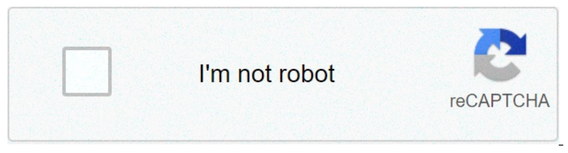

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What is reforming in organic chemistry

Reforming is a process designed to increase the volume of gasoline that can be produced from a barrel of crude oil. Hydrocarbons in the naphtha stream have roughly the same number of carbon atoms as those in gasoline, but their structure is generally more complex. Reforming rearranges naphtha hydrocarbons into gasoline molecules. The reforming process involves three separate catalytic reactors, each one taking place under carefully controlled temperature and pressure levels. Naphtha is mixed with hydrogen and fed through each reactor chamber in sequence. Additional hydrogen formed by the catalytic reactors is recovered and put to use in subsequent reforming and in other processes throughout the refinery. The other products of reforming are light gases and a high-octane gasoline blending component called reformate. The octane rating of reformate is important because it affects the octane rating of the gasoline you buy at the pump. By controlling the temperature and flow rate of the reformer, refinery operators can increase the octane rating of the reformate, but that also has the effect of producing less reformate. The reverse is also true: If demand for high-octane gasoline is lower, the reformer can be adjusted to produce more reformate with a lower octane rating. »next Working off-campus? Learn about our remote access options Volume 27, Issue 14 p. 4715-4722 Glycolic acid is a useful and important α-hydroxy acid that has broad applications. Herein, the homogeneous ruthenium catalyzed reforming of aqueous ethylene glycol to generate glycolic acid as well as pure hydrogen gas, without concomitant CO2 emission, is reported. This approach provides a clean and sustainable direction to glycolic acid and hydrogen, based on inexpensive, readily available, and renewable ethylene glycol using 0.5 mol % of catalyst. In-depth mechanistic experimental and computational studies highlight key aspects of the PNNH-ligand framework involved in this transformation. As a service to our authors and readers, this journal provides supporting information supplied by the authors. Such materials are peer reviewed and may be re-organized for online delivery, but are not copy-edited or typeset. Technical support issues arising from supporting information (other than missing files) should be addressed to the authors. Please note: The publisher is not responsible for the content or functionality of any supporting information supplied by the authors. Any queries (other than missing content) should be directed to the corresponding author for the article. Copyright © 2015 - 2021 Revision World Networks Ltd. Steam methane reforming (SMR) is a process in which methane from natural gas is heated, with steam, usually with a catalyst, to produce a mixture of carbon monoxide and hydrogen used in organic synthesis and as a fuel. In energy, SMR is the most widely used process for the generation of hydrogen. In SMR, methane reacts with steam under 3-25 bar pressure (1 bar= 14.5 psi) in the presence of a catalyst to produce hydrogen, carbon monoxide, and a relatively small amount of carbon dioxide. Steam reforming reaction is endothermic, i. e. heat must be supplied to the process for the reaction to proceed. In a “water-gas shift reaction,” the carbon monoxide and steam are reacted using a catalyst to produce carbon dioxide and more hydrogen. In a final process step called “pressure-swing adsorption,” carbon dioxide and other impurities are removed from the gas stream, leaving essentially pure hydrogen. Steam reforming can also be used to produce hydrogen from other fuels, such as ethanol, propane, or even gasoline. Steam-Methane Reforming Reaction CH4 + H2O (+heat) → CO + 3H2 Water-Gas Shift Reaction CO + H2O → CO2 + H2 (+small amount of heat) CT-CO2ARTM Chiyoda CO2 Reforming Technology CT-CO2ARTM is a unique and advanced technology utilizing CO2 as a reforming agent to efficiently produce synthetic gases of varying H2/CO ratios This technology enables the monetization of low-calorie, CO2-containing natural gas fields and can also enable the efficient reuse of CO2 emitted from various industrial processes. Synthesis gases are the feeds for producing various chemicals (Oxo-Synthesis, MMA, Acetic acid, etc.). The CT-CO2ARTM technology consumes CO2 as a reforming agent and in tandem with its unique reforming catalyst, achieves high energy-efficiency. CT-CO2ARTM is thus, an environmentally-friendly technology due to significant reduction in emissions. Capabilities Synthesis gas production under optimum conditions with a novel catalyst Chiyoda’s proprietary catalyst, having high resistance to carbon formation (even under CO2 reforming conditions), results in significant reductions in the requirement of steam and CO2. Consequently, CT-CO2ARTM produces synthesis gases with high energy-efficiency and without any carbon formation. High energy-efficiency and cost competitiveness Compared to conventional steam-reforming, CT-CO2ARTM reduces the volume of reformer feed gas by 60%. This results in improved energy efficiency together with a significant reduction of capital investment, operating costs and CO2 emissions. Specifically, for production of syngas with an H2/CO ratio of 1.0, capital costs are reduced by more than 20% compared