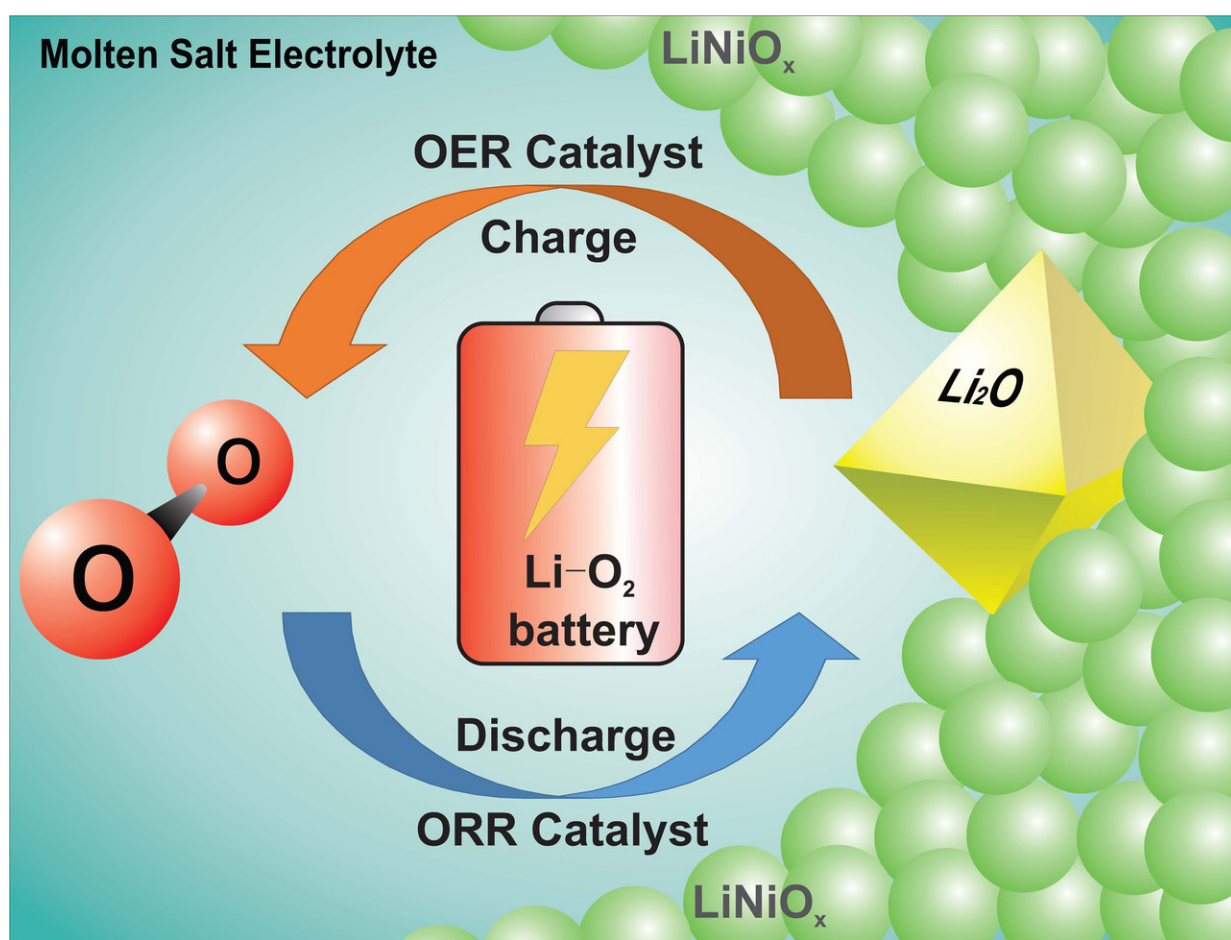


# Chemists make breakthrough on road to creating a rechargeable lithium-oxygen battery

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A four-electron redox process in a Li-oxygen cell is electrocatalyzed by a bifunctional lithiated nickel oxide-molten salt composite cathode at elevated temperature to form Li<sub>2</sub>O. It evolves oxygen on charge with close to 100% coulombic efficiency. Credit: Chun Xia and Chun Yuen Kwok

Chemists from the University of Waterloo have successfully resolved two of the most challenging issues surrounding lithium-oxygen batteries, and in the process created a working battery with near 100 per cent coulombic efficiency.

The new work, which appears this week in *Science*, proves that four-electron conversion for lithium-oxygen electrochemistry is highly reversible. The team is the first to achieve four-electron conversion, which doubles the electron storage of lithium-oxygen, also known as lithium-air, batteries.

"There are limitations based on thermodynamics," said Linda Nazar, Canada Research Chair of Solid State Energy Materials and senior author on the project. "Nevertheless, our work has addressed fundamental issues that people have been trying to resolve for a long time."

The high theoretical-energy density of lithium-oxygen ( $\text{Li-O}_2$ ) batteries and their relatively light weight have made them the Holy Grail of rechargeable battery systems. But long-standing issues with the battery's chemistry and stability have kept them a purely academic curiosity.

Two of the more serious issues involve the intermediate of the cell chemistry (superoxide,  $\text{LiO}_2$ ) and the peroxide product ( $\text{Li}_2\text{O}_2$ ) reacting with the porous carbon cathode, degrading the cell from within. In addition, the superoxide consumes the organic electrolyte in the process, which greatly limits the cycle life.

Nazar and her colleagues switched the organic electrolyte to a more stable inorganic molten salt and the porous carbon cathode to a bifunctional metal oxide catalyst. Then by operating the battery at 150

C, they found that the more stable product  $\text{Li}_2\text{O}$  is formed instead of  $\text{Li}_2\text{O}_2$ . This results in a highly reversible Li-oxygen battery with coulombic efficiency approaching 100 per cent.

By storing  $\text{O}_2$  as lithium oxide ( $\text{Li}_2\text{O}$ ) instead of lithium peroxide ( $\text{Li}_2\text{O}_2$ ), the [battery](#) not only maintained excellent charging characteristics, it achieved the maximum four-electron transfer in the system, thereby increasing the theoretical energy storage by 50 per cent.

"By swapping out the electrolyte and the electrode host and raising the temperature, we show the system performs remarkably well," said Nazar, who is also a University Research Professor in the Department of Chemistry at Waterloo.

**More information:** C. Xia et al., "A high-energy-density lithium-oxygen battery based on a reversible four-electron conversion to lithium oxide," *Science* (2018). [science.sciencemag.org/cgi/doi ... 1126/science.aas9343](https://science.sciencemag.org/cgi/doi/10.1126/science.aas9343)

Provided by University of Waterloo

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