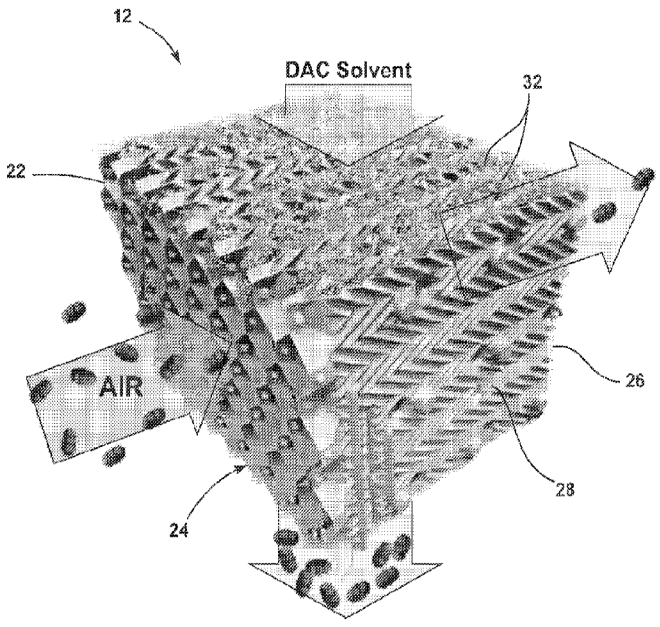
PATENT HIGHLIGHTS Q4/2024

Patent Highlights are quarterly reports on emerging patents related to process intensification. This report highlights a selection of 26 out of 450+ patents on different PI-technologies published in Q4/2024, ranging from multifunctional catalysts to hybrid separation techniques. Technologies utilizing various electricity-based energy transfer mechanisms still present a significant part of the current report, with the gravity point moving from the microwave- to plasma-assisted processing.

AIR-LIQUID CONTACTOR FOR CARBON DIOXIDE DIRECT AIR CAPTURE USING AQUEOUS SOLVENT

Publication number: WO2024205622 (A1)
Publication date: 2024-10-03
Inventor(s): JANG GYOUNG GUG [US]; CUSTELCEAN RADU [US]; TSOURIS CONSTANTINOS [US]; KASTURI ABISHEK [US] +
Applicant(s): UT BATTELLE LLC [US] +

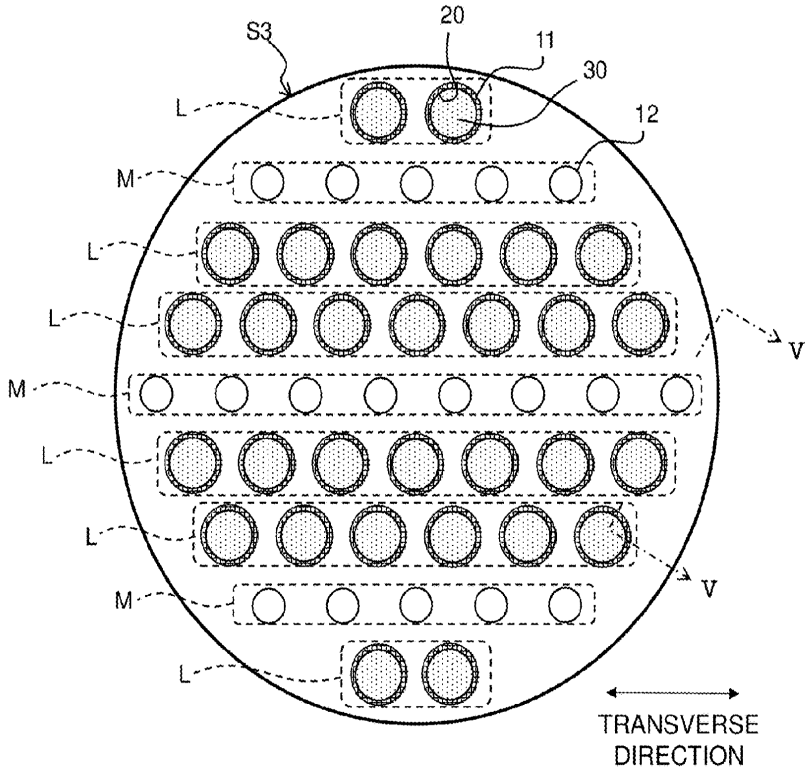
A high-flux direct air capture (DAC) contactor is provided. The contactor includes stainless steel mesh elements interlaced into a structured packing to increase the effective surface area for a suitable solvent. In laboratory testing, the contactor demonstrated significant potential in driving down the cost of solvent absorption-based DAC due to its high specific surface area and CO2 uptake efficiency, resistance to corrosion, optimal wettability, smaller relative size, and low manufacturing cost. As a potential breakthrough strategy, the highly efficient CO2 capture contactor can be employed to significantly reduce capital costs in a compact DAC system.



REACTOR

Publication number: US2024326008 (A1)
Publication date: 2024-10-03
Inventor(s): IIDA KAZUKI [JP]; NAKAGAWA KOSUKE [JP]; KAN HIROFUMI [JP]; TORII ATSUSHI [JP] +
Applicant(s): NGK INSULATORS LTD [JP] +

A monolith-type reactor includes a porous support body, a plurality of first cells through which a raw material gas flows, a plurality of second cells through which the sweep gas flows, separation membranes, and a catalyst. The first cells pass through the porous support body in a first direction. The second cells extend in the porous support body in the first direction. The separate membranes are respectively formed on inner peripheral surfaces of the first cells and permeable to a product of the conversion reaction. The catalyst is arranged inside the separation membranes, and promotes the conversion reaction. In a cross section taken along a second direction perpendicular to the first direction, the average cross-sectional area of the first cells is larger than the average cross-sectional area of the second cells.

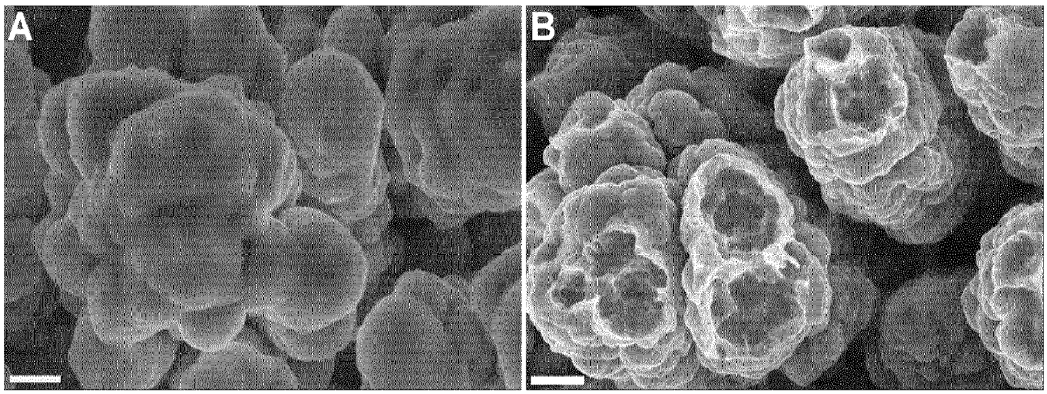


AN OXYGEN EVOLUTION REACTION ELECTRODE CATALYST ASSEMBLY COMPRISING DENDRITIC NICKEL FOAM, ITS USE AND A METHOD TO PRODUCE SAID ASSEMBLY

