NEW TECHNOLOGY SCOUTING REPORT
No. 1/2025

Reported PI technologies vs products/processes (numbers correspond to news item#)

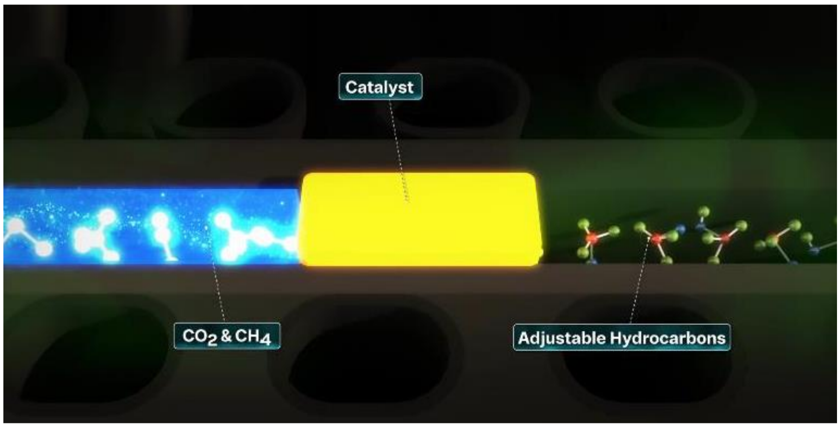
PRODUCTS & PROCESSES / PI TECHNOLOGIES	Ammonia	CCUS	Critical metals	Heat integration	Hydrogen	Isocyanate synthesis	Oil separation	Pyrolysis	Small hydrocarbon synthesis	Solids handling	Steel production
Cavitation							10				
Continuous flow						14				15	
Dividing wall column				12							
Electric processing	7	8									
Electrochemistry									9		
Heat exchange				11,13							
Microwave								4			
Plasma	2	1	3								
Water electrolysis					5,6				6		5

CLUSTER TAGS denote selected news about PI-technologies that are relevant for one or more topic clusters related to global industrial challenges and megatrends: SUSTAINABILITY, DIGITALIZATION, NEW (ADVANCED) MATERIALS and MODULARIZATION

CLUSTER TAGS: SUSTAINABILITY, MODULARIZATION

1. Cold plasma start-up wins CHEManager Innovation Pitch 2024

The Leipzig-based technology start-up EnaDyne (https://www.enadyne.de/en/) won the CHEManager Innovation Pitch 2024 in the "Value to Sustainability" category. EnaDyne is developing a revolutionary reactor technology that uses cold plasma to convert CO_2 and hydrogen carriers into sustainable chemicals and fuels in a single step. The central element of this technology is an innovative ceramic-based electrode material that offers several key advantages:



- Groundbreaking energy efficiency: The technology operates at moderate temperatures and ambient pressure, enabling the production of end products with the same or even lower energy consumption compared to traditional, fossil fuel-based processes.
- Versatile applicability: Plasma catalysis is a platform technology that enables a wide variety of synthesis processes. These include the production of C1-C4 hydrocarbons such as ethylene, methanol or formaldehyde from CO_2 in combination with a hydrogen carrier, as well as the production of green ammonia and numerous other chemical compounds.
- Economic flexibility: As an electricity-based system, plasma catalysis offers short start-up and shut-down times, which offers advantages in many sustainable use cases while reducing maintenance costs.
- Modular scalability: Its modular, container-based design makes the technology a mass-producible, drop-in solution, enabling rapid global rollout to biogas plants, industrial point sources, or the energy sector.
- EnaDyne's plasma catalysis is not only economically attractive but also plays an important role in the fight against climate change. By converting CO_2 into useful products, it reduces greenhouse gas emissions, defossilizes the chemical industry, and promotes the development of a sustainable and profitable, circular economy.

