europic
european process intensification centre

NEW TECHNOLOGY SCOUTING REPORT
No. 4/2024

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

PI TECHNOLOGIES \ PRODUCTS & PROCESSES	Air pollution and control	Carbon capture	Catalyst synthesis	High-temperature processes (cement, steel, petrochem)	Hydrogen	Refrigeration	Separation of organics	Variable load processes	Wastewater treatment
3D printing			1						
Absorptive oxidation	5								
Batch to continuous			6						
Compact evaporators							4		
Electrical heating				10,12					
Electrolysis					8,10				
Flow modulation								7	
Phase transitioning						2			
Plasma				11					13
Power-to-heat				9					
Rotating packed bed	3	3							

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 TAG: NEW (ADVANCED) MATERIALS

1. BASF expands 3D printing capacity for catalysts in Ludwigshafen

BASF announced plans to invest in additional production capacity for its X3D technology, a new additive manufacturing technology for catalysts based on 3D printing. The plant, which will produce catalysts on an industrial scale, is expected to be operational in 2026.

Catalysts produced using this technology are not only mechanically robust but also feature an open structure, which significantly reduces pressure drop across reactors and increases surface area, thus improving the performance of the catalysts.

According to BASF, the X3D technology can be applied to a wide array of catalytic materials, including both precious and non-precious metal catalysts, as well as carriers. This flexibility allows BASF to customize catalysts according to specific customer requirements by fine-tuning parameters such as infill patterns, fiber diameters, and orientations.

BASF has successfully operated commercial plants using X3D catalysts for several years. It expects this technology to shape the future for both green and traditional value chains with unparalleled efficiency and improved speed-to-market.

CHEManager
https://www.chemanager-online.com/en/news/basf-expand-3d-printing-capacity-catalysts-ludwigshafen

CLUSTER TAG: SUSTAINABILITY

2. Revolutionary air-based refrigeration system for freeze dryers

Ima Life partnered with MiraI Intex and the US company ACT to develop Kryoair, a revolutionary air-based refrigeration system for freeze dryers. Ima Life won the Best New Product/Service) at the recent Interphex New York trade show.

Kryoair is a revolutionary air-based refrigeration system for freeze dryers. Breaking away from reliance on high-GWP gases and flammable mediums, the air-based refrigeration system introduces a paradigm shift in refrigeration technology. At its core lies the air cycle technology powered by a turbo-compressor-expander, developed and supplied by Mirai Intex, augmented by the Cold Thermal Energy Storage (CTES) system from ACT. CTES harnesses the power of phase-transitioning compounds to maximize capacity per unit of volume.

This system not only avoids the use of high-GWP gases but ensures consistent cooling output across varying temperatures for freeze-drying applications. Its single-stage, oil-free turbo compressor-expander ensures reliability and durability, requiring minimal maintenance. Making the lyophilization process a more sustainable one, Kryoair can be fitted to Ima's Lyomax and Lyofast freeze dryers.

Process Worldwide
https://www.process-worldwide.com/revolutionary-air-based-refrigeration-system-for-freeze-dryers-a-60be3f98eac380cf5dbbf7dfab7c723b/?cmp=nl-206&uuid=380aa890c28097a3fe95f5bc868c3a83

CLUSTER TAGS: SUSTAINABILITY and MODULARIZATION

3. Carbon Clean launches Rotating Packed Bed technology for carbon capture

Carbon Clean's 'Cyclone CC C1' series has the capacity to capture up to 100,000 tonnes of CO_2 per year and is available in concentrations ranging from 3% to 20%. The unit is fully modular and columnless, achieving a height reduction of 70 % compared to conventional solutions. Rotating Packed Bed (RPB) technology replaces every column used in a conventional plant, which reduces the steel required by 35 % and lowers the unit's carbon footprint. The unit footprint is up to 50 % smaller than conventional carbon capture plants, with its largest equipment sizes reduced by a factor of 10. Each unit is prefabricated, skid-mounted and delivered on road truckable modules, cutting the costs associated with transport, logistics, site preparation and installation. Cyclone CC C1 uses first-of-a-kind technology to reduce the total installed cost of carbon capture by up to 50 % compared to conventional solutions.