Publication number; US2024328005 (A1)
Publication date: 2024-10-03
Inventor(s): PEUGEOT ADÈLE [FR]; FONTECAVE MARC [FR]; CREISSEN CHARLES [GB]; SCHREIBER MORITZ WILHELM [BE] +
Applicant(s): TOTALENERGIES ONETECH [FR]; COLLEGE FRANCE [FR] +

The present disclosure relates to a method to produce an oxygen evolution reaction electrode catalyst assembly comprising a dendritic nickel foam. The method is remarkable in that it comprises the steps of (a) providing a dendritic nickel foam

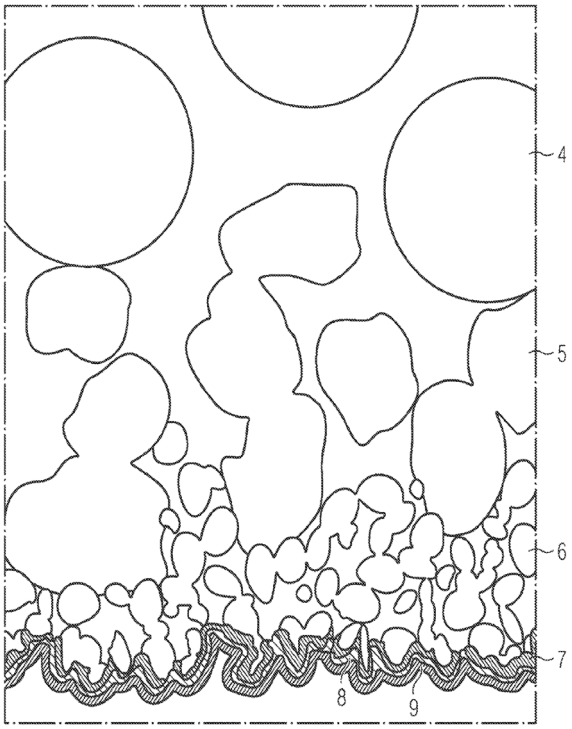
material; (b) etching the dendritic nickel foam material by placing it in a etch solution being an acidic aqueous solution or an aqueous solution of metal chloride and recovering an etched dendritic nickel foam with nickel dendrites showing a chimney-like structure.



HYBRID STRUCTURED POROUS TRANSPORT ELECTRODES WITH ELECTROCHEMICALLY ACTIVE TOP-LAYER

Publication number: US2024368781 (A1)
Publication date: 2024-11-07
Inventor(s): SCHULER TOBIAS [CH]; BÜCHI FELIX [CH] +
Applicant(s): SCHERRER INST PAUL [CH] +

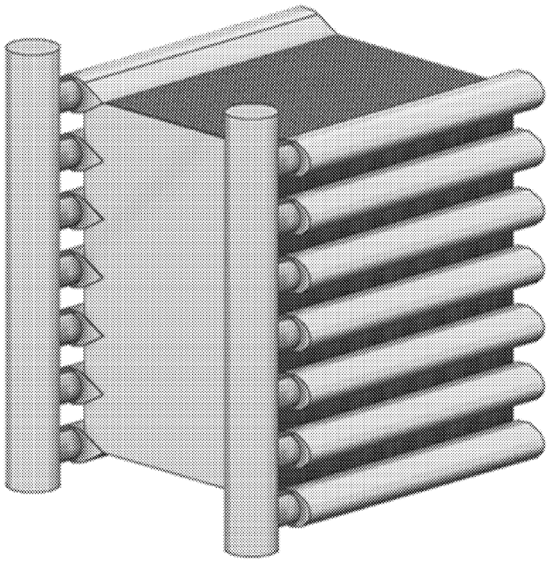
A hybrid, porous transport electrode with increased efficiency, durability and catalyst utilization includes a first support porous layer and a second intermediate porous layer including fibers and non-defined shaped particles of a conductive material, a mean particle size decreasing from layer to layer from a bipolar plate towards a membrane. Said first porous layer is made from sintered fibers of the conductive material and the second layer is made from non-defined shaped particles of a conductive material, said first porous layer having a contact surface oriented towards the bipolar plate having a bigger pore size than the second porous layer having a contact surface oriented towards the membrane. An electrochemically active top layer includes an electrochemically active material or mixtures thereof on the second porous layer, the top layer having a contact surface oriented towards the membrane and smaller pore size than the second and first layers.



DESIGNS AND APPLICATIONS OF A LOW-DRAG, HIGH-EFFICIENCY MICROCHANNEL POLYMER HEAT EXCHANGER

Publication number: US2024410662 (A1)
Publication date: 2024-12-12
Inventor(s): NARAYANAN VINOD [US]; RASOULI ERFAN [US] +
Applicant(s): UNIV CALIFORNIA [US] +

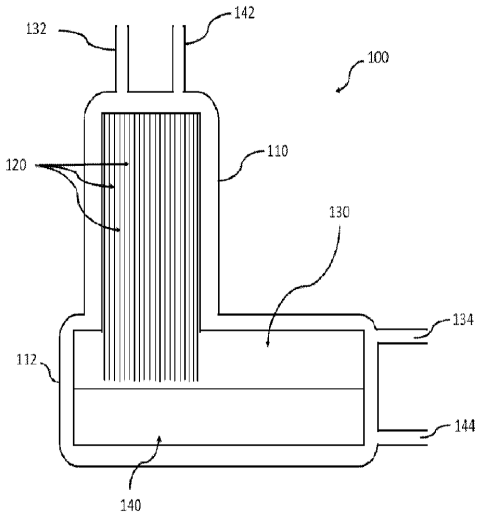
Designs and applications of a polymer heat exchanger that includes a set of polymer plates with internal flow passages configured to carry a first gas or liquid. The set of plates is organized into a stack, wherein consecutive plates in the stack are separated by fins to form intervening flow passages for a second gas or liquid. The system includes a first liquid or gas flow pathway, which flows from an inlet, through the internal flow passages, to a first liquid or gas outlet. It also includes a second liquid or gas flow pathway, which flows from an inlet, through the intervening second gas or liquid passages, to an outlet. The first liquid or gas flow pathway flows in a direction opposite to a direction of the second liquid or gas flow pathway to provide a counterflow design that optimizes heat transfer between the two flow pathways.



