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Application of Microfluidic Techniques to Pyrochemical Salt Sampling and Analysis

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Microfluidic techniques enable production of micro-samples of molten salt for analysis by at-line and off-line sensors and detectors. These sampling systems are intended for implementation in an electrochemical used fuel treatment facility as part of the material balance and control system. Microfluidics may reduce random statistical error associated with sampling inhomogeneity because a large number of uniform sub-microliter droplets may be generated and successively analyzed. The approach combines two immiscible fluids in a microchannel under laminar flow conditions to generate slug flows. Because the slug flow regime is characterized by regularly sized and spaced droplets, it is commonly used in low-volume/high-throughput assays of aqueous and organic phases. This scheme is now being applied to high-temperature molten salts in combination with a second fluid that is stable at elevated temperatures. The microchip systems are being tested to determine the channel geometries and absolute and relative phase flow rates required to achieve stable slug flow. Because imaging is difficult at the 500℃ process temperatures the fluorescence of salt ions under ultraviolet illumination is used to discern flow regimes. As molten chloride melts are optically transparent, UV-visible light spectroscopy is also being explored as a spectroscopic technique for integration with at-line microchannel systems to overcome some of the current challenges to in situ analysis. A second technique that is amenable to droplet analysis is Laser–induced Breakdown Spectroscopy (LIBS). A pneumatic droplet generator is being interfaced with a LIBS system for analysis of molten salts at near-process temperatures. Tests of the pneumatic generator are being run using water and molten salts, and in tandem with off-line analysis of the salt droplets with a LIBS spectrometer.

Country or International Organization

United States of America

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