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RAPIDLY EXPLORING AND DESIGNING ELECTRON TRANSPORT QUANTITIES IN DIELECTRIC GAS INSULATOR MIXTURES WITH APPROXIMATION THEORIES

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Abstract. Presently, most high voltage electrical infrastructure relies on SF_6, which is known as the most potent greenhouse gas with a global warming potential (GWP) approximately 23 500 times that of CO_2, and with an anticipated lifetime of up to 3200 years. To date, a number of replacements to SF_6 have been deployed in the power industry, such as dry air, N_2, CO_2, or various admixtures of natural and proprietary synthetic gases [Tian *et al.*]. Despite some adoption of replacements with lower GWP, the widespread global use of SF_6 prevails where it has not yet been bettered on an engineering basis for insulation and/or current quenching requirements. Driving the effort towards replacing SF_6 is research performing dielectric breakdown experiments or swarm experiments to characterise insulating gases. In addition to time and financial factors, there are many complexities and challenges in adequately performing and interpreting experimental measurements and so theory and simulation are vital methods to assist and complement experiments.

We discuss a semi-analytic method for approximating the density-reduced critical electric field for arbitrary mixtures of gases from swarm data of pure gases. This then enables a quick and affordable scan of very large parameter spaces of material choices or design configurations. The computational sieve approach to rapidly explore, trial, and assess potential scenarios can then inform the design of targeted experiments. We outline the theoretical basis of the approximation from electron fluid conservation equations, and validate how a mixture's critical electric field can be computed from the transport data of electrons in the pure gases. We demonstrate validity of the method in mixtures of N_2 / O_2, and SF_6 / O_2. We highlight an application of the method to approximate the critical electric field for mixtures of SF_6 and HFO1234ze(E), in which a positive synergy of an elevated critical electric field is seen in mixtures. To improve the utility of the proposed methods, we conclude with a demonstration of extending the presently published method [Garland *et al.*], which uses computed swarm coefficients, towards using only experimentally measured quantities.

References

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