At the heart of Cyclone CC C1 is the breakthrough combination of two process intensification technologies: rotating packed beds (RPBs) and Carbon Clean's proprietary APBS-Cdrmax solvent. The application of RPBs to a carbon capture plant is a gamechanger for the sector. Using RPBs to replace the columns used in conventional carbon capture solutions both reduces the size of the plant and accelerates the mass transfer process, increasing CO2 absorption. Carbon Clean's high-performing APBS-Cdrmax solvent achieves substantial Opex savings through outperforming the industry standard solvent. APBS-Cdrmax lowers energy demand by 10-25 %, reduces corrosion by a factor of 20, decreases degradation by a factor of 10, and has a lifespan that is five times longer than conventional solvents.

With its space-efficient design, Cyclone CC C1 offers a viable, cost-effective route to decarbonization, particularly for small-to-midsize emitters. Cyclone CC C1 is also ideal for emitters of all sizes looking to deploy carbon capture units across multiple flue gas emission sources. Cyclone CC's 'Lego-block', 'plug and play' design makes it simple and cost-effective to install.

Process Worldwide
https://www.process-worldwide.com/carbon-clean-launches-columnless-carbon-capture-series-a-4ca54734caf37e976f10cf26c03c5e65/?cmp=nl-a4c38030-50a7-41e2-b488-959594b07e4f

CLUSTER TAG: SUSTAINABILITY

4. UIC commercializes largest Short Path Evaporator

UIC has developed, designed, carried out and supplied the world's biggest short path evaporator, with a heating surface of 80 m². The installation has an inner diameter of 2.6 m and a total height of 16 m, yielding a total volume of 70 m³. The unit is designed for pressures up to 78 bar.

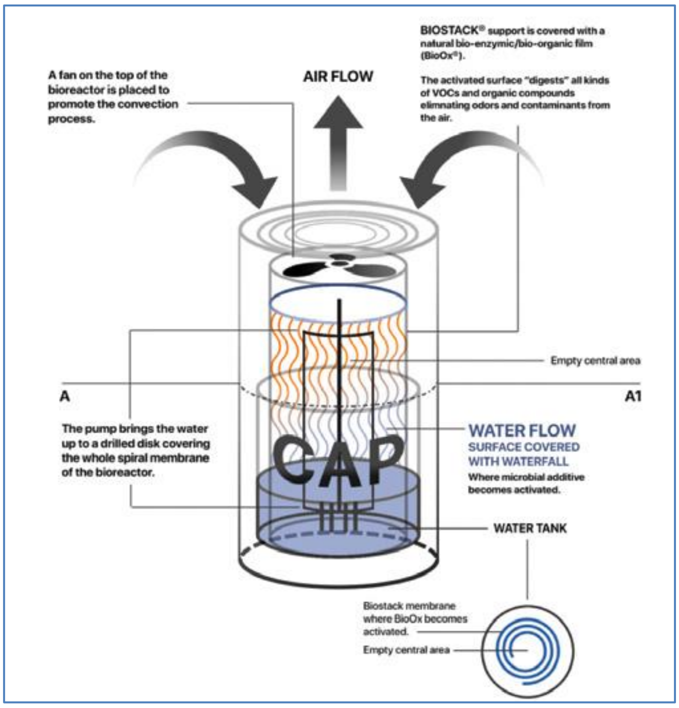
The areas of application for large short path evaporators are the polymer, lactic acid, fish oil and edible oil industries. Typical applications of short path evaporators are the separation of pesticides, monomers, mineral oil residues and heavy boilers with a dark color.

Process Worldwide
https://www.process-worldwide.com/uic-attains-world-record-in-short-path-distillation-a-16ab512338c963cb65b4973bb468b73c/?cmp=nl-a4c38030-50a7-41e2-b488-959594b07e4f

CLUSTER TAG: SUSTAINABILITY

5. Full destruction of airborne contaminants in a compact bioreactor

There are many categories of air contaminants that may be encountered in industry, from volatile organic compounds to aerosols to viruses, as well as a range of particulate matter and ultra-fine particles, which also vary greatly in size and properties. This makes it difficult for a single air-cleaning technology to comprehensively handle such contaminant mixtures.