ENZYMATIC MICROCHANNEL FIBER CONTACTORS

Publication number: WO2024229274 (A1)
Publication date: 2024-11-07
Inventor(s): WOOD LESLIE [US]; KOHL SCOTT D [US]; LANIER WILLIAM [US] +
Applicant(s): CHEMTOR LP [US] +

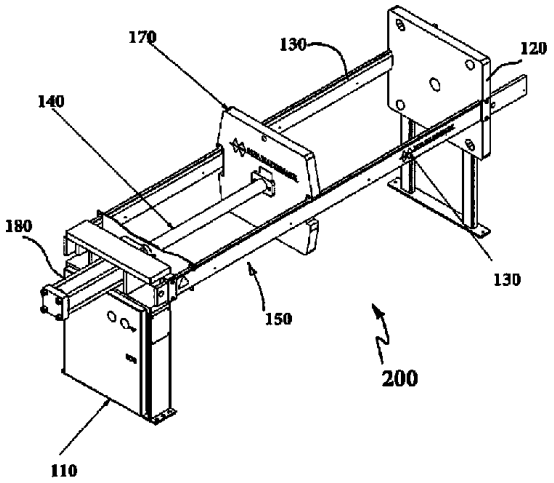
An immobilized enzyme fiber contactor includes a plurality of fibers disposed within a hollow conduit. The fibers have an enzyme selected from an oxidoreductase, a transferase, a hydrolase, a lysase, an isomerase, or a ligase attached thereto. The enzymes can be attached to the fibers via an anchor group and, optionally, a bifunctional crosslinker. The enzymes can be applied, stripped, and reapplied without disassembling the reactor or discarding the fibers. The immobilized enzyme fiber contractor can be used to conduct two-phase or single-phase enzymatic reactions.



SYSTEM FOR PURIFICATION OF BIOACTIVE PROTEINS, AND RELATED METHODS

Publication number: AU2023253595 (A1)
Publication date: 2024-11-28
Inventor(s): HLUBB CHRISTOPHER; CARTER BRANDON +
Applicant(s): HP BIOENGINEERING LLC +

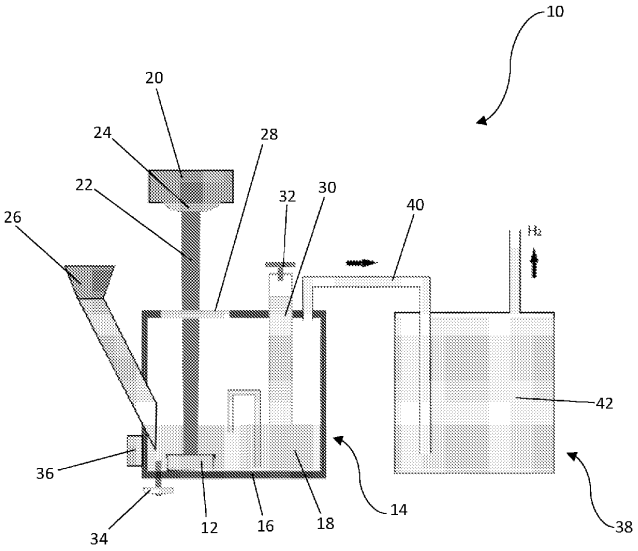
A system for purifying bioactive proteins in a fluid that includes at least one fractal subsystem and a filter press structured and arranged to support at least one fractal subsystem in a horizontal arrangement to provide a selectively adjustable bed depth, wherein each fractal subsystem is in fluid communication with every other fractal subsystem each fractal subsystem. The fractal subsystem may include a resin chamber and a pair of fractal packs, wherein the pair of fractal packs is disposed on opposing sides of the resin chamber. The resin chamber may include a frame, a plenum space through the frame for holding a resin, a pair of mesh screens for containing the resin within the plenum space, and a pair of feed material ports adapted to at least one of introduce a fluid into the plenum space or remove a fluid from the plenum space.



HYDROGEN PRODUCTION SYSTEM

Publication number: AU2023260653 (A1)
Publication date: 2024-11-07
Applicant(s): HYDROGEN RENEWABLE ENERGY AUSTRALIA PTY LTD [AU] +

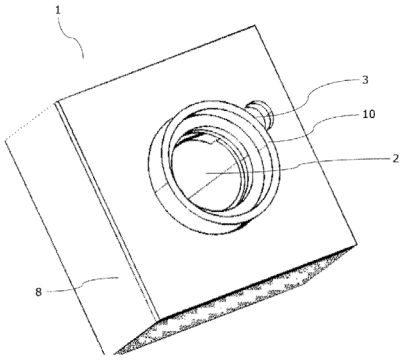
Embodiments of the present disclosure provides a hydrogen production system comprising a cartridge and a hydrogen production device. The cartridge comprises a receptacle for holding a metalloid or metalloid alloy, and a catalyst. The hydrogen production device comprises a reaction chamber configured to receive the cartridge and a reaction liquid, and a laser integrated in or adjacent to the reaction chamber. The laser is configured to direct a beam to a target surface of the cartridge to create a breach in the target surface, allowing the metalloid or metalloid alloy, and a catalyst to mix with the reaction liquid creating a reaction mixture. The laser may be further configured to control the onset and rate of hydrogen generation in the reaction mixture by controlling the heating of a reaction area surrounding the breach. A method of hydrogen generation using the hydrogen production system is also disclosed.

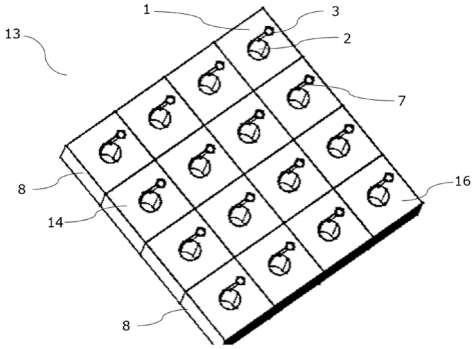


A MASSIVE PARALLEL PLASMA REACTOR ARRAY FOR GAS CONVERSION APPLICATIONS

Publication number: AU2023232924 (A1)
Publication date: 2024-10-24
Inventor(s): TRENCHEV GEORGI; SCHELTJENS GILL; ZIEGLER DAVID +
Applicant(s): D CRBN BV [BE] +

The current invention relates to a reactor module for converting chemical compounds into materials, gases or energy, wherein the reactor module is suitable for contiguous radial stacking, comprising: a reaction chamber and at least one inlet pressure chamber, wherein at least one tangential flow channel, connected to said inlet pressure chamber, wherein said tangential flow channel is further connected to the reaction chamber tangentially to its circular cross-section, wherein said tangential channel is suitable for directing the flow of reactant gas into the reaction chamber. The invention also relates to a reactor stack comprising two or more reactor modules contiguously stacked in the radial plane. The invention also relates to the use of aforementioned module or a stack of modules for gas conversion.