CHEManager

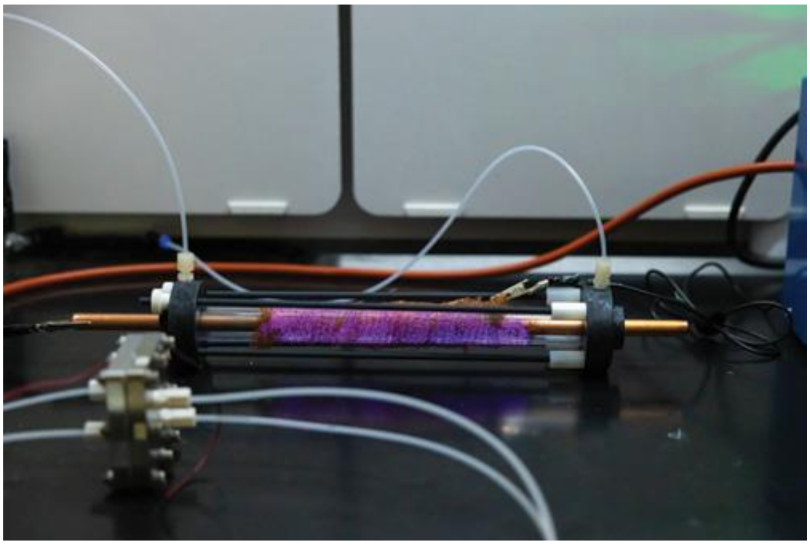
Innovation Pitch article: https://www.chemanager-online.com/news/and-winners-are-cynio-enadyne-und-green-li-ion
Read CHEManager's interview with EnaDyne: https://www.chemanager-online.com/news/der-tesla-fuer-die-chemie

CLUSTER TAG: SUSTAINABILITY

2. Plasma plays a part in cleaner ammonia production

Despite the abundance of nitrogen and hydrogen, industrial ammonia synthesis remains an energy-intensive process. Electrochemical methods have been suggested as potentially lower energy alternatives to traditional ammonia synthesis, but these newer technologies often struggle with achieving key performance metrics. By integrating a plasma field with an electrochemical reactor, a new technology developed at the State University of New York at Buffalo (SUNY Buffalo; www.buffalo.edu) is able to efficiently produce ammonia from only air and water at room temperature.

The dual nature of the technology helps overcome the challenges of other alternative ammonia-synthesis routes. The advantage of plasma is its ability to readily break nitrogen triple bonds, but it lacks the selectivity to direct the reaction toward ammonia. Conversely, electrochemical systems enable conditions for ammonia selectivity, but they experience difficulties with nitrogen activation.



Within the plasma-electrochemical process, air, the primary reactant, is humidified with water and passed through a plasma field, where nitrogen is broken into reactive species. These reactive nitrogen species then recombine with oxygen and hydrogen to form a complex mixture of NOxHy compounds. This mixture is fed to an electrochemical reactor, where the NOxHy compounds are selectively converted into ammonia. The team has stably operated a reactor system producing around 1 g/day of ammonia for over 1,000 h.

