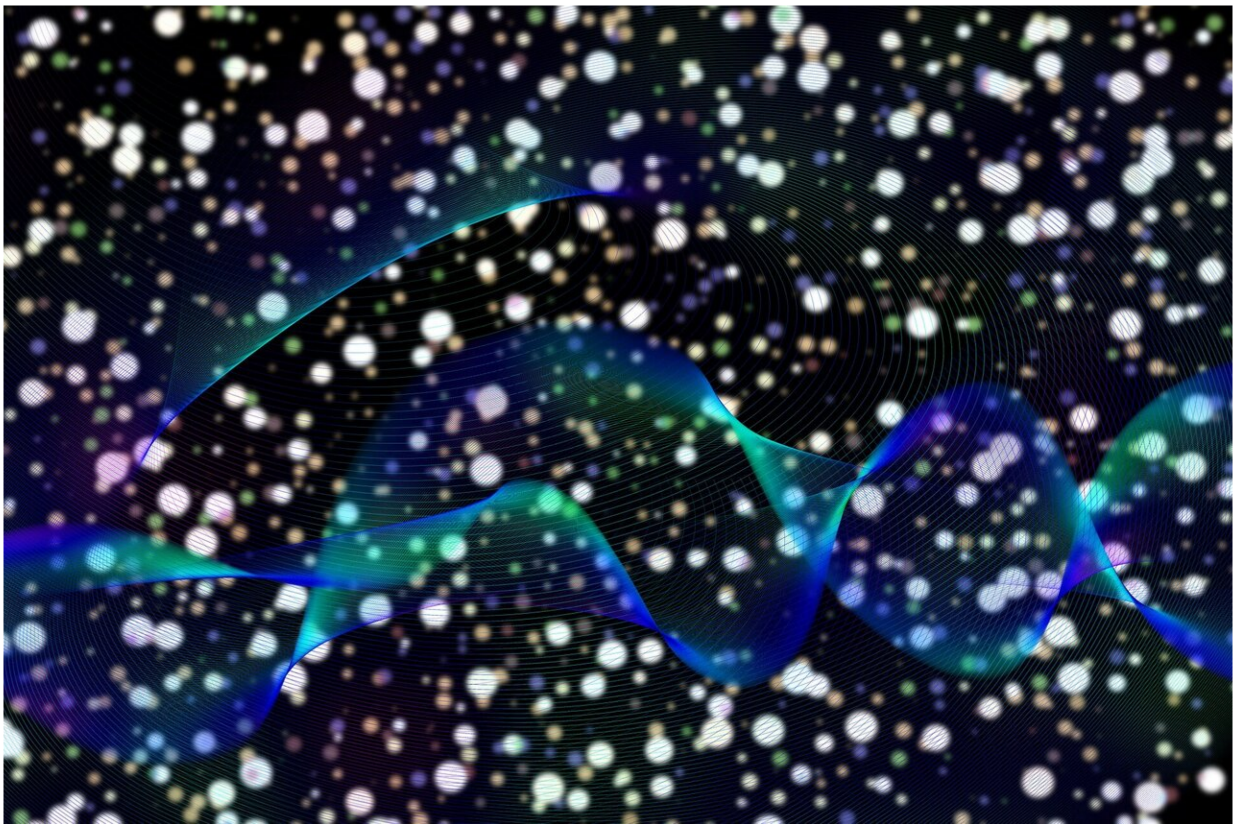
Research touts lower-cost, longer-life battery

August 18 2020, by Jeff Renaud



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New materials engineering research led by Western could translate into significant real-world benefits like greater range for electric vehicles and longer battery life for cell phones.

Researchers from Western Engineering, Western's department of chemistry and Soochow University-Western University Center for Synchrotron Radiation Research collaborated with the Canadian Light Source (CLS) at the University of Saskatchewan on a pair of studies to determine if they could harness the might of phosphorene while mitigating its two main deterrents—cost and durability—and they've done it.

The theoretical capacity of phosphorene—a two-dimensional material, which consists of a single layer of black phosphorus—is almost seven times that of anode materials currently used in lithium-ion batteries. Currently, commercially-available black phosphorus is costly, at roughly $1,000 per gram and it also breaks down quickly when it is exposed to air.

In the first paper, the research team applied a novel process to produce a low-cost black phosphorus from inexpensive (approximately $0.10/gram), low-purity red phosphorus—reducing the cost by almost 300 percent. The resulting black phosphorus had nearly the same purity and electronic properties as that made using traditional methods and high-purity red phosphorus, which is worth around $40/gram.

Drastically slashing the cost of manufacturing black phosphorus means their results are scalable, according to lead researcher Weihan Li from Western.

"The low price makes it possible to realize the future large-scale application of black phosphorus and phosphorene in energy- and electronic-related fields, such as nano-photonics, nanoelectronics, optoelectronics, secondary batteries, and electrocatalysts," said Li, a postdoctoral fellow jointly supervised by chemistry professor T.K. Sham, Canada Research Chair in Materials and Synchrotron Radiation and engineering professor Xueliang (Andy) Sun, Canada Research Chair in Development of Nanomaterials for Clean Energy.

With the second study, the researchers wanted to better understand, at nanoscale and in real time, where degradation (oxidization) starts on phosphorene, and how it spreads. While previous research has documented that degradation does indeed occur, this study was the first to clearly image the process in detail. The team used a number of different synchrotron techniques at the CLS to collect these images. The researchers found that phosphorene begins to break down at the thinnest regions first, and that the degraded regions accelerate the breakdown of adjacent regions.

According to Li, their discovery paves the way for developing strategies to protect phosphorene when it is used in electronics and other devices.

"It makes it possible to prepare air-stable phosphorene-based electronic devices and energy-related devices," said Li.

Sun credits the CLS for playing a critical role in both studies.

"Compared with other resources in the world, the user support from the CLS is fantastic," said Sun. "Without the help of the CLS, we could not have combined several different synchrotron techniques in the two works. Moreover, conducting the in-situ studies would not have been possible without the help of the beamline scientists."

More information: Weihan Li et al. Phosphorene Nanosheets Exfoliated from Low-Cost and High-Quality Black Phosphorus for Hydrogen Evolution, *ACS Applied Nano Materials* (2020). DOI: 10.1021/acsanm.0c01101

Weihan Li et al. Phosphorene Degradation: Visualization and Quantification of Nanoscale Phase Evolution by Scanning Transmission X-ray Microscopy, *Chemistry of Materials* (2020). DOI: 10.1021/acs.chemmater.9b04811

Provided by University of Western Ontario