with conventional technologies. For an H2/CO ratio of 0.5, the reduction is even more significant, exceeding 40%. CT-CO2ARTM is thus economically competitive. Applicable range Direct production of Synthesis gases with a wide range of H2/CO ratios Direct production of synthesis gases with a wide range of H2/CO ratios is efficiently accomplished using CT-CO2ARTM, by varying the feed gas ratios such as steam/carbon ratio and CO2/carbon ratio. B—PERFORMING OPERATIONS; TRANSPORTING B01—PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL B01J—CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS OR COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS B01J21/00—Catalysts comprising the elements, oxides, or hydroxides of magnesium, boron, aluminium, carbon, silicon, titanium, zirconium or hafnium B01J21/06—Silicon, titanium, zirconium or hafnium; Oxides or hydroxides thereof B01J21/066—Zirconium or hafnium; Oxides or hydroxides thereof B—PERFORMING OPERATIONS; TRANSPORTING B01—PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL B01J—CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS OR COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS B01J23/00—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 B01J23/38—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of noble metals B01J23/40—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of noble metals of the platinum group metals B01J23/46—Ruthenium, rhodium, osmium or iridium B01J23/462—Ruthenium B—PERFORMING OPERATIONS; TRANSPORTING B01—PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL B01J—CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS OR COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS B01J23/00—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 B01J23/70—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of the iron group metals or copper B01J23/89—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of the iron group metals or copper combined with noble metals B01J23/8913—Cobalt and noble metals B—PERFORMING OPERATIONS; TRANSPORTING B01—PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL B01J—CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS OR COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS B01J23/00—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 B01J23/70—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of the iron group metals or copper B01J23/89—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of the iron group metals or copper combined with noble metals B01J23/8933—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of the iron group metals or copper combined with noble metals also combined with metals, or metal oxides or hydroxides provided for in groups B01J23/02 - B01J23/36 B01J23/8946—Catalysts comprising metals or metal oxides or hydroxides, not provided for in group B01J21/00 of the iron group metals or copper combined with noble metals also combined with metals, or metal oxides or hydroxides provided for in groups B01J23/02 - B01J23/36 with alkali or alkaline earth metals B—PERFORMING OPERATIONS; TRANSPORTING B01—PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL B01J—CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS OR COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS B01J37/00—Processes, in general, for preparing catalysts; Processes, in general, for activation of catalysts B01J37/02—Impregnation, coating or precipitation B01J37/0201—Impregnation C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B3/00—Hydrogen; Gaseous mixtures containing hydrogen; Separation of hydrogen from mixtures containing it; Purification of hydrogen C01B3/02—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen C01B3/32—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen by reaction of gaseous or liquid organic compounds with gasifying agents, e.g. water, carbon dioxide, air C01B3/34—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen by reaction of gaseous or liquid organic compounds with gasifying agents, e.g. water, carbon dioxide, air by reaction of hydrocarbons with gasifying agents C01B3/38—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen by reaction of gaseous or liquid organic compounds with gasifying agents, e.g. water, carbon dioxide, air by reaction of hydrocarbons with gasifying agents using catalysts C01B3/382—Multi-step processes C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B3/00—Hydrogen; Gaseous mixtures containing hydrogen; Separation of hydrogen from mixtures containing it; Purification of hydrogen C01B3/02—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen C01B3/32—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen by reaction of gaseous or liquid organic compounds with gasifying agents, e.g. water, carbon dioxide, air by reaction of hydrocarbons with gasifying agents C01B3/38—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen by reaction of gaseous or liquid organic compounds with gasifying agents, e.g. water, carbon dioxide, air by reaction of hydrocarbons with gasifying agents using catalysts C01B3/40—Production of hydrogen or of gaseous mixtures containing a substantial proportion of hydrogen by reaction of gaseous or liquid organic compounds with gasifying agents, e.g. water, carbon dioxide, air by reaction of hydrocarbons with gasifying agents using catalysts characterised by the catalyst