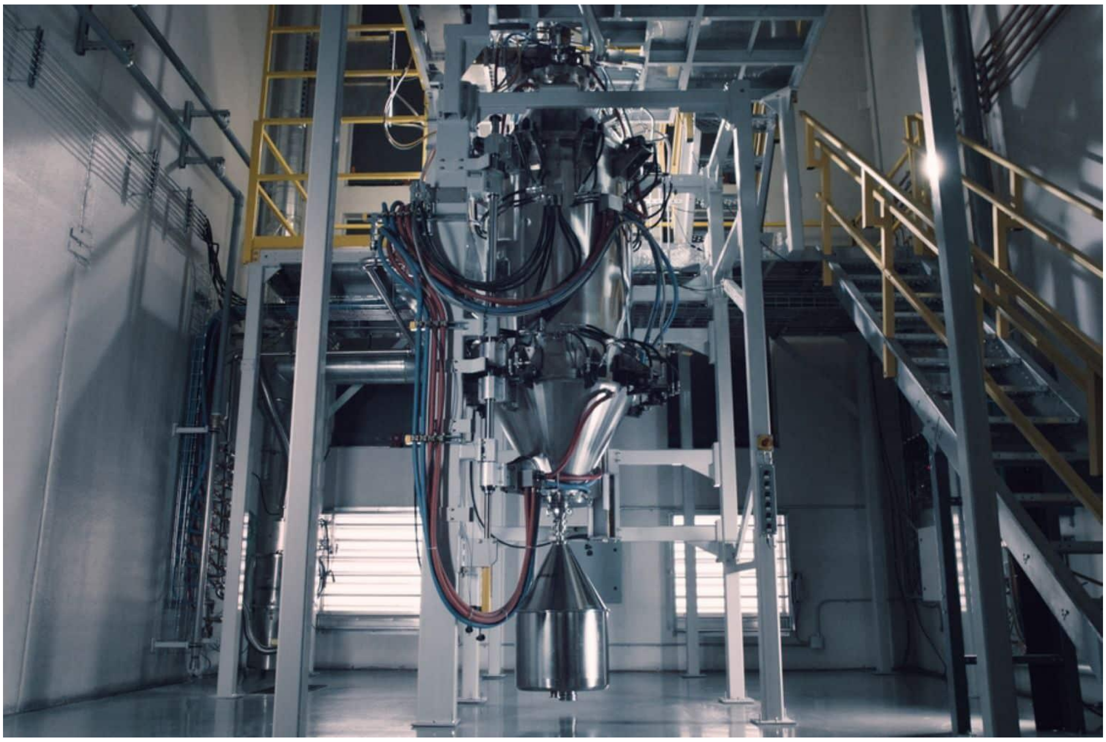
Chemical Engineering, March 2025 Issue

CLUSTER TAGS: SUSTAINABILITY, NEW (ADVANCED) MATERIALS

3. MIT's microwave plasma technology recovers critical materials

Making critical materials today creates toxic byproducts and environmental hazards. 6K (https://www.6kinc.com/) uses a new production process to recover critical materials without toxic byproducts. The company is scaling its microwave plasma technology, UniMelt, which uses controlled thermal plasma to melt or vaporize materials into precise particles. This technology converts metals like titanium, nickel, and refractory alloys into particles for additive manufacturing in various industries. It also creates battery materials for electric vehicles, grid infrastructure, and data centers. Microwave plasma technology had several advantages over traditional techniques. It can eliminate several high-energy steps, reducing production times from days to hours. For batteries and critical minerals, the process also works with recycled feedstocks. The technology completely eliminates toxic waste and recycles all byproducts, including water.

Today, 6 K's additive manufacturing operates out of a factory in Pennsylvania. The company's systems can produce about 400 tons of material annually and make more than a dozen types of metal powders. To expand its battery materials business, 6K is building a 100,000-square-foot production facility in Jackson, Tennessee. When construction is complete next year, the company says it will produce 13,000 tons of material annually.



Inceptive Mind

https://www.inceptivemind.com/mit-technology-brings-critical-materials-production-toxic-byproducts/41736/

CLUSTER TAG: SUSTAINABILITY, MODULARIZATION

4. Commercialization of continuous microwave assisted pyrolysis modules

Lummus and Resynergi have commercialized Continuous Microwave Assisted Pyrolysis (CMAP) Modules. The technology has the ability to convert plastic waste into circular pyrolysis products significantly faster and more efficiently than traditional pyrolysis methods.

Unlike conventional pyrolysis, Resynergi CMAP Modules use microwave energy to break down plastic molecules faster, with significant reduction in CO_2 emissions compared to conventional polymer production. Its modular design allows for rapid deployment, making it possible to install and operate units in months rather than years.

Process Worldwide

https://www.process-worldwide.com/lummus-resynergi-announce-commercialization-of-cmap-modules-a-71904f5710ee53e629e724dbf5cf984a/?cmp=nl-a4c38030-50a7-41e2-b488-959594b07e4f&uuid=B9F278CE-FE14-4C1B-86B2-1213ADF9EE12

CLUSTER TAG: SUSTAINABILITY

5. Hydrogen plant powers sustainable steel production

In September 2023, Swedish steel manufacturer Ovako opened the world's first plant to produce fossil-free hydrogen for heating steel before rolling. The new hydrogen plant is located at the Hofors steel mill, around 200 km north of Stockholm. Electrification efforts began in earnest in 2012 for its heat treatment furnaces. Melt shops and heat treatment furnaces now run on fossil-free Nordic electricity, reducing emissions significantly. The remaining challenge was the heating furnaces, which reach 1,200°C using fossil fuels like liquid petroleum gas (LPG) to heat steel to the required temperature for hot-rolling. Producing hydrogen through water electrolysis offers an indirect form of electrification for the heating furnaces, bypassing the need for fossil fuels entirely. Ovako conducted its first lab tests using hydrogen to heat steel for rolling in 2019. A year later, the process was tested in the actual furnaces, which showed that the switch to hydrogen had no effect on the quality of the steel.