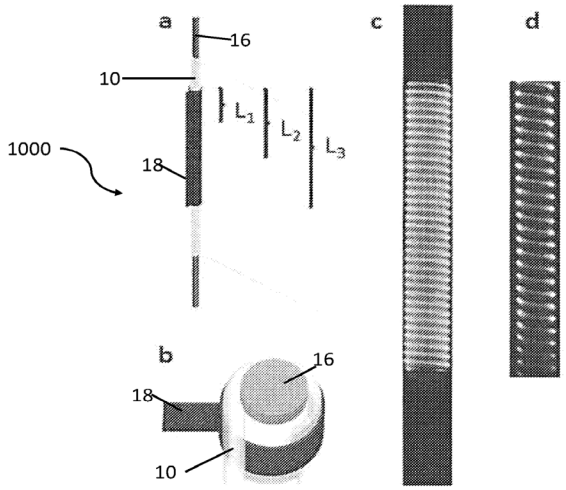




COAXIAL DIELECTRIC BARRIER DISCHARGE PLASMA BIPHASIC MICROREACTOR FOR CONTINUOUS OXIDATIVE PROCESSES

Publication number: US2024350999 (A1)
Publication date: 2024-10-24
Inventor(s): DIMITRAKELLIS PANAGIOTIS [US]; CAMELI FABIO [US]; VLACHOS DIONISIOS G [US] +
Applicant(s): UNIV DELAWARE [US] +

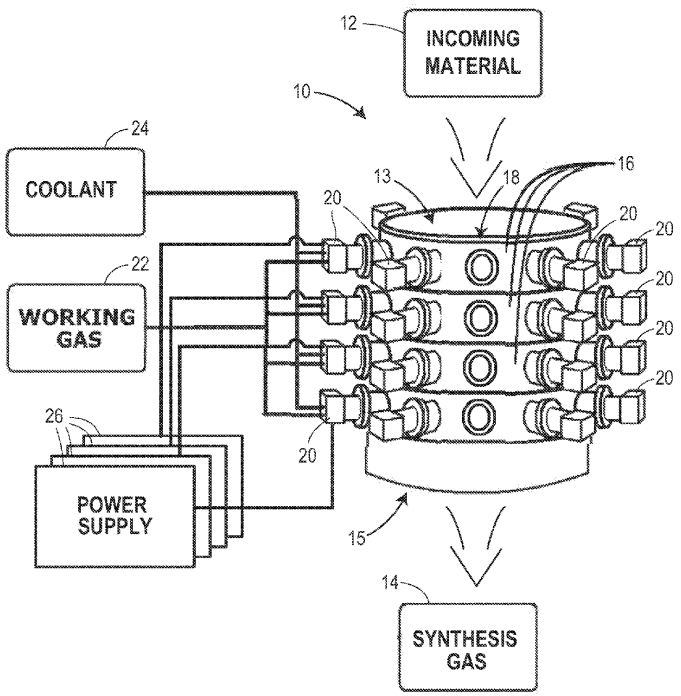
A reactor assembly for igniting and sustaining a plasma and method for performing a reaction. The assembly includes an elongated cylindrical inner electrode; a dielectric tube arranged helically around the elongated cylindrical inner electrode to form a helical reactor. The reactor assembly also includes an annular outer electrode arranged around at least a portion of the exterior of the helical reactor. The assembly includes a power source to provide a voltage across the elongated cylindrical inner electrode and the annular outer electrode. A process stream including at least a gas flows through the dielectric tube. The voltage is applied across the elongated cylindrical inner electrode and the annular outer electrode such that at least a portion of the flow of the process stream through the dielectric tube is exposed to the voltage and the plasma is ignited and sustained.



PLASMA/IONIC REACTOR

Publication number: EP4441427 (A1)
Publication date: 2024-10-09
Inventor(s): KONG PETER C [US]; BITSOI RODNEY J [US] +
Applicant(s): COGENT ENERGY SYSTEMS INC [US] +

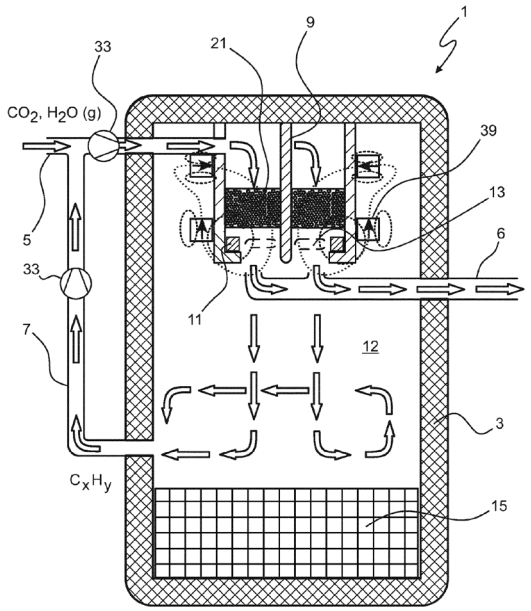
A hybrid plasma or ionic reactor includes the basic components of both a plasma jet reactor and a plasma arc reactor, which components operate simultaneously to provide hot ionic gas and electrical arcing within a reaction chamber in a manner that significantly increases processing of material within the reaction chamber. Additionally, an improved plasma or ionic reactor uses multiple sets of arc electrodes disposed around a reaction chamber in a unique offset manner that operates to create a larger area in the center of the reaction or plasma chamber where the arcs travel between an anode and a cathode of a pair of electrodes, thereby effectively increasing the size of the reaction zone in which the arcs are present. Still further, an improved plasma or arc reactor includes structure to introduce, from multiple different electrodes, a working or cooling gas, used to cool the electrodes and provide for plasma creation within a reaction chamber, in a manner that causes the gas to flow in a sustained vortex across the width of the chamber, which aids in the creation of a confined or directed stream of gas within the reaction chamber which further aids in the creation of stable arcs in the chamber.



