UNDERSTANDING & PARAMETRIZATION OF PLASMA DISCHARGES THROUGH ADVANCED NUMERICAL MODELING: APPLICATIONS IN CO_2 CONVERSION AND HIGH-VOLTAGE POWER GRIDS

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ABSTRACT

Non-thermal plasma discharges gain significant momentum as an alternative, sustainable, electrified path to enable chemical processes at low temperature and beyond thermodynamic limitations [1]. At the same time and in the energy sector, they pose hazards for the safe and reliable operation of low-loss, high-voltage distribution and transmission grids [2]. In both fields, a deep understanding of complex plasma physics and different discharge regimes as well as a quick but accurate parametrization of plasma induced effects is essential. In this work, we show how advanced modeling through self-consistent plasma simulations can foster both this understanding and parametrization. First, we focus on plasma-assisted direct CO_2 splitting, and present numerical results of a coaxial packed bed Dielectric Barrier Discharge (DBD) reactor [3], unveiling spatiotemporal inhomogeneous, glow to streamer to surface discharge transitions which significantly impact the CO_2 conversion efficiency: CO molecules and O atoms are mainly formed during each microdischarge and streamer-surface ionization waves development. Then, we report on partial discharge (PD) ignition in H_2 bubbles floating in biobased dielectric oils, the latter being the insulation medium of a high-voltage (HV) transformer configuration. In this scope, we parametrize the PD ignition voltage over various operating and geometrical parameters (worked conducted in the framework of the SSTAR EU funded project [4]) . Emphasis is put on the multiscale (both in time and space) nature of plasma discharges, the limiting factors for efficient plasma modeling and guidelines for the development of robust plasma modeling tools incorporating multi-physical aspects.

KEYWORDS: Plasma discharges, Plasma chemistry, CO_2 splitting, partial discharge, high-voltage grids

REFERENCES

[1] Miao, Yu, et al. "Application-oriented non-thermal plasma in chemical reaction engineering: A review." Green Energy and Resources (2023): 100004.

[2] Zaitsev, Ievgev O., and Vladislav V. Kuchanskyy. "Corona discharge problem in extra high voltage transmission line." Systems, Decision and Control in Energy II (2021): 3-30.

[3] Kourtzanidis, Konstantinos. "Full cycle, self-consistent, two-dimensional analysis of a packed bed DBD reactor for plasma-assisted splitting: spatiotemporal inhomogeneous, glow to streamer to surface discharge transitions." Plasma Sources Science and Technology 32.10 (2023): 105016.

[4] https://sstar-project.eu/