The Hofors mill now operates a 20-MW alkaline electrolyzer, comprising eight electrolyzer stacks, capable of producing 3,880 cubic meters of hydrogen per hour, along with oxygen. By using fossil-free hydrogen, the plant has the potential to reduce the site's carbon footprint by 20,000 tons a year.

The electrolyzer is located near the furnaces at Hofors, allowing the hydrogen production process to be seen as 'borrowing' water for a short time. The plant takes water from the local supply and splits it into hydrogen and oxygen. These are then combined again to create oxyfuel, which is injected into the furnace. When burned, the oxyfuel returns to water. This approach requires only a few minutes of storage as a buffer for fluctuations in production and demand.

Hydrogen Tech World

https://hydrogentechworld.com/fossil-free-hydrogen-plant-powers-progress-in-sustainable-steel-production

CLUSTER TAGS: SUSTAINABILITY, MODULARIZATION

6. BASF Inaugurates water electrolyzer at Ludwigshafen Site in Germany

Germany's largest proton exchange membrane (PEM) electrolyzer has begun operations at the BASF site in Ludwigshafen. The plant for the production of CO_2-free hydrogen has a connected load of 54 MW and will produce up to one ton per hour of the site's critical chemical feedstock. The electrolyzer is expected to reduce greenhouse gas emissions at BASF’s main plant by up to 72,000 metric tons per year.

The water electrolyzer, built in collaboration with Siemens Energy, is embedded in the production and infrastructure at the Ludwigshafen site, making it unique worldwide in its interface and integration into a chemical production environment. A total of 72 so-called stacks – modules in which the actual electrolysis process takes place – were installed in the plant.

The emission-free production of hydrogen – using electricity from renewable sources – represents an important cornerstone for the market ramp-up of chemical products with a reduced carbon footprint. The hydrogen produced will be fed into the site's integrated hydrogen grid and from there made available to the production plants as a raw material. In addition to using it as a starting material for chemical products, BASF plans to make the hydrogen available, for example, for mobility in the Rhine-Neckar metropolitan region to support the development of a regional hydrogen economy.

Hydrogen is used, among other things, in the production of ammonia and methanol and is required for the production of vitamins. Currently, hydrogen at the Ludwigshafen site has primarily been produced using natural gas-based steam reforming or as a co-product or by-product. With the electrolyzer, BASF is now taking an important step in the technological transition for H_2 production.

CHEManager and Process Worldwide

Article in CHEManager: https://www.chemanager-online.com/news/basf-nimmt-54-mw-wasserelektrolyseur-betrieb

Article in Process Worldwide: https://www.process-worldwide.com/basf-inaugurates-water-electrolyzer-at-ludwigshafen-site-in-germany-a-8f37064a4084b7eaab56546fe376394e/?cmp=nl-a4c38030-50a7-41e2-b488-959594b07e4f&uuid=B9F278CE-FE14-4C1B-86B2-1213ADF9EE12

CLUSTER TAG: SUSTAINABILITY

7. World's largest electric ammonia cracking system successfully tested

Syzygy Plasmonics and Lotte Chemical have commissioned and completed performance testing of the world's largest all-electric ammonia cracking system in Ulsan, South Korea. This marks the second installation of Syzygy's Rigel reactor cell, the other being located at the company's demonstration facility in Houston, Texas.

While many agree that low-carbon hydrogen will play a major role in reducing global emissions, transporting it to energy importing countries is difficult and costly because it must be compressed, liquified, and transported at -253°C. Combining nitrogen with low-carbon hydrogen from regions with ready access to renewable electricity yields low-carbon ammonia, which is easier to store and transport. When it arrives on location, the ammonia can be cracked with Syzygy's Ammonia e-Cracking systems to provide the low-carbon hydrogen energy importers need. Successful testing of this technology sets the stage for opening the hydrogen economy.