SOLID PLASMA REACTOR AND METHOD OF OPERATING A FIXED BED REACTOR

Publication number: EP4479173 (A1)
Publication date: 2024-12-25
Inventor(s): BIRKE KAI PETER [DE]; LAMBARTH MAIKE [DE]; RENNINGER STEPHAN [DE]; STEIN JAN SAMUEL [DE] +
Applicant(s): CYCLIZE GMBH [DE] +

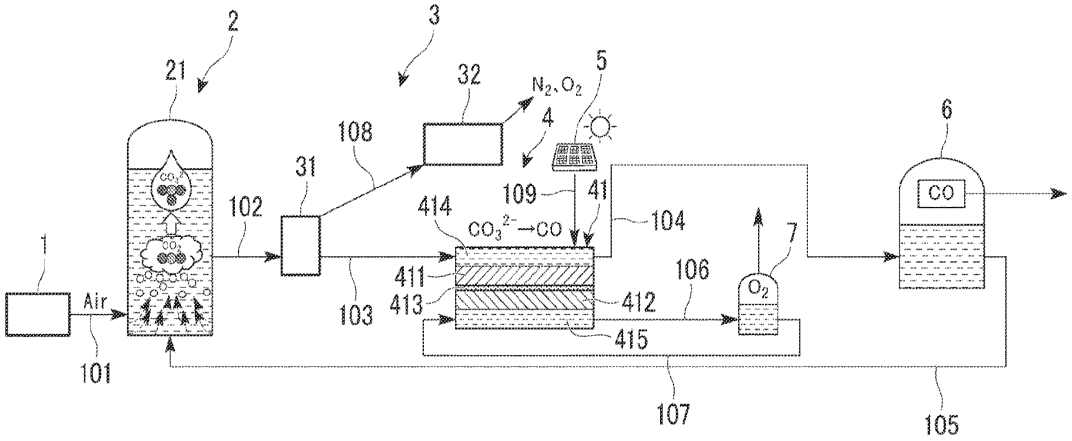
The invention relates to a solid plasma reactor and to methods for operating a fixed bed reactor. According to the invention, they enable the pyrolysis of a wide variety of plastic fractions and organic solids. In addition, lime, for example, can be burned very effectively and without fossil fuels.



CARBON DIOXIDE TREATMENT DEVICE AND CARBON DIOXIDE TREATMENT METHOD

Publication number: US2024325972 (A1)
Publication date: 2024-10-03
Inventor(s): OIKAWA HIROSHI [JP] +
Applicant(s): HONDA MOTOR CO LTD [JP] +

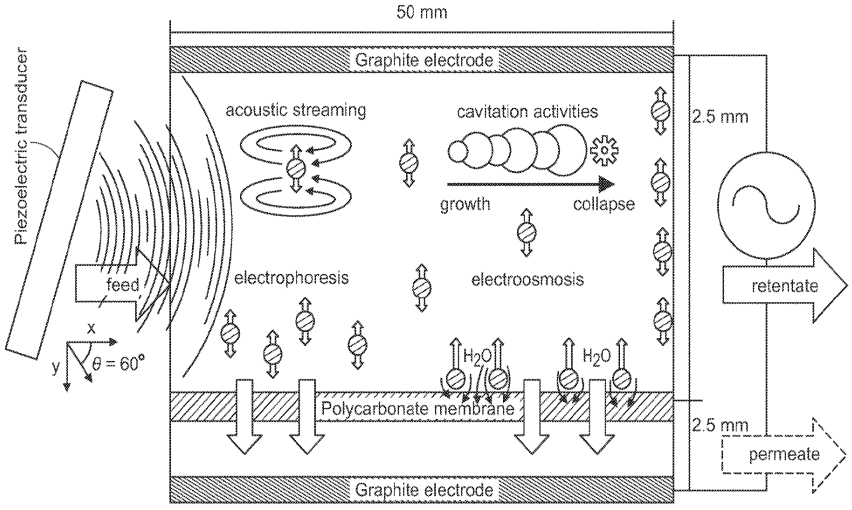
The present application aims to reduce energy consumption when collecting carbon dioxide and improve reaction efficiency when electrochemically reducing carbon dioxide. The present invention provides a carbon dioxide treatment device, including an absorption device that absorbs carbon dioxide, a removal device that removes air components from an electrolytic solution containing the carbon dioxide absorbed by the absorption device, an electrochemical reaction part having an electrolysis cell that electrochemically reduces the carbon dioxide absorbed by the absorption device to carbon monoxide, and a solar power generation device that supplies electric power to the electrochemical reaction part.



MEMBRANE FILTRATION CELL WITH ELECTRIC FIELD AND ACOUSTIC FIELD

Publication number: US2024399312 (A1)
Publication date: 2024-12-05
Inventor(s): BADIREDDY APPALA RAJU [US]; SHEN YUXIANG [US] +
Applicant(s): UNIV OF VERMONT AND STATE AGRICULTURAL COLLEGE [US] +

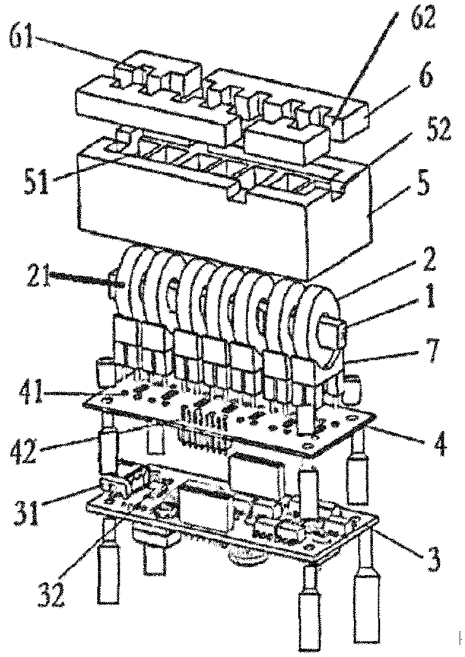
A membrane filtration cell is provided which includes a fluid passageway and a filtration membrane positioned within the passageway, the filtration membrane dividing the fluid passageway into two chambers, a retentate chamber and a permeate chamber. A first electrode is positioned in the retentate chamber and a second electrode is positioned in the permeate chamber, where the first electrode and the second electrode are configured to apply an electric field across the filtration membrane. The membrane filtration cell also includes an acoustic device configured to apply an acoustic field across the retentate chamber, where the synergistic combination of the electric field and the acoustic field prevents fouling on the filtration membrane. A method of filtering water is provided which includes generating an electric field across a filtration membrane with a first electrode positioned in the retentate chamber and a second electrode positioned in the permeate chamber, and generating an acoustic field across the retentate chamber with an acoustic device, where the synergistic combination of the electric field and the acoustic field prevents fouling on the filtration membrane.



