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Efficiency improvement of Mn_2O_3/Mn_3O_4 redox reaction by means of different operation strategies

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ABSTRACT

The next generation of Concentrated Solar Power (CSP) technologies considers working at temperatures beyond the maximum working temperature affordable by the current thermal energy storage (TES) systems, where the thermochemical energy storage (TCS) technology is strongly considered as a potential candidate that might cover this gap. TCS technology is based on reversible chemical reactions, counting with a wide range of candidates that could operate at temperatures above 565°C, where metal oxides redox reactions have been considered as one of the most promising technologies, as they can be used in open air atmosphere. Among the studied redox materials, the Mn_2O_3/Mn_3O_4 redox couple presents lower cost and toxicity compared to other candidates and has been proposed as a suitable material for TES in CSP although some controversy has been identified regarding its ability to maintain its full energy storage capacity under a relevant number of cycles, required for this application. In this work, the influence of different parameters, such as temperature and heating and cooling rates, has been deeply addressed, aimed to explain this controversy and improve the response of this material for a long-term use. An appropriate selection of these parameters has been proved to improve the heat storage capacity by 1.46 times in a 10 cycles test, although different degrees of sintering has been found, demonstrating the main weakness of this material, which in case of applying inappropriate strategies might conduct to a complete loss of its cyclability. At the same time, a new approach has been successfully studied for the first time, aimed to improve the efficiency of the TES by means of decreasing the storage temperature and conducting the oxidation reaction at much lower temperatures than previous studies, under a heating up step with an optimal reaction rate.

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