The Rigel cell immediately hit desired performance levels and operated flawlessly throughout all phases of the trial. Steady-state operation eclipsed previous performance, and by manipulating flowrate and light intensity during separate testing phases, the cell produced all-time best achievements of 11 kWh/kg, 81 % energy efficiency, 99 % conversion, and 290 kg/day of hydrogen. Data from this trial gives Syzygy a clear pathway to achieve 8 kWh/kg of hydrogen at the cell level in future Rigel cell designs. The plan is now to build a small commercial plant together.

Process Worldwide

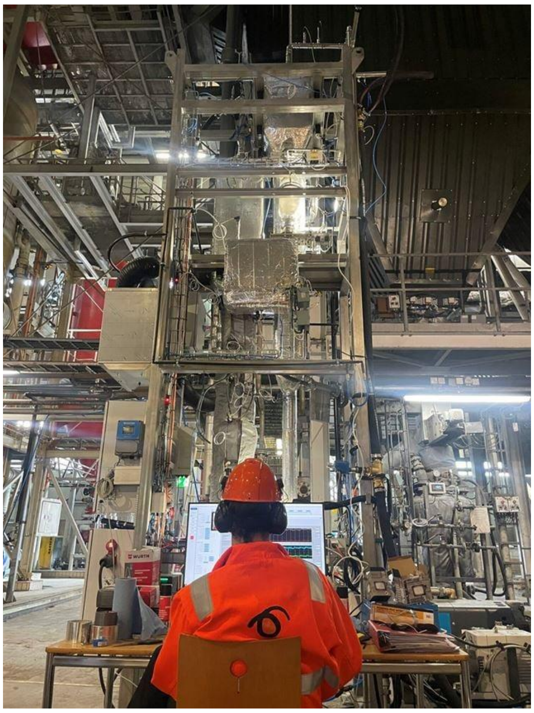
https://www.process-worldwide.com/syzygy-plasmonics-lotte-chemical-successfully-complete-trial-of-ammonia-e-cracking-unit-a-d903f07e080b144454f135758f2d9c12/?cmp=nl-a4c38030-50a7-41e2-b488-959594b07e4f

CLUSTER TAG: SUSTAINABILITY

8. Electrically powered heat and vacuum pumps simplify CO_2-capture retrofits

Meeting climate-change goals requires steep reductions in greenhouse-gas emissions from existing power plants and hard-to-abate industry operations. However, the energy required to release captured CO_2 from sorbent material is a challenge for the economic viability of these efforts. Also, retrofitting carbon-capture and storage (CCS) systems onto existing plants can be complicated and costly. Now, a CCS technology using electrically driven heat and vacuum pumps is positioned to address both issues, especially in situations where little or no waste heat is available from the host plant.

The technology, known as continuous swing adsorption reactor (CSAR), was developed by researchers at the independent research organization SINTEF (Trondheim, Norway; www.sintef.no), along with collaborators at CCS technology developer Caox AS (Stavanger, Norway; www.caox.no). A successful demonstration using CSAR to capture CO_2 from flue gas was recently completed at a waste incineration facility near Bergen, Norway. CSAR represents a novel approach to providing heat for releasing CO_2 from sorbent material, and can be cost-effectively retrofitted onto existing facilities because it is powered by electricity rather than steam.



CSAR features two fluidized-bed reactors, one for adsorbing CO_2 from flue gas, and the other for desorption of the gas. As the flue gas enters the first reactor, the CO_2 is adsorbed by polyethyleneimine (PEI) sorbent, which circulates between the two reactors. This binding process occurs at low temperature and generates heat. The heat is then transferred to the desorption reactor via a heat pump, where it is used to release the CO_2 from the sorbent, this time at a higher temperature. The heat pump is used to transfer the heat between the reactors, while the vacuum pump assists in releasing the CO_2. Combined, the two pumps transfer heat efficiently, and consume minimal energy.

