Clarkson University
Department of Chemical and Biomolecular Engineering
SEMINAR (Student Presentation)

"Unraveling the Significance of Transport Effects in the Design of Plasma Reactors for Water Treatment Applications"

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Nonthermal plasma (NTP) processing has been applied in the areas of surface modification, waste treatment, nanomaterial synthesis, and biomedicine. Moreover, some NTP-based technologies have already become integral to the respective industries, e.g., etching or wound healing. However, NTP application to wastewater treatment on an industrially viable scale has been limited. Developing a robust NTP reactor for water treatment is a multifaceted endeavor that requires careful consideration of the relevant physicochemical phenomena. Unfortunately, the understanding of microscopic (i.e., interfacial chemistry) and macroscopic (i.e., reactor scale mixing) processes is incomplete and requires further investigation.

This work combined bulk liquid chemistry measurements and fluid dynamic investigations to develop a holistic description of critical physical and chemical processes relevant to NTP reactor performance toward the degradation of dissolved contaminants. The bulk liquid chemistry measurements revealed the rates of contaminant degradation and plasma-generated reactive species production. Meanwhile, the hydrodynamic investigations enabled characterization of the key flow features and their effect on contaminant transport toward the plasma-liquid interface. The results revealed three contaminant degradation regimes: (1) The convection-limited regime, in which degradation rates are proportional to both characteristic flow velocity and solute bulk liquid concentration; (2) The diffusion-limited regime, in which the degradation rates are proportional to solute bulk liquid concentration; (3) The reactive species limited regime, in which degradation rates are proportional to the rates of plasma-induced reactive species production. The discovered regimes were correlated to microscopic states of the plasma-liquid interface, and a generalized criterion for optimal utilization of plasma-generated species by dissolved contaminants was developed. An efficient NTP reactor design was developed based on the findings. The proposed reactor design exhibits high energy efficiencies (G_{50} > 100 g/kWh) and meets the energy requirement target for a viable industrial water treatment process (E_{EO} < 1 kWh/m^3).

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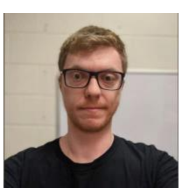
CAMP 175



Mikhail (Michael) Vasilev is a PhD candidate working in the plasma research laboratory at Clarkson University under the guidance of Dr. Selma Mededovic Thagard. Michael's research interests lie in mass transport characterization of electrical discharge reactors. Prior to joining Clarkson University, he graduated with a Master's degree in Chemical Engineering at Texas A&M University – Kingsville.