

**EXPERIMENTAL EVALUATION OF ENTROPY GENERATION EXTREMA IN LOW
TEMPERATURE PLASMA CHEMISTRY**

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ABSTRACT

The concept of thermodynamic equilibrium has been valuable for predicting the direction of chemical reactions in systems governed by local equilibrium, as well as establishing a theoretical maximum for conversion and yield. Low temperature plasmas are open driven systems characterized by extreme nonequilibrium, wherein chemical species have different temperatures by more than an order of magnitude, at the same location in space. Such systems have been proposed to be governed by superlocal equilibrium, where the new term means temperature is local in both space and species. There are no established methods based upon thermodynamics for predicting the direction and maximum extent of chemical reactions in a low temperature plasma as a function of the state variables. There is an idea from nonequilibrium thermodynamics that a stationary end-state should be reached, for a given set of constrained variables, at which the entropy generation rate reaches an extremum. In systems that operate near equilibrium, it is believed that the unconstrained variables should arrange themselves to minimize the entropy generation rate at the stationary state. On the other hand, for systems that operate very far away from equilibrium, it has been proposed that the unconstrained variables should arrange themselves to maximize the entropy generation rate at steady state. Considering these opposing viewpoints, it is unclear what to expect for chemical reactions in low temperature plasmas. In this work, experimental data, from measurements of chemical reactions in a well-characterized low temperature plasma, will be used to test the two opposing hypotheses for the extremum of the entropy generation rate. The results of this work contribute evidence to the general debate about the entropy generation rate extremum in systems that operate far from equilibrium. The evidence can be used in assessments of the general applicability of the maximum entropy production principle, which has far ranging consequences for nonequilibrium systems such as human societies and the terrestrial environment.

Keywords: Plasma chemistry, superlocal equilibrium, maximum entropy production, nonequilibrium thermodynamics, entropy generation.