INTEGRATED MAGNETIC SEPARATION APPARATUS

Publication number; WO2024244166 (A1)
Publication date: 2024-12-05
Inventor(s): HUANG XIAN [CN]; YANG ZHEN [CN]; HU CHENGUANG [CN]; DU KANG [CN]; LIU XINQUAN [CN]; LIN SI [CN] +
Applicant(s): BEIJING SAVANT BIOTECHNOLOGY CO LTD [CN]; TIANJIN SAVANT BIOTECHNOLOGY CO LTD [CN] +

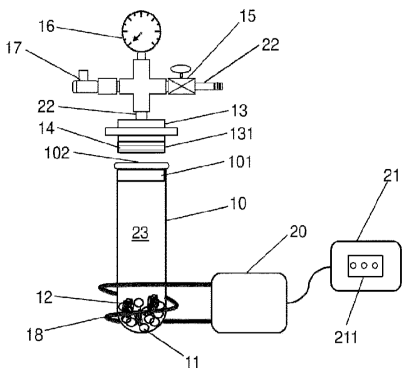
The present invention relates to an integrated magnetic separation apparatus. The integrated magnetic separation apparatus comprises: a micro-pipe, which is a horizontally arranged linear hollow pipe, and comprises a first liquid inlet, a second liquid inlet, a first liquid outlet and a second liquid outlet, the first liquid inlet and the first liquid outlet being respectively arranged at two ends of the micro-pipe; a coil array, which comprises several annular magnetic coils arranged in parallel, the micro-pipe penetrating internal cavities of the annular magnetic coils, and the annular magnetic coils being arranged at intervals on the outside of the micro-pipe; and a drive circuit board, which is electrically connected to the coil array, and is used for controlling a current of the coil array. In the present invention, by means of controlling the annular magnetic coils, after being powered on, the small annular magnetic coils can generate a uniform electric field or a gradient electric field without needing to be subjected to mechanical displacement or rotation, and then magnetic beads are controlled to move in the micro-pipe, thereby realizing reactions and washing.



METHOD FOR CONVERTING PLASTIC INTO HYDROCARBON(S)

Publication number: WO2024231394 (A1)
Publication date: 2024-11-14
Inventor(s): CHAUDRET BRUNO [FR]; GHOSH SOURAV [FR]; OURLIN THIBAULT [FR] +
Applicant(s): INSTITUT NAT DES SCIENCES APPLIQUEES DE TOULOUSE [FR]; CENTRE NAT RECH SCIENT [FR]; UNIV TOULOUSE 3 PAUL SABATIER [FR] +

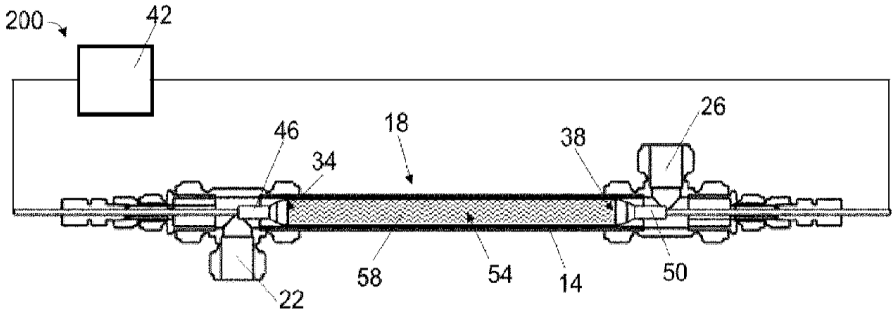
The invention concerns a method for converting into hydrocarbon(s) a solid or liquid substrate (11) selected among substrates formed of plastics material and heavy oils, by a conversion reaction of hydrogenolysis and/or pyrolysis, occurring in a given temperature range. This method comprises contacting, in a reactor (10), the substrate (11) and a microscale heating element (12) formed of a ferromagnetic metal compound, under an oxygen-free atmosphere (23), and heating this heating element (12), at a temperature within said temperature range, by electromagnetic induction by means of a magnetic field inductor (18) external to the reactor (10).



A VESSEL WITH A JOULE HEATING ELEMENT AND METHODS OF USING THE SAME

Publication number: WO2024200203 (A1)
Publication date: 2024-10-03
Inventor(s): SCHUCKER ROBERT C [NL]; CATON NATHAN [NL]; FAZZINI MARCO [NL]; NAGAKI DICK ALAN [NL]; LOILAND JASON [NL] +
Applicant(s): SABIC GLOBAL TECHNOLOGIES BV [NL] +

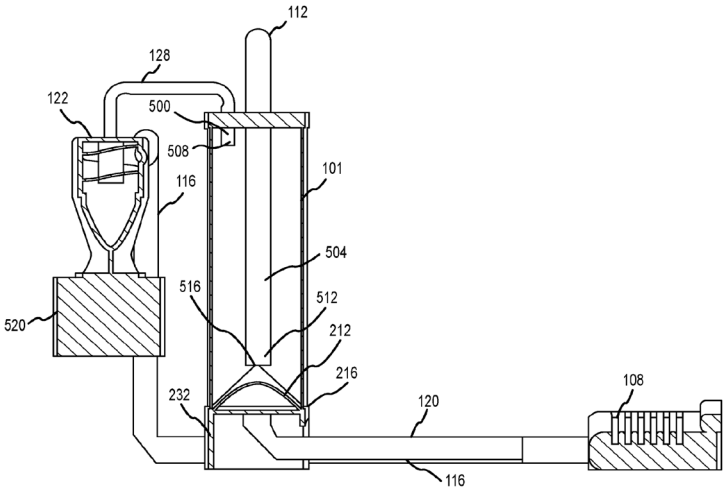
This disclosure includes vessels having Joule heating elements and methods of using the same. In some vessels, the Joule heating element has electrically-resistive elements in the form of wires extending from a first end of the heating element to a second end of the heating element. The electrically-resistive elements define a void volume between the electrically-resistive elements and between the electrically-resistive elements and the vessel, the void volume is configured to permit liquid to flow therethrough from the first end of the heating element to the second end of the heating element. In some methods, a polymeric feed stream is passed through the vessel and heat is transferred from the electrically-resistive heating elements to the polymeric feed stream to produce a product stream that includes depolymerized polymers. The feed stream includes plastic waste, and the product stream includes depolymerized plastic waste.



REACTOR AND PROCESS FOR PRODUCING CARBONACEOUS MATERIALS

Publication number: US2024391766 (A1)
Publication date: 2024-11-28
Inventor(s): JANGBARWALA JUZER [US]; SARKISSIAN ARAM [US] +
Applicant(s): PACT FUEL LLC [US] +

In embodiments of this disclosure, a rotating media fluidized bed reactor for the decomposition of a gaseous hydrocarbon into nanofibers and other carbonaceous materials and hydrogen having a stationary or rotating distributor comprises a substantially hollow gas impermeable structure in fluid communication with one or more peripheral gas distributors to create a slip velocity vortex of reactant gas flow around the gas impermeable structure.



