AFR Technology Provides Safer and Cheaper Manufacturing of Energetic Materials

S2719 — Advanced Flow Reactor (AFR) Energetics Manufacture

Objective

N-alkyl-N-(2-nitroxyethyl) nitramines (NENAs) have been demonstrated to be effective energetic plasticizers in gun propellants while reducing sensitivity to unplanned stimuli relative to nitroglycerin. The use of NENAs in gun-propelling charges has increased the demand for NENA materials; thus, sustainable manufacture of NENA blends requires investment to demonstrate and document a safe, economical method. A fully continuous process is envisioned as the solution.

The scope of this Energetics Manufacturing Technology Center (EMTC) project is to adapt the existing batch co-nitration chemistry to a continuous Advanced Flow Reactor (AFR). The co-nitration synthesis of methyl/ethyl NENA is planned as the design criteria for the AFR. Methyl/Ethyl NENA is produced via separate methyl and ethyl batch syntheses, followed by physical blending to create the 58% methyl / 42% ethyl ratio. Co-nitration of the two components provides improvements by reducing the number of reactions and has been demonstrated at the laboratory scale.

Butyl NENA synthesis is planned as a second NENA demonstration.

Payoff

Continuous nitration via AFR offers a number of benefits compared to batch NENA processes. Batch synthesis utilizes multiple reactors to complete the two-step synthesis, as well as flow-on wash and separations. Through consolidation, a continuous process will provide improvements in the following areas.

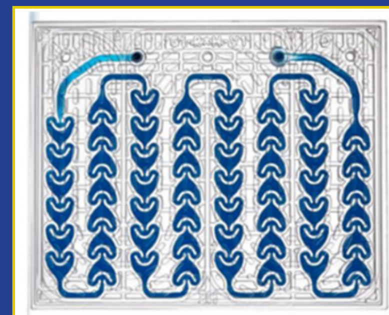
Improved Safety – The actual amount of material participating in the nitration reaction at any given time is reduced from the multi-gallon batch reactor size to grams at the continuous flow reactor size. Due to the small quantity undergoing the synthesis reaction, there is a much higher contact surface area with the temperature control plates for a given reaction volume, resulting in better heat transfer and reaction temperature control, as well as prevention of runaway reactions.

Improved Product Quality – Reaction kinetics are more stable with consistent reaction temperatures and heat transfer. Once the continuous flow reaction has reached a steady state, material produced will have consistent quality from start to finish.

Reduced Footprint – Production rates for an AFR unit with an anticipated footprint of 24 square feet will be comparable to production rates utilizing standard batch reactors that would occupy a footprint of 2,490 square feet, including associated chillers and temperature control units, which equates to a 100-times reduction in plant footprint.

Implementation

The successful completion of this project will result in a fully operational NENA production facility at Naval Surface Warfare Center Indian Head Division capable of producing metric tons of material annually, as well as a demonstrated methyl/ethyl NENA and butyl NENA production capability that meets existing reference quality requirements.



PERIOD OF PERFORMANCE:
October 2016 to December 2022

PLATFORM:
Energetics / Navy Gun-Launched Systems

CENTER OF EXCELLENCE:
EMTC

POINT OF CONTACT:
Mr. Charles R. Painter
(301) 744-6772
charles.r.painter@navy.mil

STAKEHOLDER:
PEO IWS, 3C

TOTAL MANTECH INVESTMENT:
$3,170,000