NATIONAL ENERGY TECHNOLOGY LABORATORY

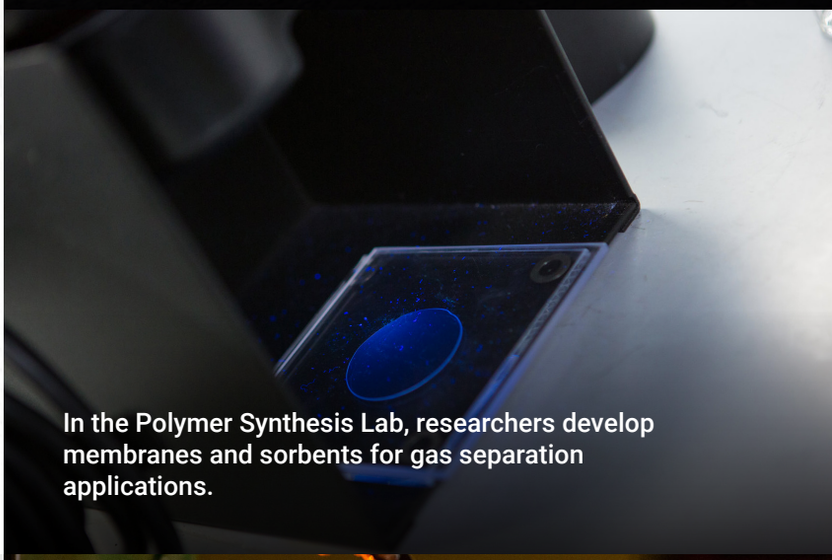
Advanced Energy Materials

NETL is a national leader in the discovery, development, and deployment of advanced materials that support the nation's energy systems and industrial infrastructure. Leveraging expertise in computational modeling, laboratory research, and field validation, NETL advances both high-performance structural materials for extreme environments and functional materials critical for next-generation sensing, separations, catalysis, and energy conversion technologies. Progress in these areas strengthens energy delivery, enhances manufacturing competitiveness, and enables new opportunities across sectors.

R&D Applications

- Advanced, Intelligent Manufacturing of Alloys
- Advanced Material Performance in Severe Environments
- Corrosion-Resistant Materials
- Coatings and Surface Treatments
- Alloy-Based Catalysts and Electrochemical Technologies
- Cathode Infiltration Technologies
- Catalysis for Material Development and Computational Work
- Sorbents for Gas Separation and Mineral Recovery
- Advanced Sensing Technology for Infrastructure Resilience

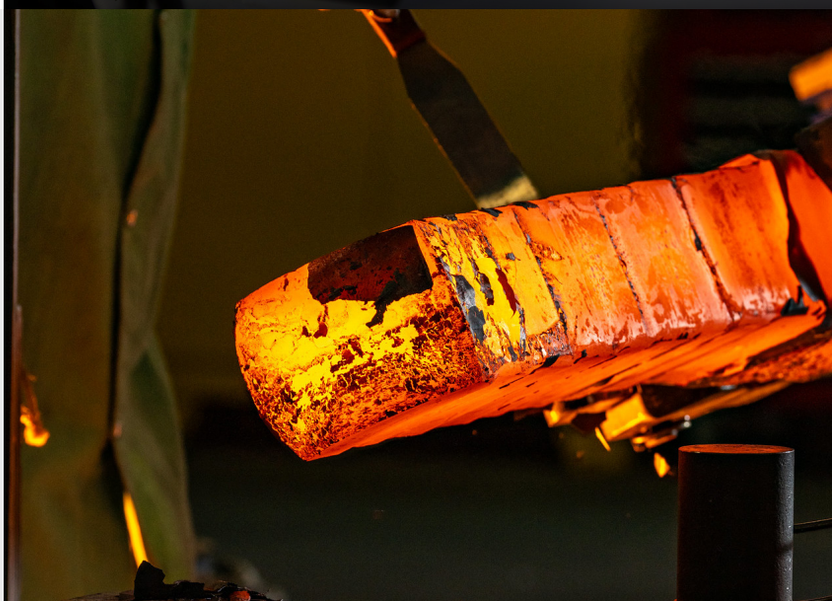
Researchers use the Metals Melting Facility to design unique materials for service in extreme environments.