The air-cleaning technology developed by BioOx claims to capture and destroy a wide array of airborne contaminants using a novel bioreactor system. Unlike competing systems that only absorb contaminants but do not destroy them, BioOx can oxidize hydrocarbons to CO_2 and H_2O biologically. This means no regeneration is required. Within the BioOx reactor, enzymatic media are immobilized on a specialized spiral-biosupport membrane. Water is pumped up from the bottom of the reactor, where it flows down the membrane, keeping the media moist. Water is distributed evenly from above the biosupport, exposing contaminants to the enzymes, which are activated to begin bio-oxidation upon water contact. A fan at the top of the reactor promotes convection, creating a clean air dome. As water flows into the tank, it captures contaminants via Bernoulli's principle in tiny bubbles. Once the air pollutants are captured, brought into the unit and digested by the media, the clean air dome expands to cover a larger and larger area. The special spiral design of the bio-support membrane supports contaminant contact with the enzymes due to the turbulence created by cyclone action.

The BioOx system is especially well-suited for manufacturing areas where quality control is key as product batches change and invisible air contaminants may remain, such as in the production of paint or flavor ingredients. The BioOx reactor has been demonstrated in a variety of facilities with up to 90 kg/day contaminant destruction.

https://bioox.us/

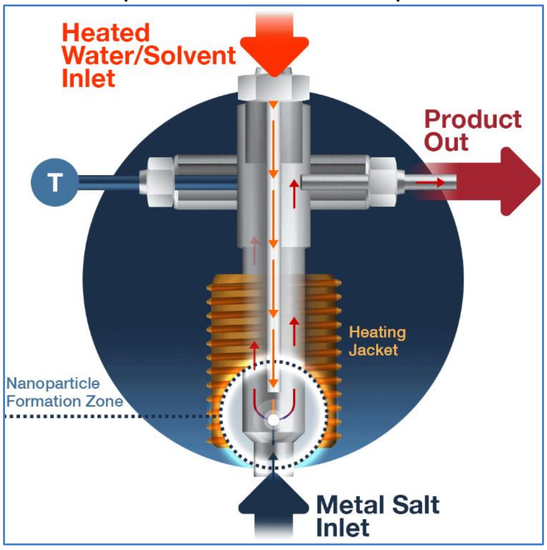
Chemical Engineering, October 2024 Issue

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

6. Process for continuous production of MOFs plans scale-up

Metal-organic frameworks (MOFs) have shown great potential for a number of applications, including as carbon-capture materials, but their use commercially has been limited by production methods, which are generally expensive batch processes. With the development of a continuous process for producing a range of MOFs at industrial scale, Promethean Particles aims to lower the costs of making MOFs and expand production volumes. While current prices for the supply of a common MOF material, known as UiO-66, is quoted as high as $60,000 per kg by other MOF manufacturers, Promethean believes they can reach a target of $30 per kg for their MOF products by further developing the continuous-flow process. Promethean will now build a new facility with the capability to expand their production capacity by 5–10 times, compared to their current capacity of 1,000 tons per year.

In Promethean's process, called continuous flow hydrothermal or solvothermal synthesis (CFHS or CFSS), a solution of metal salts and a solution of organic linkers are combined at a specified temperature in a patented counter-current reactor, which can be operated at elevated pressure. Within the reactor, the two solutions mix in turbulent flow and nucleation of MOF particles occurs. By carefully controlling the temperature and pressure of the reactor, as well as the fluid flowrates, the mixing dynamics can be influenced, meaning the structural properties of the resulting MOF could be controlled. These properties include particle size, shape or crystallinity. Once the particles form, the continuous-flow nature of the process allows an option for secondary and tertiary ingredients to be introduced in situ, to further modify the MOFs and obtain the desired properties. The product from the reactor is a suspension of MOF particles in water or other carrier solvent.



