Argonne NATIONAL LABORATORY

SCALABLE PROCESSES FOR MANUFACTURING TAILORED NANOMATERIALS IN CONTINUOUS FLOW REACTORS

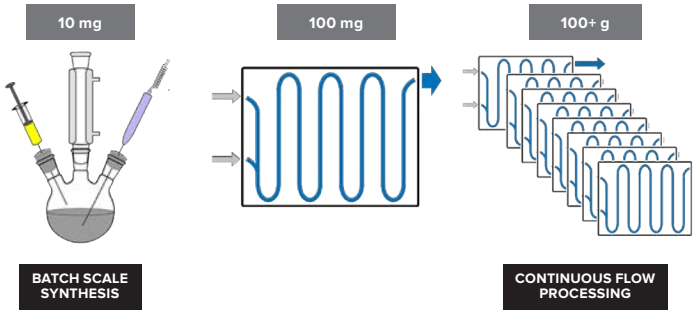
OVERVIEW

Argonne National Laboratory is developing a process based on microfluidic continuous flow reactor technology to automate the tuning of nanomaterial parameters to attain desired properties. This will create the first program in the U.S. that enables the rapid process optimization, scale up and transition of nanomaterials from discovery to manufacturing. This technology platform also will increase efficiency and production control of complex hard-to-make emerging nanomaterials that currently can only be produced in limited quantities through small scale batch processing. It also will lower the cost by expediting the discovery and evaluation of new catalyst architectures and eliminate costly trial-and-error approach based on batch-to-batch syntheses.

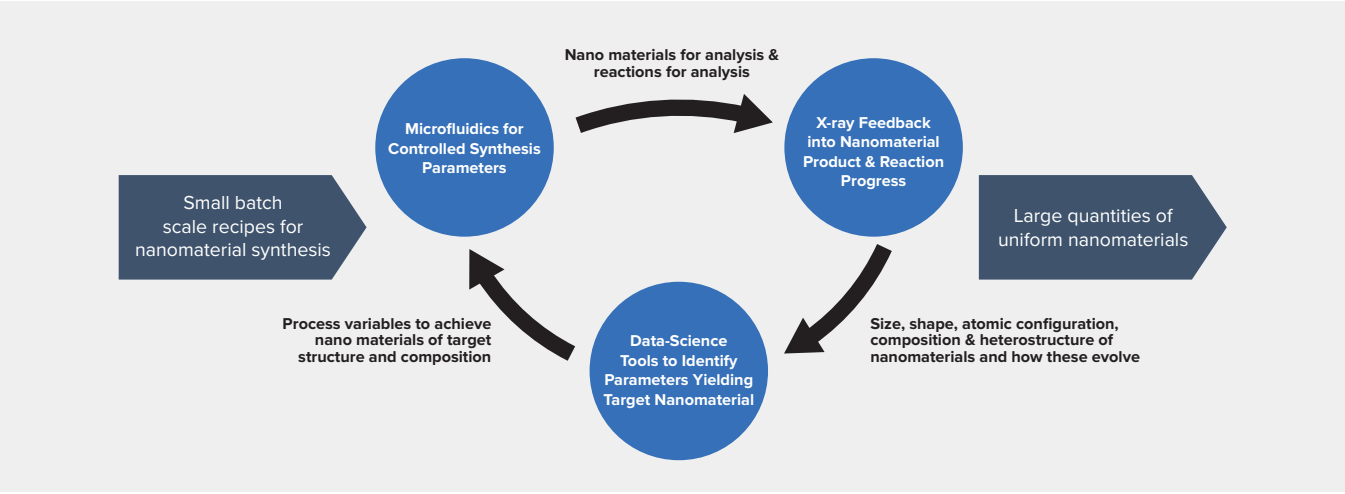
The continuous flow process will make possible an affordable manufacturing of nanomaterials for a wide variety of applications, including catalysts for use in chemical manufacturing and electrocatalysts for fuel cells. Argonne has world-leading expertise and a suite of cutting-edge R&D tools for in-situ and ex-situ nanomaterial characterization and a machine learning-based platform to support science based manufacturing.

INDUSTRIAL BENEFITS OF ARGONNE'S CONTINUOUS FLOW PROCESSING OVER BATCH PROCESSING

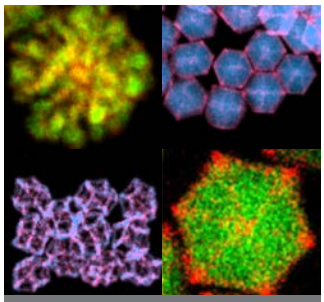
- Expedite optimization of process parameters for desired nanomaterial composition and morphology
- Accelerate new material transition to market by eliminating the need to scale up from batch processing
- Reduce cost and manufacturing steps needed for scaling up batch processes
- Provide uniform, high quality materials by eliminating batch-to-batch variability
- Increase the safety of manufacturing processes under high pressures or temperatures
- Simplify on-demand production of complex chemicals in multi-step processes
- Expedite new material development by enabling faster screening and production
- Accelerate identification of new tailored catalyst architectures for process intensification



INTEGRATED APPROACH



ARGONNE HOUSES ALL THE NEEDED EXPERTISE AND CAPABILITIES



Expertise in development and batch synthesis of advanced nanomaterials

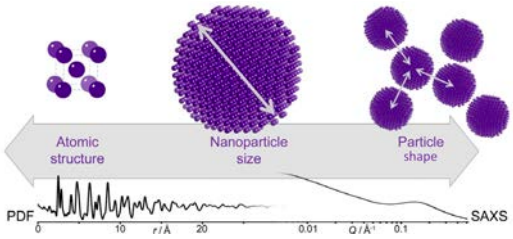
Materials Engineering Research Facility (MERF) for scale up of advanced materials

Advanced Photon Source (APS) for in-situ, real-time studies of reactions in synthesis pathways under operating conditions in microfluidic cells

Argonne Leadership Computing Facility (ALCF) for high-performance computing simulations and machine learning

APS supports a suite of techniques capable of understanding the nanomaterial structure and reaction process:

- Pair Distribution Function (PDF) analysis
- Small Angle X-ray Scattering (SAXS)
- X-ray Absorption Near Edge Structure (where oxidation state is important)



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Kris Pupek
Project Lead
Argonne Design Works
Phone: 630-252-1547
Email: kpupek@anl.gov
argonnedesignworks.anl.gov