From renewable fuels to oxygen production on Mars by means of CO_2 plasma-assisted decomposition

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The study of CO_2 plasmas has a long history that can be traced back to the 60s with the investigation on CO_2 kinetics applied to the development of the CO_2 lasers. Nowadays, this subject is once again receiving a special attention due to its importance for the production of CO_2-neutral fuels and the possibility of *in situ* resource utilization on Mars. The first point is driven by the goal of transforming CO_2 into high-energy density chemicals that can integrate energy storage pathways. This would offer large-scale energy storage capacity, with the potential to decrease atmospheric CO_2 emissions. The second point relates to the idea of oxygen production on Mars by converting CO_2 directly from the Martian atmosphere. This would provide a supply of oxygen and a source of fuel for future manned missions. Both topics require a detailed description of the plasma-assisted CO_2 dissociation mechanisms and a comprehensive knowledge on the various kinetics associated to CO_2 plasmas, involving electron, vibrational, chemical and surface interactions. In this work we present our recent modeling and experimental efforts, aiming at understanding CO_2 plasmas, with special emphasis at describing the mechanisms responsible for molecular dissociation. This talk is divided in two parts. In the first part, we present an experimentally-validated and self-consistent model targeting at establishing a reaction mechanism of non-thermal CO_2 plasmas. The model couples the electron Boltzmann equation to a rate balance equations involving ~70 CO_2 individual vibrational states. The kinetic scheme and the corresponding rate coefficients are validated via comparison between the model predictions and recent experimental data, both attained during this investigation and already available in literature. In the second part, we present a joint experimental and theoretical investigation focused on the differences between CO_2 plasmas operating on Earth and on Mars, with special interest on the understanding of the mechanisms leading oxygen production.

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