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A Cold-Start Free Fuel Cell Fed with a Rechargeable "Gasoline"

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Extended Abstract

In the last decades, driven by the depletion of conventional fossil fuels, the mission for finding alternative systems for sustainable power generation becomes more and more urgent [1]. Among the diverse kinds of novel power generation systems, the direct liquid fuel cells, are believed to be one of the most important candidates [2]. However, their poor performance at low temperatures, particularly in the sub-zero environment, greatly restricted their world-wide applications [3]. Recently, a novel rechargeable "gasoline", named the electrically rechargeable liquid fuel (e-fuel), has been proposed and proved to be an effective approach for storing intermittent renewable power [4]. In comparison to the conventional liquid fuels, this rechargeable "gasoline" has many advantages including: i) wide material selectivity; ii) rechargeability; and iii) fast reaction kinetics even on catalyst-free electrode. Furthermore, it also possesses a freezing point of as low as ~ -30˚C. [5]

In this work, fed with this rechargeable "gasoline", we develop, characterize and demonstrate a passive liquid fuel cell capable of stably generating electricity in a sub-zero environment. By applying a cold-start-free strategy, where the cell does not need any auxiliary/internal equipment for rapid warm up at the beginning of its operation, the cell temperature is able to be maintained at sub-zero while being able to achieve a stable and high performance. It is found that, utilizing the rechargeable "gasoline", the cell is able to achieve a peak power density of 110.34 mW cm^{-2} and a maximum current density of 244.72 mA cm^{-2} even at -20 ˚C, demonstrating it as a highly attractive candidate for applications under a wide range of operating temperature. To the best of our knowledge, neither traditional direct liquid fuel cells nor hydrogen-oxygen fuel cells have ever been observed to operate successfully under the aforementioned operating conditions, while a great improvement is also achieved even in comparison to our previous work [5]. This important breakthrough is thus believed to provide an important direction for the advancement of fuel cell technology for operation under sub-zero temperatures, especially for supplying future FCEVs under all-climate conditions.

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