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C2Po1D-07: Test platforms for ortho-para hydrogen conversion at cryogenic conditions

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Large-scale, low-energy-consumption hydrogen liquefaction technologies are crucial for the widespread adoption of liquid hydrogen. However, fundamental data on continuous ortho-para hydrogen conversion at cryogenic temperatures remain limited. To address this, a series of test platforms has been established to investigate ortho-para hydrogen conversion under a wide range of cryogenic conditions, providing essential data that support the precise design of cryogenic hydrogen heat exchangers. These platforms range from small-sample catalyst tests at 77 K to intermediate-scale single-channel plate-fin heat exchanger tests, and finally to a large-scale prototype heat exchanger. At the smallest scale, catalyst performance is measured at 77 K to obtain conversion rates, pressure drops, and useful correlations. At the intermediate scale, a plate-fin heat exchanger configuration is used with a single hydrogen flow channel containing approximately 2 kg of catalyst, sandwiched between two helium coolant channels. This setup operates at 30 to 80 K, with mass flows from 0 to 1 g/s, pressures up to 3 MPa, and inlet ortho-para hydrogen concentrations of 25% to 50%. At the largest scale, a prototype facility operates at 80 to 300 K, supporting mass flows up to 3 g/s (about 0.26 tons per day) and pressures up to 3 MPa. These systematic experiments provide a comprehensive dataset covering a wide range of conditions. The resulting data enable the development of accurate models and correlations for flow, heat transfer, and conversion, ultimately guiding the optimization and improved performance of cryogenic hydrogen liquefaction systems.

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