Ball milling provides high pressure benefits to battery materials

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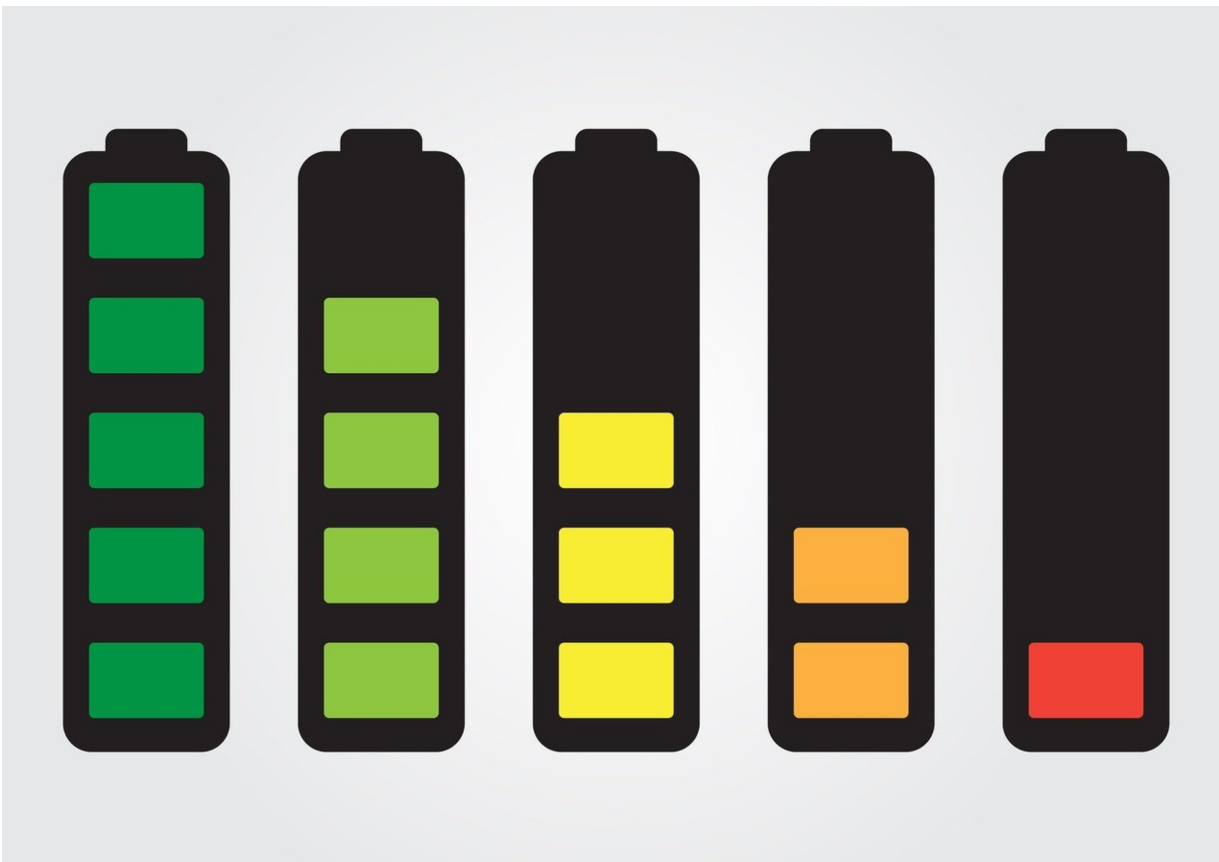

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Cheaper, more efficient lithium-ion batteries could be produced by harnessing previously overlooked high pressures generated during the manufacturing process.

Scientists at the University of Birmingham have discovered that routine ball milling can cause high pressure effects on battery materials in just a matter of minutes, providing a vital additional variable in the process of synthesizing battery materials.

The research, led by Dr. Laura Driscoll, Dr. Elizabeth Driscoll and Professor Peter Slater at the University of Birmingham is published in *RSC Energy Environmental Science*.

The use of ball milling has been a huge area of growth in the lithium-ion battery space to make next generation materials. The process is simple and consists of milling powder compounds with small balls that mix and make the particles smaller, creating high-capacity electrode materials and leading to better performing batteries.

Previous studies had led experts to believe that the synthesis of these materials was caused by localized heating generated in the milling process. But now researchers have found that dynamic impacts from the milling balls colliding with the battery materials create a pressure effect that plays an important role in causing the changes.

Peter Slater, Professor of Materials Chemistry and Co-Director of the Birmingham Centre for Energy Storage at the University of Birmingham, said, "This discovery was almost an accident. We ball milled lithium molybdate as a model system to explore oxygen redox in batteries, and noticed that there was a phase transformation to the high-pressure spinel polymorph, a specific crystal structure that has only previously been made under high-pressure conditions.

"Local heating alone could not explain this transformation. To test this theory, we then ball-milled three other battery materials and our findings from these milling experiments reinforced our conclusion that local heating could not be the only reason for these changes."

The researchers also found that applying heat would cause some compounds to return to their pre-milled state, signifying that an additional variable was at play in the original synthesis: pressure being key.

As an example, production of the high-pressure spinel polymorph of Li_2MoO_4 was only previously achieved in a high temperature and high-pressure chamber under a pressure more than 10,000 times the pressure of Earth's atmosphere. The new research shows, however, that just a few minutes of ball milling can have the same effect.

Co-author Dr. Elizabeth Driscoll said, "This discovery provides the opportunity to develop cheaper, more energy efficient processes for battery manufacturers, and also to explore avenues for new materials. We found similar results, for example, when we ball-milled disordered rocksalt phases, which could be the key to producing better performing batteries.

"This improved understanding of the effect of ball milling on battery materials is incredibly exciting for researchers in this space, but also for the future of battery development as we were able to show that from five minutes of ball milling we could achieve the transformations that would usually require energy-intensive and specialist equipment.

"As we move towards an increasingly electric future in order to limit pollution and reach net zero, it is vital that we continue to expand our knowledge and understanding of battery technology, so we can create the most efficient batteries possible. Our findings open the door to a world of new possibilities and discoveries and will hopefully play a part in a greener future for us all."

More information: Laura L. Driscoll, Under Pressure: Offering Fundamental Insight into Structural Changes on Ball Milling Battery Materials, *RSC Energy Environmental Science* (2023).

Provided by University of Birmingham

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