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Editorial Note on Advanced Lithium Ion

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EDITORIAL NOTE

A substance was found that should have the unusual property of being able to store and lose electrons without the normal redox reactions associated with it. The redox-less method, expected to occur in a material based on fluoride-ion, could allow next generation batteries to be long-lasting, high power.

Atoms in their electrodes turn from positive to negative charges in a traditional battery, such as lithium-ion, and vice versa, when they lose or gain electrons as the battery charges or discharges. This suggests that the material's atoms are diminished or oxidized, allowing the electrodes of the battery to shrink or rise in thickness, in some cases by up to 30 percent. This inevitably allows electrodes to break through several charging and discharge cycles and reduces battery life and output.

'Scientists are so used to assuming that electrons can only be contained on atoms, that everybody thought that electron transfer was a natural consequence of reduction and oxidation'. But eight years ago, Warren asked if there could be a substance in which negative ions could be exchanged and replaced by electrons.

Today, Warren's laboratory has been active in studying a class of materials called electrides. This have a matrix structure that keeps electrons separated from atoms, giving the likelihood of electrons acting like negative ions and thereby completely avoiding redox reactions. Computer simulations led the researchers to possible candidates for electrons, the most interesting being yttrium difluorocarbene (Y2CF2), which models say would reversibly lose the fluoride ions to become [Y2C]2+(e-)2, where the two fluoride ions are substituted by two electrons.

'Fluoride-ion batteries are one of the most technically interesting in the quest for high-energy density battery chemistry that can exceed industrial lithium-ion and empower innovative applications such as electric travel,' says Mauro Pasta, who researches energy storage at Oxford University, UK. Electrids could become one of the most promising high-capacity active fluoride-ion battery materials if validated experimentally.

"With a battery electrode that has both atoms and electrons, during the discharge process of the battery, we can lose electrons, but the atoms within the material do not oxidize or decrease," Warren states. 'Because an electron swaps for a fluoride, and the substance barely changes volume because the electron appears to be the same size as the fluoride.' This means that there would not be cracking and lack of energy to the same degree as in traditional batteries.

What's more, the team finds that the existing commercial lithium-ion batteries have twice the power of its redox-less battery system. For every three host atoms, this is because translating Y2C to Y2CF2 stores two fluoride ions. Meanwhile, for every three host atoms, the strongest lithium-ion batteries store one lithium ion.

However, as most known electrides are heavy and can only store a minimal amount of charge, the suggestions that it would have 'no practical significance for fluoride-ion batteries'.