http://www.prometheanparticles.co.uk/

Chemical Engineering, October 2024 Issue

CLUSTER TAGS: SUSTAINABILITY and DIGITALIZATION

7. Variable speed drives boost chemical plant efficiency

Variable speed drives (VSDs) have transformed motor control in the chemical industry over recent decades. Also known as variable frequency drives or adjustable speed drives, these electronic devices offer unprecedented control over electric motor speed and torque, providing a level of precision and efficiency that was previously unattainable with traditional motor control methods. The fundamental principle behind VSDs lies in their ability to modulate the frequency and voltage supplied to electric motors. This capability allows for precise matching of motor speed to the required load, resulting in substantial energy savings and improved process control. In a typical chemical plant, where motors drive everything from pumps and fans to mixers and conveyor systems, the potential for energy savings through VSD implementation is enormous. VSDs can cut energy consumption by up to 50% by leveraging the cubic relationship between motor speed and power—even a modest 20% speed reduction can halve energy use.

To put these savings into perspective, let's consider a real-world example: A chemical plant uses a ~90% efficient, 33 hp pump operating 24/7 at full speed on a cooling tower fan, consuming approximately 27 kW of power. By implementing a VSD and reducing the average speed to be between 75% and 85% over the course of a given year, the power consumption would drop to about 11.5 kW-16.8 kW. This adjustment could result in annual energy savings of around 92,400 kWh-138,400 kWh. At an electricity rate of $0.10/kWh, this translates to annual cost savings of $9,200-$13,800 per year for a single pump. When considering the cost of energy in this example for the full-speed pump is $23,650, the savings are significant.

Not all motor-driven systems are suitable for VSDs, so process evaluations are essential to identify applications with variable load requirements. In chemical processing, prime candidates for VSD implementation often include but are not limited to: centrifugal pumps for fluid transfer and circulation, cooling tower fans, process air blowers, agitators and mixers with variable load requirements.

Chemical Processing
https://www.chemicalprocessing.com/voices/energy-saver/article/55238532/energy-saver-variable-speed-drives-boost-chemical-plant-efficiency

CLUSTER TAGS: SUSTAINABILITY and NEW (ADVANCED) MATERIALS

8. China's first factory-based seawater hydrogen production research project

The project integrates direct seawater electrolysis with renewable energy-powered green hydrogen production, achieving an hourly output of 20 m^3 of green hydrogen. This innovative approach not only offers a new solution for coastal regions to utilize renewable energy for green hydrogen production but also provides an alternative pathway for the utilization of high-salinity industrial wastewater.

The project adopts a factory-based operation model, leveraging a portion of the green electricity generated by Qingdao Refinery's floating photovoltaic power station. Through electrolysis, seawater is split into hydrogen and oxygen, with the produced hydrogen seamlessly integrated into the Qingdao Refinery's pipeline network for use in refining processes or hydrogen-powered vehicles.

Seawater hydrogen production holds significant potential. By directly converting seawater into hydrogen, renewable energy can be transformed into green hydrogen, which is relatively easier to store and utilize. Moreover, this process conserves precious freshwater resources, offering a new pathway for the development of the hydrogen energy industry. However, seawater hydrogen production also comes with challenges. Seawater contains approximately 3% salt, and impurities, such as chloride ions, can corrode electrolytic electrodes, while cationic deposits may clog equipment channels, reducing efficiency and causing damage. Sinopec Qingdao Refinery, in collaboration with the Dalian Institute of Petroleum and Petrochemicals, has successfully overcome these challenges through a series of specialized equipment innovations and unique process designs, including chlorine-resistant electrode technology, high-performance electrode plate design, and a seawater circulation system.

Hydrogen Tech World
https://hydrogentechworld.com/sinopec-completes-seawater-hydrogen-production-project-at-its-qingdao-refinery

CLUSTER TAG: SUSTAINABILITY

9. Power to high-temperature heat

Heavy industrial processes, like steel, cement and glass manufacturing require high-temperature heat. Electrifying these processes to reduce carbon emissions with currently available solutions, such as using green hydrogen is prohibitively expensive.

