

Hydrogen Generation via Fuel Reforming

John F. Krebs

Argonne National Laboratory

Reforming is the conversion of a hydrocarbon based fuel to a gas mixture that contains hydrogen. The H_2 that is produced by reforming can then be used to produce electricity via fuel cells. The realization of H_2 -based power generation, via reforming, is facilitated by the existence of the liquid fuel and natural gas distribution infrastructures. Coupling these same infrastructures with more portable reforming technology facilitates the realization of fuel cell powered vehicles. Three reforming methods will be discussed: catalytic steam reforming, partial oxidation reforming (POX) and autothermal reforming (ATR). Catalytic steam reforming (CSR) is an endothermic process that uses water to selectively oxidize the fuel to H_2 and CO_2 . Steam reforming is employed commercially for converting lower alkanes and alcohols and produces the highest concentration of H_2 of the three methods. Partial oxidation (POX) reforming is an exothermic reaction that uses a substoichiometric amount of oxygen, generally from air, to convert the fuel to a H_2 -containing stream. The substoichiometric amount of O_2 used results in significant production of carbon monoxide (CO). Autothermal reforming (ATR) is a nearly thermo-neutral process that employs both steam and oxygen to convert the hydrocarbon fuel to a H_2 -containing stream. The ratio of $O_2:C$ and $H_2O:C$ is critical for optimal H_2 output and for balancing the energetics of the endothermic steam reforming and exothermic partial oxidation reactions, hence autothermal. Similar to the POX product stream the autothermal reformat stream contains CO and the H_2 is further diluted by the nitrogen added from air. Contaminants in the product stream, such as CO and hydrogen sulfide (H_2S), can significantly degrade the performance of current polymer electrolyte membrane (PEM) fuel cells. Removal of such contaminants requires extensive processing of the product stream prior to utilization by the fuel cell to generate electricity. Generally, sulfur is removed first by passing the reformat stream over an adsorbent such as zinc oxide. Carbon monoxide is then removed by converting it to additional H_2 , via the water-gas shift (WGS) reaction, through reaction with additional steam. For transportation applications the entire fuel processing system must be as small and lightweight as possible to achieve desirable performance requirements. Current efforts at Argonne National Laboratory are focused on catalyst development and reactor engineering of the autothermal processing train for transportation and distributed generation applications.