SYSTEMS AND METHODS FOR ALKENE OLIGOMERIZATION

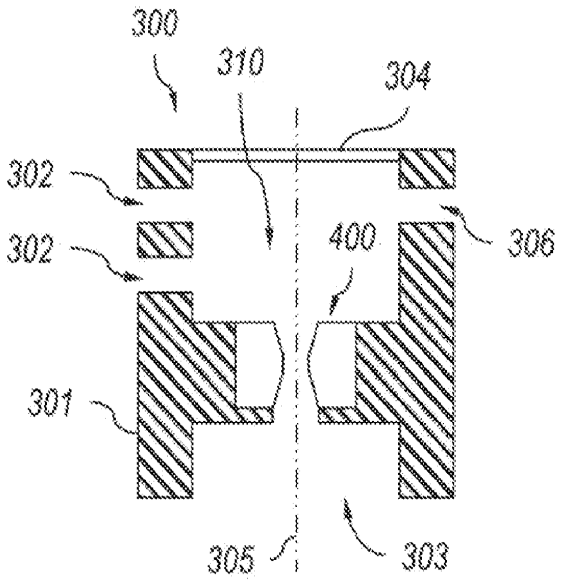
Publication number; WO2024263777 (A1)
Publication date: 2024-12-26
Inventor(s): DESPAGNET-AYOUB EMMANUELLE [US] +
Applicant(s): CALIFORNIA INSTITUTE OF TECH [US] +
Classification:
- international: B01J21/18; B01J23/74; B01J31/14; C10G50/00
- cooperative:
Application number: WO2024US34815 20240620 Global Dossier
Priority number(s): US202363521925P 20230620

Abstract of WO2024263777 (A1)
Systems and methods for multifunctional catalyst systems supported on carbon nanotubes (CNTs) for olefin oligomerization are described. The catalyst systems can directly convert CO2 to jet-range (C12-C18) hydrocarbons. This conversion can be achieved by a cooperative, tandem catalyst system supported on CNTs converting CO2 to olefins (C2-C9) with the catalyst systems followed by oligomerization.

DISTRIBUTED NON-EQUILIBRIUM CHEMICAL AND MATERIAL SYNTHESIS USING COMBINED PLASMA ACTIVATION AND PROGRAMED HEATING AND QUENCHING

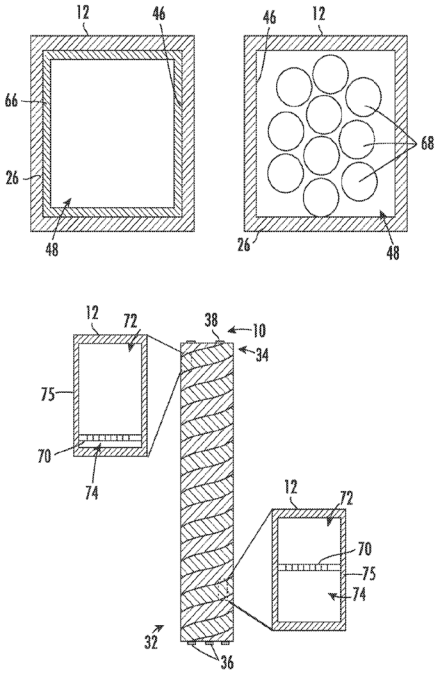
Publication number: US2024367138 (A1)
Publication date: 2024-11-07
Inventor(s): JU YIGUANG [US]; HU LIANGBING [US] +
Applicant(s): UNIV PRINCETON [US]; UNIV MARYLAND [US] +

The approach disclosed herein is a process for non-equilibrium chemical and materials processing using the combination of non-equilibrium plasma, non-equilibrium multi-functional catalysis, a precisely programed heating and quenching (PHQ), and supersonic reaction quenching to dynamically change the chemical equilibrium and increase the yield and selectivity of the products. An important feature of the disclosed approach is to realize an efficient and high selectivity synthesis method of chemicals and materials by using non-chemical equilibrium, non-equilibrium catalysts, and non-equilibrium of excited states via active control of molecule excitation by low temperature hybrid plasma, dynamics of chemical reactions by programed heating and supersonic quenching, and the design of non-equilibrium catalysts by thermal shocks and plasma coupling to enable distributed and electrified chemical synthesis of hydrogen, ammonia, valued carbon and other chemical products at atmospheric conditions. As such, the disclosed approach will enable distributed, electrified, low-carbon, and non-equilibrium chemical and material synthesis using renewable electricity, fossil fuels, biomass, and other abundant or waste resources.



REACTOR WITH COUNTER HELICAL FLOW CHANNELS AND METHOD OF USING SAME

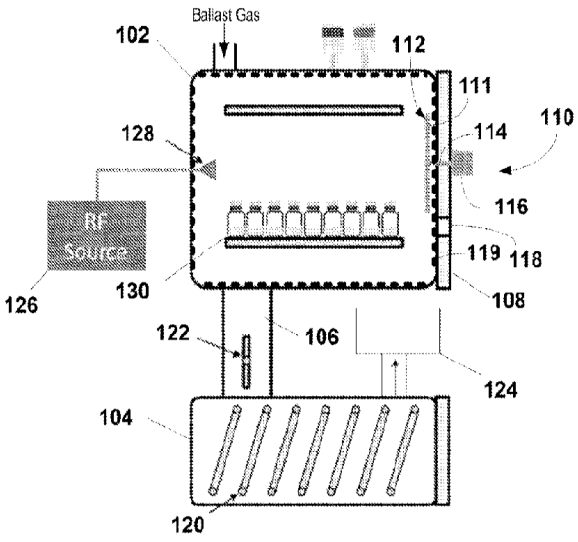
Publication number; WO2024254025 (A1)
Publication date: 2024-12-12
Inventor(s): LAVRIC ELENA DANIELA [FR] +
Applicant(s): CORNING INC [US] +



Embodiments of the disclosure relate to a reactor. The reactor includes a first helical channel having a plurality of first turns and a second helical channel having a plurality of second turns. The plurality of second turns of the second helical channel alternate with the plurality of first turns of the first helical channel. The reactor also includes a permeable membrane that divides the first helical channel into a first passage and a second passage along a length of the first helical channel. The permeable membrane is configured to control a flow of fluid between the first passage and the second passage.

MODULAR RF-HEATING SYSTEM FOR FREEZE-DRYING

Publication number: WO2024243593 (A1)
Publication date: 2024-11-28
Inventor(s): PEROULIS DIMITRIOS [US]; ALEXEENKO-PEROULIS ALINA [US]; STRONGRICH ANDREW DAVID [US]; DARWISH AHMAD NAIF [US] +
Applicant(s): PURDUE RESEARCH FOUNDATION [US] +