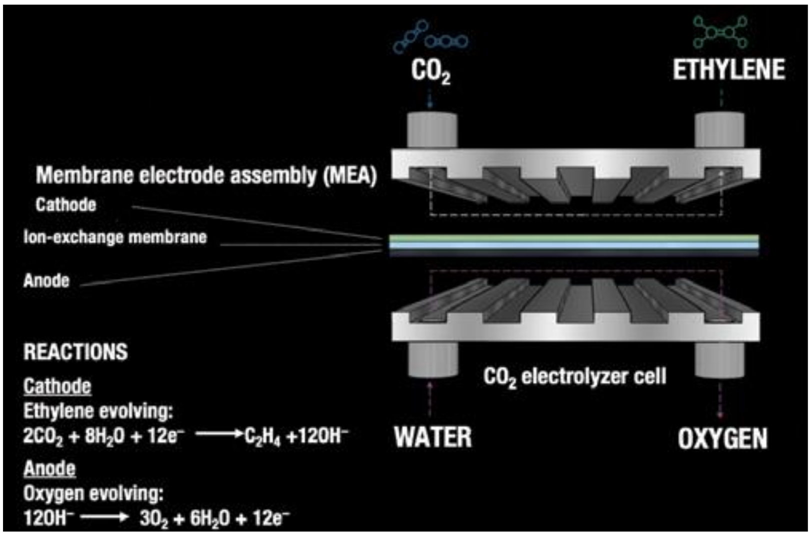
The research showed that CSAR technology competes very well with other CCS technologies that utilize heat such as temperature-swing adsorption. Following the successful demonstration at the waste incinerator, SINTEF plans to further test the 100 kg per day CO_2 pilot plant at a cement factory in Spain in 2026.

Chemical Engineering, January 2025 Issue

CLUSTER TAGS: SUSTAINABILITY, MODULARIZATION, NEW (ADVANCED) MATERIALS

9. Single-step process for electrified ethylene production

Developing sustainable pathways to ethylene is a key element in decarbonizing the process industries. A new electrolysis technology developed by CERT Systems (Toronto, Ont., Canada; www.co2cert.com) can produce ethylene from CO_2 and water, splitting the CO_2 molecule and reforming it into ethylene using renewable energy. The Direct CO_2 Electrolysis technology is a single-step process to generate sustainable ethylene, while other processes to convert CO_2 into ethylene require a separate source of hydrogen or an intermediate feedstock, such as syngas or ethanol. This process only requires CO_2 and water as reactants, reducing complexity and cost. Similar to the production of "green" hydrogen via water electrolysis, the process depends on a membrane electrode assembly and an electrocatalyst to facilitate the ethylene and oxygen evolution reactions. Unlike most water-electrolysis systems, CERT's catalysts do not require any precious metals. CERT's technology is designed to be agnostic to the source of CO_2, meaning that industrial emissions or atmospheric CO_2 can be successfully converted into ethylene.



The process' emissions-processing performance was first demonstrated in the field at Shepard Energy Centre natural-gas power plant in Calgary, Alta., Canada, performing conversions up to 100 kg of CO_2 per day. The next steps in scaling the technology will be to expand the system's range of tolerance for different feed compositions and moving to a commercial-scale pilot plant following funding. Beyond decarbonizing ethylene-based processes, the company plans to apply its technology to other chemical pathways, such as the production of sustainable aviation fuel (SAF).

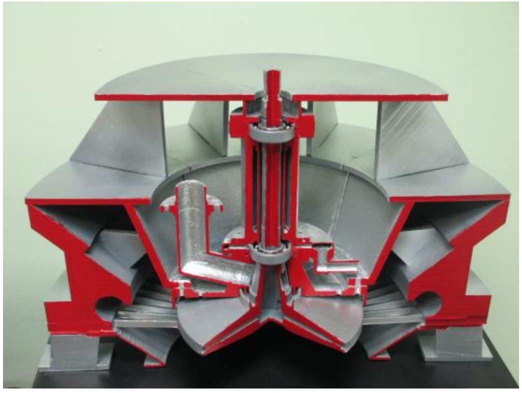
Chemical Engineering, February 2025 Issue

CLUSTER TAG: SUSTAINABILITY

10. Efficient cavitation-based method for challenging oil separations

Many separation processes depend on chemical or thermal principles, such as solvent extraction or distillation, but in some cases, mechanical methods can provide effective separations with lower cost and energy requirements.

