Ultrafast metal-ion batteries based on new organic cathode material have been developed

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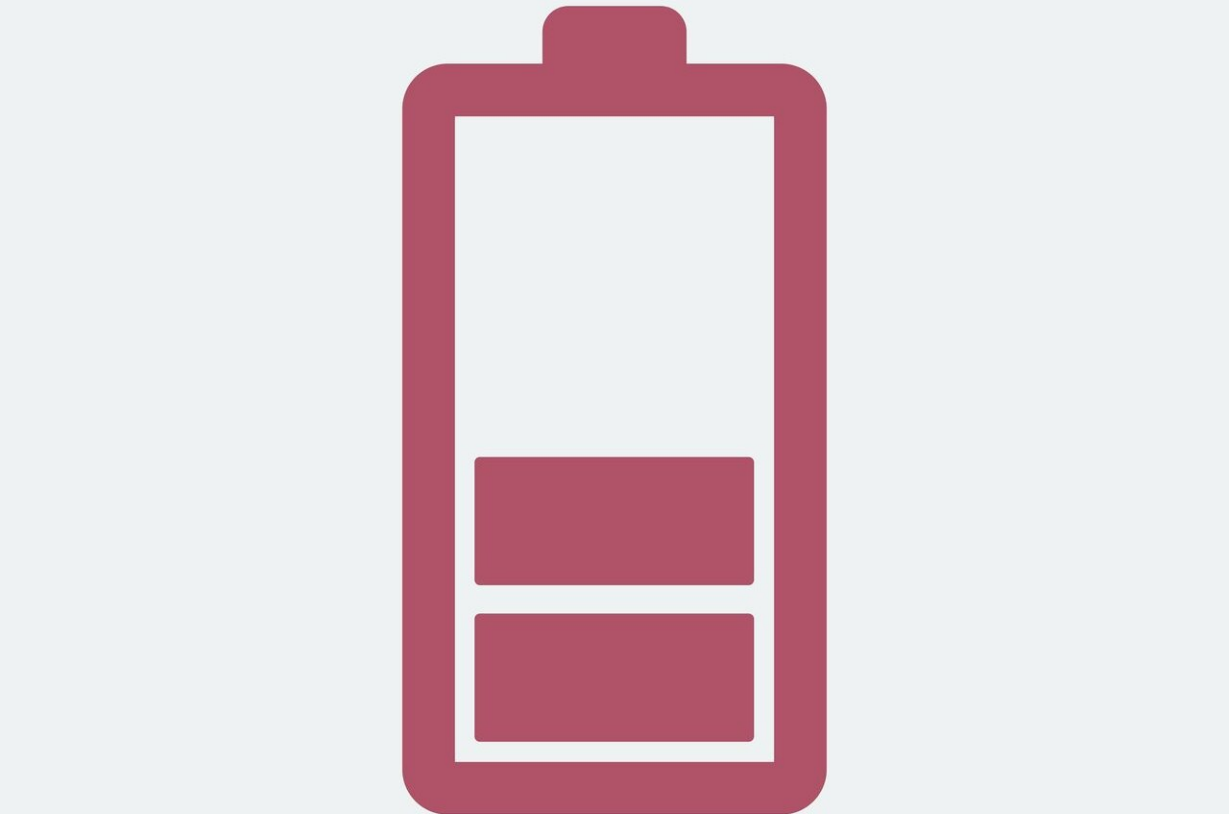

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Researchers from Skoltech Center for Energy Science and Technology, IPCP RAS and D.I. Mendeleev University of Chemical Technology have

designed a new polymer cathode material for ultrafast metal-ion batteries with superior characteristics. The results of this work were published in the *Journal of Material Chemistry A*.

In recent decades, world energy consumption has been increasing significantly due to the population growth, industrialization and the development of a large variety of household appliances and electronics, with a particular increase in the number of mobile devices and electric vehicles. There is therefore an urgent need to develop electrochemical energy storage technologies and devices capable of storing sufficient amounts of energy and releasing it quickly on demand. Despite the fact that lithium-ion batteries based on inorganic layered oxides and phosphates dominate the market, further enhancing their performance is challenging since they are composed of heavy elements restricting the achievable capacity.

This problem can be solved by application of organic compounds as cathode materials. Organic cathodes offer such advantages as high energy density, impressive charge/discharge rate capability and good resistance to strong mechanical deformations. Another important advantage is their environmental friendliness, since organic materials are comprised of only naturally abundant elements (C, H, N, O, S) and can be obtained from renewable resources. In the absence of heavy metals, their recycling can be done in the same way as for common household waste, e.g. food plastic. Moreover, the use of organic cathodes allows one to replace expensive lithium salts in the electrolyte with much cheaper sodium and potassium analogs.

Among the numerous projects of Professor Pavel Troshin's research team, special attention is paid to the design of novel polyphenylamine type compounds, which represent one of the most promising families of organic cathode materials for metal-ion batteries.

"Cathode materials based on polytriphenylamine and its analogues described in the literature demonstrate rather outstanding characteristics in metal-ion batteries. In particular, they demonstrate high discharge potentials, good cycling stability, and can operate at high charge/discharge rates. However, low specific capacities limit commercialization of this group of materials. Therefore, we focused our efforts on molecular design and synthesis of a new group of macromolecules, which potentially can deliver a higher energy density. Indeed, one of the designed materials demonstrated an excellent performance while charged and discharged at the current rates of up to 200C (full charge and discharge takes 18 seconds only, editor's note). It is important that besides lithium, we also succeeded in assembling sodium- and potassium-ion batteries based on the same material," says the first author of the published work, Skoltech Ph.D. student, Filipp Obrezkov.

Thus, the obtained results confirm a significant potential of using organic compounds as cathodes for ultrafast metal-ion batteries. Further development of this project may result in the development of a new generation of battery materials with even higher specific capacity and energy density achievable at high current densities, which are urgently needed to satisfy the current and future demand on the portable devices and electric vehicles market.

More information: Filipp A. Obrezkov et al, An ultrafast charging polyphenylamine-based cathode material for high rate lithium, sodium and potassium batteries, *Journal of Materials Chemistry A* (2019). DOI: 10.1039/C8TA11572A

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