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Proton Conduction at High Temperature in High-Symmetry Hydrogen-Bonded Molecular Crystals of Ru^{III} Complexes with Six Imidazole–Imidazolate Ligands

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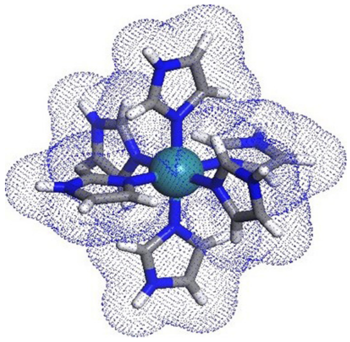

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Invited for the cover of this issue is mainly the group of Makoto Tadokoro and co-workers at Tokyo University of Science. Other co-workers are Masaki Itoh, Ryota Nishimura, Kensuke Sekiguchi (TUS students), Dr. Norihisa Hoshino (Tohoku Univ.), Dr. Hajime Kamebuchi (Nihon Univ.), Dr. Jun Miyazaki (Tokyo Denki Univ.), Prof. Motohiro Mizuno (Kanazawa Univ.) and Prof. Tomoyuki Akutagawa (Tohoku Univ.). The image depicts on two mechanisms of proton transport rotations of the proton-conductive starburst molecule $[Ru^{III}(HIm)_3(Im)_3]$. Read the full text of the article at 10.1002/chem.202201397.

What is the most significant result of this study?

Fuel cells often fall short when it comes to operating at temperatures beyond 100 °C owing to their dependence on water as a proton conduction medium. To overcome this issue, a team of Prof. Tadokoro and co-researchers designed a new hydrogen-bonded starburst-shaped metal complex consisting of ruthenium(III) ion coordinated six imidazole-imidazolate groups, operating multi-proton careers with high temperature stability. The resulting single molecular crystal shows excellent proton conductivity even at temperatures as high as 180 °C. Then, the proton transport mechanisms in the high temperature region are not only clarified on heavy rotations of individual six imidazole groups, but also whole molecular rotation becomes the main one above 130 °C.

How would you describe to the layperson the most significant result of this study?

As the world is moving towards more environmentally friendly and sustainable sources of energy, fuel cells are receiving a lot of attention. The main advantage of fuel cells is that they use hydrogen, a clean fuel, and produce only water as a by-product while generating electricity. This new and clean source of electricity could replace conventional lithium-ion batteries, which currently power all modern electronic devices. Therefore, imidazole, a nitrogen-containing organic compound, has been considered a promising candidate for developing a high-temperature proton conductor. However, imidazole has a very low proton transfer rate and melts at 120 °C. To overcome this issue, we introduced the new strategy of six imidazole moieties into a ruthenium(III) ion to design a new metal complex operating multi-proton careers with high temperature stability.

What do you consider the exiting developments in the field?

Our team believes that their study could act as a new driving principle for proton-conducting solid-state electrolytes. The insights from their novel molecular design could be used to develop new high-temperature proton conductors as well as improve the functionality of the existing ones. "Fuel cells hold the key to a cleaner and greener tomorrow. Our study offers a roadmap for improving the performance of these carbon-neutral energy resources at high temperatures by designing and implementing molecular proton conductors that can transfer protons efficiently at such temperatures".