Eirex (Vaughan, Ont., Canada; www.eirex.ca) has developed a proprietary technology that harnesses the energy of controlled hydrodynamic cavitation — the formation and collapse of bubbles within a turbulent liquid flow — to facilitate separation processes, such as the removal of the heavy fraction from crude oil or oil-sands tailing ponds.



Eirex's process introduces a necessary cavitation-generating turbulence into an accelerating, dynamically pressurized feedstock, such as heavy crude oil, bitumen, oil sands or petroleum refinery streams. Such a dynamic excitation creates areas of low pressure within the fluid, leading to the formation of multiple bubbles. These bubbles then violently implode, generating extremely high, localized temperatures accompanied by intense shock waves. Eirex's rotor-disintegrator module delivers narrow-pulse high-voltage discharges to induce electrohydrodynamic destruction, followed by hydrodynamic disintegration, leading to the separation of different liquid fractions of the feed.

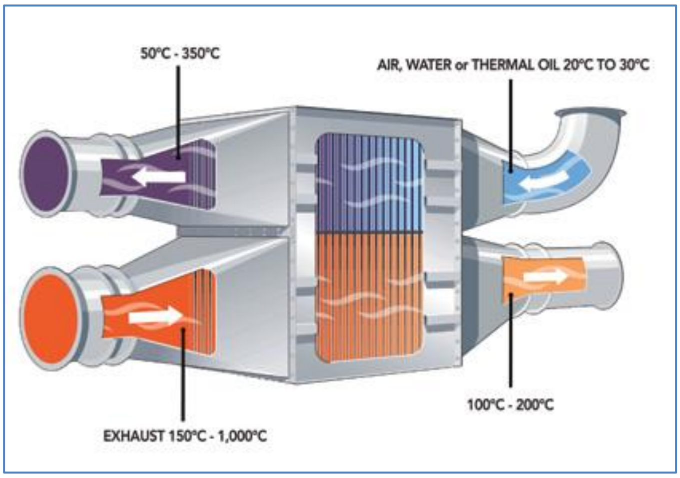
The company has also developed prototype devices for its cavitation process aimed at tailings recovery at mining sites, viscosity reduction in bitumen and heavy oil and polymer recycling. Eirex also recently entered into a collaboration with Canadian life-sciences firm DiagnaMed Holdings Corp. to commercialize a version of the cavitation technology for the extraction of hydrogen from water, which could potentially enable onsite production of "clean" hydrogen at much lower costs than electrolysis.

Chemical Engineering, March 2025 Issue

CLUSTER TAG: SUSTAINABILITY

11. Update on heat exchange solutions

Heat exchange technologies play a pivotal role in industrial sustainability efforts because they are at the forefront of enabling more environmentally friendly chemical processes, while also serving as a core mechanism in evolving clean technology and electrification projects. However, to find success in traditional or developing applications, selection of the right heat exchange technology is essential, as it will provide more energy-efficient performance, greater reliability and lower operational costs. Fortunately, innovative heat-exchange solutions are available to suit every industry need and overcome common process challenges in both existing and emerging applications.



You can find the full article on page 12 of this document: https://aimediaserver6.com/chemenghirespdfs/ChemEng_Feb2025.pdf

Chemical Engineering, February 2025 Issue

CLUSTER TAG: SUSTAINABILITY

12. Dividing wall columns increase distillation efficiency

A recent article sums up the benefits of dividing wall columns and gives new examples of industrial implementations.

This technology promises up to 40% energy savings while reducing capital costs and carbon footprint in industrial chemical processes. Three key takeaways:

1. Dividing wall columns can slash energy use by up to 40% compared to conventional distillation methods, while simultaneously reducing capital costs by 30% and operating costs by 40%.
2. The technology is now proven in real-world applications, with success stories including a Southeast Asian refinery that achieved a 42% energy reduction in FCC naphtha splitting, and an extractive DWC installation that maintained 99% product purity while cutting energy use by 30%.
3. The future outlook is expanding beyond traditional petrochemicals, with promising applications in biomass processing and renewable chemical production, plus potential for additional gains when combined with other technologies like vapor recompression heat pumps, which could push energy savings even higher.

