RE³ Workshop 2017
Renewable Energy & Energy Efficiency

David Graves

UC Berkeley

Air Plasma to Improve Nitrogen Utilization Efficiency

Current worldwide fixed nitrogen utilization efficiency (NUE) is low, leading to significant environmental problems. For example, NH3 released from bacterially degraded, N-containing organic waste such as animal manure, if not trapped, will escape to the environment, triggering a series of damaging reactions. [1] One way to improve NUE employs air plasma to create NOx followed by water absorption to form HNO3. Acidifying organic waste with nitric acid traps NH3 as NH4NO3, thus increasing the nitrogen content of the resulting organic fertilizer and reducing the environmental effects of NH3 emission. This technology would reduce but not eliminate the need for synthetic fertilizers by recycling otherwise wasted NH3. Fixing nitrogen this way uses only electricity, air, water and a source of organic waste containing nitrogen. Plants could be relatively small and located near organic waste sources. Large ammonia plants are located mostly where inexpensive natural gas is available. The proposed technology would replace some of this natural gas use with distributed, renewable sources of energy. The barrier to this technology is the currently low energy efficiency of atmospheric pressure air plasma processes. I will review the evidence that atmospheric pressure air plasma creates NOx via non-equilibrium processes, probably due to the formation of high N2 vibrational and/or electronic energy levels from electron impact excitation. The plasma channels the applied electrical energy into chemically active states before the energy can be degraded into non-productive heat, but many details are not understood. Preliminary results to increase plasma process energy efficiency by combining air plasma with heterogeneous catalysis need to be bolstered and expanded with understanding of the electron-driven, tandem plasma-catalysis process. The successful implementation of plasmas for this application could help motivate study for other plasma electro-catalytic applications in chemical processing.

[1] J. Galloway et al., “The Nitrogen Cascade,” BioScience, 53(4), 341-356, 2003.