Alternative to nitrogen: Oxygen plasma can improve the properties of electrode materials

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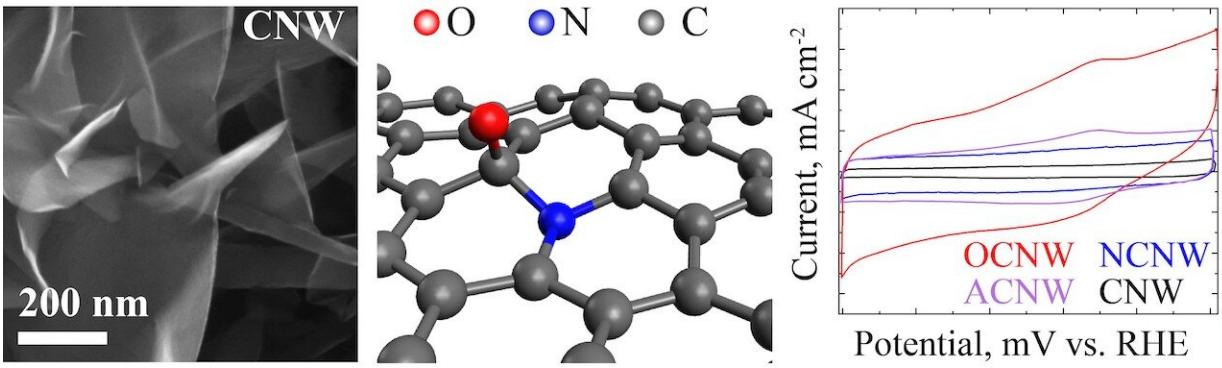

SEM image of Carbon NanoWalls (CNW), a possible position of oxygen and nitrogen heteroatoms, cyclic voltammetry curves in acidic electrolyte. Credit: Skolkovo Institute of Science and Technology

A group of scientists from Skoltech and Lomonosov Moscow State University (MSU) showed that nitrogen is not the only element that can help enhance the specific capacitance of supercapacitors.

The advancement of renewable energy sources calls for new materials with enhanced electrochemical performance. Electrodes in electrochemical current sources are most often made of carbon. The properties of carbons are improved using a whole panoply of surface modification techniques, such as adding metal oxides, creating multilayer coatings or expanding the specific surface area. Incorporating

the doping atoms of nitrogen, fluorine, chlorine and other elements in the carbon lattice is a recent trend in surface modification that dramatically alters the material's electrochemical characteristics without 'contaminating' the electrolyte solution during charging and discharging.

Earlier, Skoltech scientists showed that embedding nitrogen into the carbon lattice multiplies the electrochemical capacitance. Recently, the same team from the Skoltech Center for Design, Manufacturing and Materials (CDMM) and their colleagues from MSU have looked into the effect of nitrogen and oxygen heteroatoms on the material's electrochemical characteristics.

"We modified the carbon materials' surface using DC plasma in atmospheres of nitrogen, oxygen, and their mixture, so as to implant oxygen and nitrogen atoms in the carbon lattice. By changing the plasma contents, one can control surface functionalization," explains Stanislav Evlashin, the first author of the paper and a senior research scientist at Skoltech.

Modifying the carbon lattice by other atoms disrupts its structure and makes it less 'perfect,' which leads to a change in the electrochemical characteristics.

Electrochemical measurements in an acidic medium revealed the highest oxygen content and electrochemical capacitance in the samples modified in oxygen plasma. The results of the study suggest that nitrogen is not the only enhancer of the supercapacitors' specific capacitance and oxygen is sometimes even more effective. The scientists attribute the result both to surface functionalization (i.e. imparting new properties to the surface) and the changes in the crystal lattice. Unlike nitrogen, oxygen is much easier to insert in the crystal lattice.

The scientists' findings will contribute to the development of new

generation supercapacitors.

More information: S. A. Evlashin et al, Role of Nitrogen and Oxygen in Capacitance Formation of Carbon Nanowalls, *The Journal of Physical Chemistry Letters* (2020). DOI: 10.1021/acs.jpclett.0c01274

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