Project Description:
Microwave decomposition of methane does not generate CO/CO₂ byproducts or consume water resources like conventional steam reforming, so the need for water-gas-shift and CO₂ removal stages, along with stock desulphurization and steam generation are eliminated. Microwave plasma processing offers reaction intensification, opening opportunities for reducing system costs and producing portable, modular, reactor systems for remote locations and stranded natural gas resources. This project’s objectives included: 1) optimizing reactor design and process conditions for hydrogen production, testing the capability to tune carbon product characteristics, 2) evaluating methane conversion, product yields and selectivity, 3) determining impact upon carbon and hydrogen production for other natural gas components, and 4) analyzing the reactor energy requirements and process CO₂ benefits.

Project Funding:
$213,163

Project Duration:
12/01/2018 – 08/30/2021

Technology Line:
Fuel Cell Technologies
Accomplishments:
This study addresses the capability to tune product characteristics by evaluating the selectivity of product yields and forms. Gas mixture composition governs the dominant carbon form. Diluting methane with inert gases promotes formation of the 2D nanographene structures: e.g. CH\textsubscript{4}/Ar ratios of the order of 1:10 are well-suited for NG formation, while addition of H\textsubscript{2} improves the graphitic quality of both nanographene and graphitic carbon black forms. Conversely, high concentrations of methane favor formation of 3D structured carbon aerosols similar in form to a graphitic carbon black. Characterization by TEM, XRD and TGA reveal structural features of the two forms. Additive tests using a pre-formed carbon black show that while the MW plasma heating is intense (causing partial annealing), it does not appear to cause disaggregation or disassembly of the carbon particles. Their intact form and assemblies rule out their hypothesized deconstruction as the path for nanographene formation. Overall, the attractive economic profile and environmental footprint of the microwave plasma pyrolysis enables coproduction of clean hydrogen.

A new form of carbon was also produced by the microwave plasma process. Structurally it is analogous to a “gold-standard” conductive carbon black known as Ketjen black (Akzo-Nobel). H Quest Vanguard, Inc. considers this a valuable carbon form and viable commercial product.

NETL Collaboration:
Dr. Lekse served as the point of contact for both collaborative efforts with whom experimental options (at NETL) were to be identified. A CRADA was established in December 2020; however, it was not implemented before the project ended because NETL was not staffed due to COVID-19.

Relevant Presentation: