C4-FN-based gas mixtures can be used as alternatives to SF_6 in high voltage equipment. SF_6 has a high dielectric strength and excellent current interruption properties, but also has a high global warming potential. C4-FN-based gas mixtures have a much lower global warming potential than SF_6, while at the same time having a similarly high dielectric strength, permitting the design and construction of equipment that is as compact as SF_6 equipment for the same rating. Compact equipment not only takes less space and permits optimal use of the limited land resources available, but it also minimizes CO_2-equivalent emissions related to manufacturing, resulting in lower overall CO_2-equivalent emissions when considering all sources of emissions (life-cycle assessment).

Mixtures of C4-FN, CO_2, and O_2 have been demonstrated to have excellent current interruption performance in gas circuit breakers and many such circuit breakers are already installed and operating in the power grid. The special reporter has raised a question regarding the variety of C4-FN based gas mixtures that exist for use in electrical equipment and specifically mentioned oxygen. In this contribution we address this question—focusing on circuit breakers—and point out that oxygen is an important constituent of C4-FN-based gas mixtures designed for use in high-voltage circuit breakers. The most important reason for using oxygen is that, in its absence, decomposition of C4-FN can result in the formation of solid, conductive carbon (graphite). The presence of conductive deposits on insulating materials can lead to reduced dielectric strength, initiation of partial discharge, and even initiation of flashovers in high-voltage equipment and should be avoided. Extensive laboratory tests have been performed that confirm that exothermic reaction of C4-FN with oxygen does not result in any practical problems for gas mixtures used in electrical equipment, even when considering severe conditions, such as internal arc faults.

Controlled laboratory tests to assess C4-FN decomposition were performed on a circuit breaker test device. The test device was based on a live-tank circuit breaker with a rating of 145 kV, 40 kA (short-circuit current), 3150 A (rated current). Special gas-sampling equipment was designed to acquire gas samples remotely and automatically during short-circuit current arc tests. In those tests the initial oxygen concentration in the gas mixture was varied in a controlled way. A clear qualitative difference was observed in the amount and color of the switching dust generated when comparing tests performed with gas mixtures that contained no oxygen and tests that contained 10 mol% oxygen. In the absence of oxygen, the switching dust had a darker color, a different consistency, and a higher electrical conductivity.

Thus, it is important for C4-FN-based gas mixtures used in circuit breakers to include oxygen. The presence of oxygen prevents the formation of solid, conductive carbon that can reduce the dielectric withstand voltage at the surfaces of insulating material in the equipment.