B—PERFORMING OPERATIONS; TRANSPORTING B01—PHYSICAL OR CHEMICAL PROCESSES OR APPARATUS IN GENERAL B01J—CHEMICAL OR PHYSICAL PROCESSES, e.g. CATALYSIS OR COLLOID CHEMISTRY; THEIR RELEVANT APPARATUS B01J21/00—Catalysts comprising the elements, oxides, or hydroxides of magnesium, boron, aluminium, carbon, silicon, titanium, zirconium, or hafnium B01J21/02—Boron or aluminium; Oxides or hydroxides thereof B01J21/04—Alumina C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/02—Processes for making hydrogen or synthesis gas C01B2203/0205—Processes for making hydrogen or synthesis gas containing a reforming step C01B2203/0227—Processes for making hydrogen or synthesis gas containing a reforming step containing a catalytic reforming step C01B2203/0244—Processes for making hydrogen or synthesis gas containing a reforming step containing a catalytic reforming step the reforming step being an autothermal reforming step, e.g. secondary reforming processes C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/08—Methods of heating or cooling C01B2203/0805—Methods of heating the process for making hydrogen or synthesis gas C01B2203/0838—Methods of heating the process for making hydrogen or synthesis gas by heat exchange with exothermic reactions, other than by combustion of fuel C01B2203/0844—Methods of heating the process for making hydrogen or synthesis gas by heat exchange with exothermic reactions, other than by combustion of fuel the non-combustive exothermic reaction being another reforming reaction as defined in groups C01B2203/02 - C01B2203/0294 C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/10—Catalysts for performing the hydrogen forming reactions C01B2203/1041—Composition of the catalyst C01B2203/1047—Group VIII metal catalysts C01B2203/1052—Nickel or cobalt catalysts C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/10—Catalysts for performing the hydrogen forming reactions C01B2203/1041—Composition of the catalyst C01B2203/1047—Group VIII metal catalysts C01B2203/1064—Platinum group metal catalysts C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/10—Catalysts for performing the hydrogen forming reactions C01B2203/1041—Composition of the catalyst C01B2203/1047—Group VIII metal catalysts C01B2203/1064—Platinum group metal catalysts C01B2203/107—Platinum catalysts C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/10—Catalysts for performing the hydrogen forming reactions C01B2203/1041—Composition of the catalyst C01B2203/1082—Composition of support materials C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/12—Feeding the process for making hydrogen or synthesis gas C01B2203/1205—Composition of the feed C01B2203/1211—Organic compounds or organic mixtures used in the process for making hydrogen or synthesis gas C01B2203/1217—Alcohols C01B2203/1223—Methanol C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/12—Feeding the process for making hydrogen or synthesis gas C01B2203/1205—Composition of the feed C01B2203/1211—Organic compounds or organic mixtures used in the process for making hydrogen or synthesis gas C01B2203/1217—Alcohols C01B2203/1229—Ethanol C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/12—Feeding the process for making hydrogen or synthesis gas C01B2203/1205—Composition of the feed C01B2203/1211—Organic compounds or organic mixtures used in the process for making hydrogen or synthesis gas C01B2203/1235—Hydrocarbons C01B2203/1247—Higher hydrocarbons C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/14—Details of the flowsheet C01B2203/142—At least two reforming, decomposition or partial oxidation steps in series C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/14—Details of the flowsheet C01B2203/142—At least two reforming, decomposition or partial oxidation steps in series C01B2203/143—Three or more reforming, decomposition or partial oxidation steps in series C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/14—Details of the flowsheet C01B2203/146—At least two purification steps in series C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/14—Details of the flowsheet C01B2203/148—Details of the flowsheet involving a recycle stream to the feed of the process for making hydrogen or synthesis gas C—CHEMISTRY; METALLURGY C01—INORGANIC CHEMISTRY C01B—NON-METALLIC ELEMENTS; COMPOUNDS THEREOF; METALLOIDS OR COMPOUNDS THEREOF NOT COVERED BY SUBCLASS C01C C01B2203/00—Integrated processes for the production of hydrogen or synthesis gas C01B2203/80—Aspect of integrated processes for the production of hydrogen or synthesis gas not covered by groups C01B2203/02 - C01B2203/1695 C01B2203/82—Several process steps of C01B2203/02 - C01B2203/08 integrated into a single apparatus Y—GENERAL TAGGING OF NEW TECHNOLOGICAL DEVELOPMENTS; GENERAL TAGGING OF CROSS-SECTIONAL TECHNOLOGIES SPANNING OVER SEVERAL SECTIONS OF THE IPC; TECHNICAL SUBJECTS COVERED BY FORMER USPC CROSS-REFERENCE ART COLLECTIONS [XRACs] AND DIGESTS Y02—TECHNOLOGIES OR APPLICATIONS FOR MITIGATION OR ADAPTATION AGAINST CLIMATE CHANGE Y02P—CLIMATE CHANGE MITIGATION TECHNOLOGIES IN THE PRODUCTION OR PROCESSING OF GOODS Y02P20/00—Technologies relating to chemical industry Y02P20/50—Improvements relating to the production of bulk chemicals Y02P20/52—Improvements relating to the production of bulk chemicals using catalysts, e.g. selective catalysts

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