Calectra is developing a power-to-heat thermal storage technology to provide manufacturing industries with low-cost, high-temperature (up to 1600°C), emission-free process heat. The company's thermal storage system converts electricity from the grid or on-site renewables into high-temperature heat within its patent-pending bricks. This heat is then stored in the bricks and delivered to industrial manufacturers on demand. Calectra optimizes its technology for high-temperature heat delivery at low cost and at large scale.

The technology was developed at UC Berkeley and the Lawrence Berkeley National Laboratory. Replacing fossil fuels in high-temperature process-heat generation could cut CO_2 emissions by 1.8 gigatons per year, which represents about 5% of global CO_2 emissions.

https://calectra.com/

Chemical Engineering, November 2024 Issue

CLUSTER TAGS: SUSTAINABILITY and NEW (ADVANCED) MATERIALS

10. Sweden's green steel pilot project now moves to commercial scale

Hybrit is a collaboration between iron ore producer LKAB, energy firm Vattenfall, and steel manufacturer SSAB. The project launched in 2016 to phase out the use of coal in steel production and prove that it can instead be made using green hydrogen and electricity. The prize for doing so would be a huge cut in CO_2 emissions, as the steel industry is responsible for 7% across the world.

The pilot projects ran from 2018 to 2024 and focused on fossil-free production of iron ore pellets; hydrogen-based reduction of iron ore; hydrogen production through the electrolysis of water; and production of crude steel by melting sponge iron in an electric furnace. The start of the steelmaking process begins with the production of iron ore pellets. Conventionally, this involves heating the feedstock with fossil fuels to fuse the iron ore particles together but retain their porosity. To avoid the emissions from burning fossil fuels, the team built a pilot plant that trialled the use of bio-oil instead. In 2023, the plant produced 3.6 million tons of pellets and the team estimates it saved 50,000 tons of CO_2 emissions. The iron ore pellets are then reduced to produce pure iron. In conventional blast furnaces, coal is used. Hybrit built a pilot plant that instead uses hydrogen, which can be produced by splitting water with renewable energy to eliminate emissions. Iron ore pellets are fed in at the top of a furnace as an upward stream of hot hydrogen gas reacts with the oxygen in the pellets, to produce water which leaves as steam. The pilot produced more than 5,000 ton of fossil-free sponge iron. The sponge-iron was then turned into crude steel using a 10 ton electric arc furnace. This involves feeding the iron into a furnace with slag formers, biocarbon, and oxygen, where it is melted using electrodes powered by renewable electricity. The trials produced more than 1,000 ton of steel with some already been used by customers including cars made by Volvo.

For each tonne of steel produced using this method, around 5 kg of CO_2 was emitted due to the oxidation of the graphite electrodes used in the melting process. This is a significant saving over blast furnace production where around 2,200 kg of CO_2 is produced for each tonne of steel. Meanwhile, conventional direct reduction that does not use hydrogen can produce 64–383 kg of CO_2 depending on how much fossil carbon is added during the reduction step. The demonstration plant that LKAB plans to build in Gällivare will be the first step towards industrial production of sponge iron. The team expects to industrialise fossil-free steel production by 2035.

The Chemical Engineer, October 2024 Issue

CLUSTER TAGS: SUSTAINABILITY and MODULARIZATION

11. Cemex to install world-first plasma-based hydrogen process at UK plant

CEMEX is set to trial a process developed by Hiiroc that uses plasma to produce hydrogen for greener industrial heat at its cement plant in Rugby (UK). The cement major thinks the process is a better bet for producing hydrogen than water electrolysis because it requires 80% less electricity and wins out over steam methane reforming because it doesn't produce CO_2.

Hiiroc's continuous thermal plasma electrolysis process sees hydrocarbons pass through 50 kW plasma torches where an electric field splits them into hydrogen and carbon. In a second chamber, the carbon is quenched into solid carbon black and passes to a third chamber for separation. Hiiroc says that by vaporising the carbon it eliminates sooting which hinders other methane pyrolysis processes. The process is containerised and modular. It can be plugged directly into the gas grid and turned on and off to produce hydrogen when and where it's required, eliminating the need for costly and hazardous hydrogen transport or storage.

