and they have all of features that people care about in terms of performance, but they have the issue of not being widely available, and the cost fluctuates broadly with commodity prices. And, as you transition to a much higher proportion of electrified vehicles in the consumer market, it"s certainly going to get more expensive," Dinc? says.

Because of the many drawbacks to cobalt, a great deal of research has gone into trying to develop alternative battery materials. One such material is lithium-iron-phosphate (LFP), which some car manufacturers are beginning to use in electric vehicles. Although still practically useful, LFP has only about half the energy density of cobalt and nickel batteries.

Another appealing option are organic materials, but so far most of these materials have not been able to match the conductivity, storage capacity, and lifetime of cobalt-containing batteries. Because of their low conductivity, such materials typically need to be mixed with binders such as polymers, which help them maintain a conductive network. These binders, which make up at least 50 percent of the overall material, bring down the battery"s storage capacity.

About six years ago, Dinc?"s lab began working on a project, funded by Lamborghini, to develop an organic battery that could be used to power electric cars. While working on porous materials that were partly organic and partly inorganic, Dinc? and his students realized that a fully organic material they had made appeared that it might be a strong conductor.

This material consists of many layers of TAQ (bis-tetraaminobenzoquinone), an organic small molecule that contains three fused hexagonal rings. These layers can extend outward in every direction, forming a structure similar to graphite. Within the molecules are chemical groups called quinones, which are the electron reservoirs, and amines, which help the material to form strong hydrogen bonds.