In the Polymer Synthesis Lab, researchers develop membranes and sorbents for gas separation applications.

Cerium Alloy Strengthens Pipelines

Structural materials researchers at NETL have produced a stronger pipeline by using the rare earth element cerium to create a tougher steel alloy. The cerium eliminates the negative impacts of sulfur and oxygen impurities during the steel manufacturing process. Testing shows that the new alloy can improve the steel's ability to absorb energy and resist cracking by up to 50%.



Research Highlights

Novel Method Demonstrates Twentyfold Alloy Lifetime Improvement Potential

NETL researchers have developed a process to significantly increase the strength of alloys used in energy applications and other sectors. The process leverages industry-relevant manufacturing methods to carefully apply pressure and heat in a way that modifies the microstructure of the alloy, making it incredibly resistant to deformation at high temperatures. The process has demonstrated the potential to increase the service life of existing alloys by over 20 times, without the need to invest in any specialized equipment.

Scalable Anticorrosion Coating for Pipelines

Internal corrosion is a crucial problem for natural gas pipelines. NETL researchers have developed a superhydrophobic porous coating that is corrosion-resistant and can be produced at a large scale. The new spray coating method changes how the nanoparticles are assembled, reducing the assembly time and eliminating wastewater.

Accelerating Ultradeep Drilling Technology

NETL is developing a novel, ultradeep drilling simulator to better understand drilling dynamics. The simulator will help improve the technology's rate of penetration and materials performance at temperatures exceeding 480°F and pressures up to 30,000 pounds of force per square inch, which is up to three times greater than the pressure and temperature ranges of other drilling simulators.

High-Performance Gas Separation Membrane

A collaboration between NETL and Idaho National Laboratory successfully created a viable coating suitable for high-performance gas separation membranes (U.S. Patent No. 11,866,555). The innovation is particularly effective for carbon dioxide separation from flue gas. This product is the first successful cross-linking technique for polyphosphazenes that allowed the material to retain most of its properties for carbon dioxide separations.

Publications

- Hardy, M. C., Detrois, M., McDevitt, E. T., Argyrakis, C., Saraf, V., Jablonski, P. D., & Tin, S. (2020). Solving recent challenges for wrought Ni-base superalloys. *Metallurgical and Materials Transactions A, 51*, 2626-2650. https://doi.org/10.1007/s11661-020-05773-6.
- Oleksak, R. P., Detrois, M., Jablonski, P. D., Rozman, K. A., & Doğan, Ö. N. (2024). Influence of rare earth Ce additions on microstructure and mechanical properties of experimental pipeline steels. *Steel Research International, 95*(3), 2300652. https://doi.org/10.1002/srin.202300652.
- Pham, V. H., Wang, C., Gao, Y., Weidman, J., Kim, K. J., & Matranga, C. (2024). Synthesis of microscopic 3D graphene for high-performance supercapacitors with ultra-high areal capacitance. *Small Methods*, *8*(9), 2301426. https://doi.org/10.1002/smtd.202301426.
- Romanov, V. N. (2022). Adversarial ensemble modeling of multi-modal mechanical properties for iron-based alloys. *JOM*, *74*(4), 1414-1422. https://doi.org/10.1007/s11837-022-05163-w.
- Xiang, F., & Hopkinson, D. (2024). *Scalable anti-corrosion coating based on porous superhydrophobic structure* [Presentation]. MS&T24, Pittsburgh, Pennsylvania, United States. https://www.osti.gov/servlets/purl/2459261.

NETL is a U.S. Department of Energy (DOE) national laboratory dedicated to innovating and accelerating the nation's energy solutions in hydrocarbons, geothermal energy, and critical minerals production. The Lab further strengthens its impact by engaging with industry, academia, and other stakeholders through four strategically located Centers of Excellence: Coal, Critical Minerals & Advanced Alloys, Oil & Gas, and Geothermal. With research sites in Albany, Oregon; Morgantown, West Virginia; and Pittsburgh, Pennsylvania, NETL operates as one laboratory to create advanced energy technologies that support DOE's mission and enable affordable, reliable and, secure energy to fuel human prosperity.

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