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Supercritical Water Gasification of Organic Wastes for Hydrogen Production and Waste Valorization

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Abstract : Population growth and industrial development imply an increase in the energy demands and the problems caused by emissions of greenhouse effect gases, which has inspired the search for clean sources of energy. Hydrogen (H_2) is expected to play a key role in the world's energy future by replacing fossil fuels. The properties of H_2 make it a green fuel that does not generate pollutants and supplies sufficient energy for power generation, transportation, and other applications. Supercritical Water Gasification (SCWG) represents an attractive alternative for the recovery of energy from wastes. SCWG allows conversion of a wide range of raw materials into a fuel gas with a high content of hydrogen and light hydrocarbons through their treatment at conditions higher than those that define the critical point of water (temperature of 374°C and pressure of 221 bar). Methane used as a transport fuel is another important gasification product. The number of different uses of gas and energy forms that can be produced depending on the kind of material gasified and type of technology used to process it, shows the flexibility of SCWG. This feature allows it to be integrated with several industrial processes, as well as power generation systems or waste-to-energy production systems. The final aim of this work is to study which conditions and equipment are the most efficient and advantageous to explore the possibilities to obtain streams rich in H_2 from oily wastes, which represent a major problem both for the environment and human health throughout the world. In this paper, the relative complexity of technology needed for feasible gasification process cycles is discussed with particular reference to the different feedstocks that can be used as raw material, different reactors, and energy recovery systems. For this purpose, a review of the current status of SCWG technologies has been carried out, by means of different classifications based on key features as the feed treated or the type of reactor and other apparatus. This analysis allows to improve the technology efficiency through the study of model calculations and its comparison with experimental data, the establishment of kinetics for chemical reactions, the analysis of how the main reaction parameters affect the yield and composition of products, or the determination of the most common problems and risks that can occur. The results of this work show that SCWG is a promising method for the production of both hydrogen and methane. The most significant choices of design are the reactor type and process cycle, which can be conveniently adopted according to waste characteristics. Regarding the future of the technology, the design of SCWG plants is still to be optimized to include energy recovery systems in order to reduce costs of equipment and operation derived from the high temperature and pressure conditions that are necessary to convert water to the SC state, as well as to find solutions to remove corrosion and clogging of components of the reactor.

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