Chemical Processing

https://www.chemicalprocessing.com/voices/energy-saver/article/55260619/energy-saver-dividing-wall-columns-supercharge-distillation-efficiency

CLUSTER TAGS: SUSTAINABILITY, DIGITALIZATION

13. Covestro completes heat integration of TDI plant in Dormagen

Covestro has successfully completed the modernization of its TDI (toluene diisocyanate) plant at its Dormagen site. The modernized plant consumes 80% less energy than conventional processes, achieving CO_2 savings of 22,000 t/year. This is made possible by a new reactor weighing over 150 ton and almost 20 m high, which uses the resulting reaction energy to generate steam. Covestro launched the modernization in summer 2023. In total, over 3.5 km of new piping, around 14 km of cables, and hundreds of new devices, fittings, and measuring instruments were installed in the plant as part of the project.

CHEManager

https://www.chemanager-online.com/news/covestro-schliesst-modernisierung-der-tdi-anlage-dormagen-ab

CLUSTER TAG: SUSTAINABILITY

14. Flow chemistry yields a more sustainable route to isocyanates

The wide range of performance properties of polyurethane foams makes them essential in many consumer goods. Thus, there is much effort going into creating a more environmentally friendly production process for polyurethane's main building blocks, polyols and isocyanates. While much progress has been made across the industry to develop bio-based routes to different polyols, developing new technologies for isocyanates has proven more elusive, due in part to the presence of highly toxic phosgene and hydrochloric acid in conventional petroleum-derived isocyanates production.

Now, a novel flow-chemistry approach is being demonstrated to enable a biological production pathway for isocyanates, while avoiding risks associated with phosgene. Algenesis Materials' (San Diego, Calif.; www.algenesislabs.com) patented technology converts algae-based fatty acids into isocyanates via acyl azides in a continuous-flow process. Using flow chemistry, no hazardous intermediates are accumulated in large amounts, thus going right from the precursor, which is a hydrazine, to the diisocyanate. Some 25 different types of isocyanates have been produced using this method, including some that are very similar in structure and properties to toluene diisocyanate (TDI) and methylene diphenyl diisocyanate (MDI), which are widely used in polyurethane foams.

Currently, Algenesis produces several kilograms per week of renewable isocyanates, and work is ongoing to scale up to 2 ton/yr in 2025. The company has also received a grant from the U.S. Department of Defense to evaluate plans for a 10-ton/yr facility.

Chemical Engineering, February 2025 Issue

CLUSTER TAG: SUSTAINABILITY

15. Continuous manufacturing and formulation of solids

Gericke has introduced the GFS Lab for continuous manufacturing and formulation of solids. The Gericke Formulation Skid GFS is a fully automated continuous manufacturing system for dry/wet granulation, capsule filling, or standalone unit operations. It blends excipients and active pharmaceutical ingredients (API) for downstream compaction, dry/wet granulation, or capsule filling. It is available in two versions — Continuous and Mini-Blending. The Gericke Mini Blender and Loss-in-Weight Feeders are also available as stand-alone machines.

The equipment is modular, featuring full- and semi-continuous (Mini Blend) blenders and interchangeable feeders. It is flexible, capable of operating as an individual machine or integrated with other equipment. The compact design makes it portable, while its efficiency is highlighted by minimal API consumption, requiring only a few grams. Additionally, the equipment is capable of functioning without the need for scale-up to commercial equipment and is compliant with Code 21 Part 11 for data acquisition.

Process Worldwide

https://www.process-worldwide.com/continuous-manufacturing-and-formulation-of-osd-a-48f7b464532c2a7774c50646a586b394/?cmp=nl-a4c38030-50a7-41e2-b488-959594b07e4f&uuid=B9F278CE-FE14-4C1B-86B2-1213ADF9EE12