Rugby won't become 100% hydrogen fuelled. Instead, the project's engineers will work to find a "sweet spot" that allows operators to reduce fossil fuel input and dramatically increase the use of lower calorific alternative fuels. CEMEX believes that their sweet spot would be having a reduction in our carbon footprint of over 50% in fuel-related emissions.

The Hiiroc process can make use of biomethane to replace natural gas and renewable electricity to power its plasma burners. Unlike green hydrogen, the process doesn't require water. The process produces carbon black which can be used as an additive in the cement-making operations or sold for use in tyres, rubbers, plastics, inks, and toners.

The Chemical Engineer, December 2024 Issue

CLUSTER TAGS: SUSTAINABILITY and MODULARIZATION

12. Lummus, Braskem to decarbonize Brazil site with electric cracking heater

Lummus Technology and Braskem will carry out joint studies related to the industrial demonstration of Lummus' SRT-etm electric cracking heater to decarbonize one of Braskem's sites in Brazil.

The SRT-e electric cracking heater leverages Lummus' proven Short Residence Time (SRT) technology modified to operate using electricity and incorporates a modular unit-cell design that can be replicated for plants to accommodate any commercial capacity. The technology uses all commercially demonstrated components, plus an optimum heat flux profile leading to a longer radiant coil life and longer run length. In addition, decoking can be carried out on a unit-cell basis so maintaining a spare heater is not required.

This initiative is part of Braskem's ambitions to combat climate change, which includes reducing its greenhouse gas emissions by 15 percent by 2030 and attaining carbon neutrality by 2050. Expanding the use of renewable electricity and renewable materials will enable Braskem to reduce its carbon footprint in the production of ethylene, propylene and other chemicals.

Process Worldwide
https://www.process-worldwide.com/lummus-braskem-to-decarbonize-brazil-site-with-electric-cracking-heater-a-9311db215a896a39e539b6ed08747769/?cmp=nl-206&uuid=380aa890c28097a3fe95f5bc868c3a83

CLUSTER TAG: SUSTAINABILITY

13. Destroy PFAS while also producing syngas with Joule and plasma heating

The destruction of per- and polyfluoroalkyl substances (PFAS) presents unique issues in wastewater treatment, as these substances are persistent in many treatment environments, and PFAS-laden purification media is challenging to dispose of.

Now, InEnTec Inc. says that its plasma-gasification system can provide comprehensive PFAS destruction, while also producing a syngas (H_2 + CO) byproduct stream. The plasma system uses Joule heating with a molten bed of glass in the reactor chamber. On top of that molten bed of glass, plasma is generated with direct current between graphite electrodes. The concept of combining Joule heating with plasma heating makes it very efficient in comparison to other plasma technologies. The design of InEnTec's plasma system also enables it to process fluorinated compounds without the corrosion issues other plasma-based systems might encounter.

The high-temperature, reactive environment is created with ionized gas and hydrogen radicals. The presence of these hydrogen radicals helps to assist in the conversion of the carbon-fluoride bond to a hydrogen fluoride bond. Then, the carbon gets converted into either CO or CO_2, depending on where the system is running from an oxidation-reduction standpoint. Operating in a more reduced mode promotes the formation of syngas, which helps to lower operating costs by producing a useful byproduct simultaneously with PFAS destruction.

The unit's primary plasma chamber is where the majority of destruction takes place, and a downstream thermal-residence chamber keeps the syngas at a high temperature for more than 2 seconds. The hydrofluoric acid resulting from PFAS destruction is neutralized into sodium fluoride.

In recent trials with Terre Environmental LLC, the plasma unit demonstrated greater than 99.999999% (eight 9s) destruction and removal efficiency (DRE) while processing granular activated carbon (GAC) loaded with PFAS at a level that would typically exhibit breakthrough in commercial water-treatment systems. With InEnTec's system, the GAC is converted into syngas and the PFAS compounds are destroyed.

Chemical Engineering, November 2024 Issue