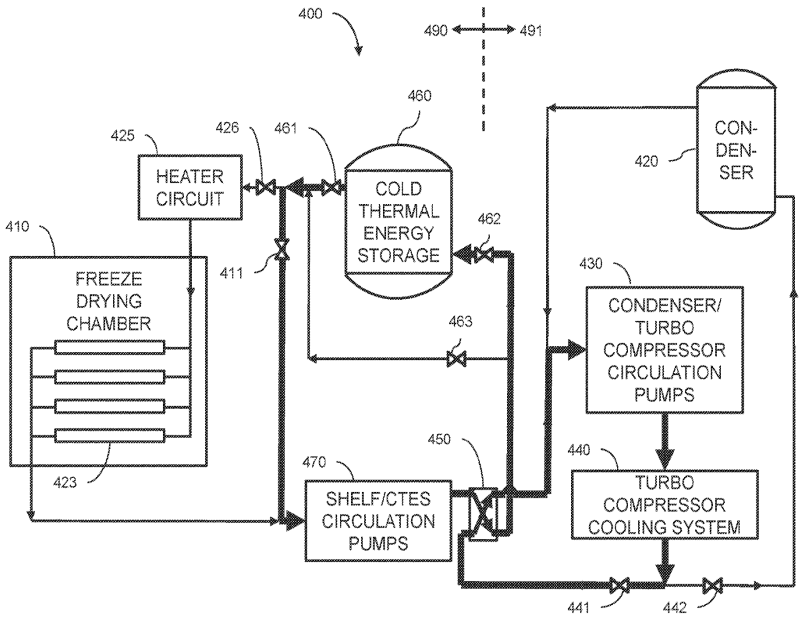


A freeze drier system may include a product chamber and a reflective scattering surface disposed in the product chamber. An RF source may be connected to an antenna directed at the scattering surface. The RF source may emit electromagnetic waves via the antenna and the scattering surface may reflect the electromagnetic waves in various directions to provide uniform heating in the product chamber.

COOLING SYSTEM FOR FREEZE DRYER

Publication number: US2024369296 (A1)
Publication date: 2024-11-07
Inventor(s): DEMARCO FRANCIS W [US] +
Applicant(s): IMA LIFE NORTH AMERICA INC [US] +

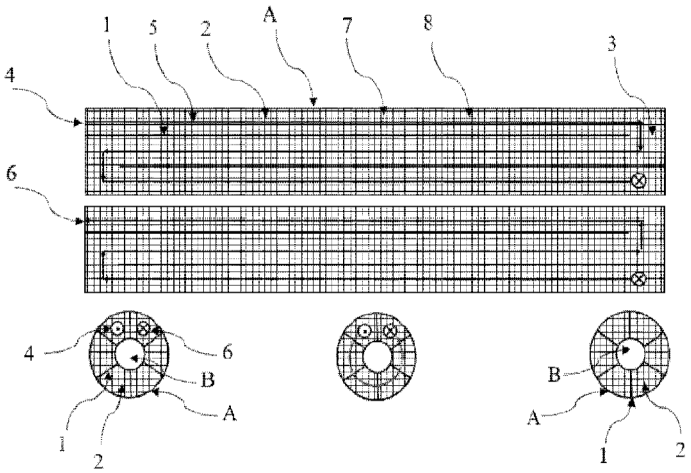
In freeze drying systems and methods, a cooling system is supplemented at peak loads with a cold thermal energy storage (CTES) system that utilizes a phase change material (PCM). The system permits the use of an alternative cooling system, such as a turbo compressor cooling system, while still meeting peak cooling capacity requirements



COMPOUND STATIC MIXER REACTOR AND APPLICATIONS THEREOF

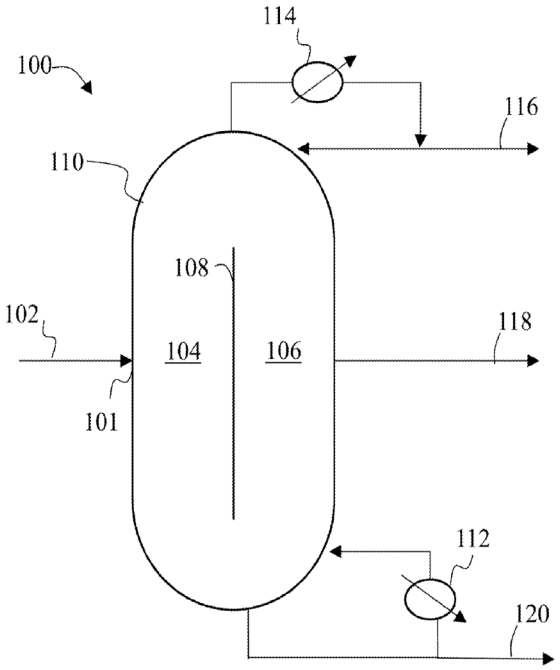
Publication number: WO2024234053 (A1)
Publication date: 2024-11-21
Inventor(s): ARORA DEEPALI [AU]; HORNUNG CHRISTIAN [AU]; CHIEFARI JOHN [AU]; RICHARDS MATTHEW [AU]; ZHU YUTONG [AU]; DODANWELA ROSHAN [AU]; DARK ROBERT [AU] +
Applicant(s): COMMW SCIENT IND RES ORG [AU] +

A compound static mixer element, a compound catalytic static mixer element, and dehydrogenation and hydrogenation processes using a compound catalytic static mixer element, configured for use with continuous flow chemical reactors, for example tubular continuous flow chemical reactors for heterogeneous catalysis reactions.



PROCESS FOR THE SEPARATION OF OLEFINS AND LOW MOLECULAR WEIGHT HYDROCARBONS IN METHANOL TO OLEFIN PROCESSES

Publication number: US2024368055 (A1)
Publication date: 2024-11-07
Inventor(s): ANDRADE NAYANA PEREIRA [BR]; DAS VIRGENS REBOUÇAS MÁRCIO [BR]; DOS SANTOS ANDRADE MÁRCIO HENRIQUE [BR]; BRITO KAROLINE DANTAS [BR]; BRITO ROMILDO PEREIRA [BR] +
Applicant(s): BRASKEM SA [BR] +



A process of purifying downstream methanol-to-olefin streams comprising separating a downstream methanol-to-olefin stream comprising one or more light and heavy components in a first column into a light component stream and a heavy component stream, purifying a light component stream with a first dividing wall distillation column thereby producing an ethylene fraction and distilling the heavy component stream thereby forming a propylene fraction.

REPLACEABLE MEMBRANE DISTILLATION MODULE AND MEMBRANE DISTILLATION PLATE THEREOF

Publication number: US2024382903 (A1)
Publication date: 2024-11-21
Inventor(s): CHANG ROGER [TW]; SHIH PO-CHUN [TW]; WANG HONG-YI [TW]; WU TING YUN [TW] +
Applicant(s): ALLIED SUPREME CORP [TW] +

A replaceable membrane distillation module has a membrane distillation plate with an upper portion and a lower portion at two ends respectively. Two upper holes and two lower holes are defined through the upper portion and the lower portion at two ends respectively. A distillation portion is recessed in at least one side of the membrane distillation plate, and a distillation membrane covers on the distillation portion that a distillation space forms between the distillation portions and the distillation membrane. Multiple channels are disposed in the membrane distillation plate to communicate one of the upper holes, the distillation space and one of the lower flow holes. A blocking element is selectively combined with one of the upper holes or one of the lower flow holes.