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Negative CO_2 emissions through the use of biofuels in chemical looping technology: A review

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HIGHLIGHTS

- Chemical looping is recognised as a promising low cost CO_2 capture technology.
- The use of biofuels in Chemical looping processes can be an up-and-coming BECCS technology.
- Different biofuels and chemical looping technologies are considered.
- Negative emissions are achieved both during combustion and syngas/H_2 production processes.
- Bio-Chemical Looping can contribute to reach the target set in the Paris Agreement.

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ABSTRACT

In order to limit the increase in the global average temperature to 2 °C or below, the Paris Agreement proposed the reduction of CO_2 emissions throughout this century. Bioenergy with CO_2 capture and storage (BECCS) technologies represent an interesting option in order to allow this goal to be metgoal, because they are able to achieve negative CO_2 emissions. Chemical looping (CL) is recognized as one of the most innovative CO_2 capture technologies owing to its low energy penalty. CL processes permit the utilization of renewable fuels in a nitrogen-free atmosphere, given that the required oxygen is supplied by solid oxygen carriers. The present work presents an overview of the status of development of the use of biofuels in chemical looping technologies, including chemical looping combustion (CLC) and chemical looping with oxygen uncoupling (CLOU) for the production of heat/electricity, as well as chemical looping reforming (CLR), chemical looping gasification (CLG) and chemical looping coupled with water splitting (CLWS) for syngas/H_2 generation. The main milestones in the development of such processes are shown, and the future trends and opportunities for CL technology with biofuels are discussed.

1. Introduction

Reducing anthropogenic emissions of CO_2 has become one of the main environmental concerns at present, as links have been found between the increase in CO_2 levels in the atmosphere and the increase in global warming. At the 21st Conference of Parties (COP-21) of the United Nations Framework Convention on Climate Change (UNFCCC) held in Paris in 2015, 194 countries signed the Paris Agreement, whose goals are to hold the increase in the global average temperature to well below 2 °C by 2100 and to pursue efforts to limit the temperature increase to 1.5 °C above preindustrial levels [1]. The Paris Agreement came into force on 4 November 2016 and currently it has been ratified by 179 countries accounting for 88.75% of total greenhouse gas emissions [2]. Several actions must be promoted if the proposed aim is to be achieved. Measures traditionally considered for the reduction of CO_2 emissions into the atmosphere [3], such as improvement in the use and generation of energy, continued use of nuclear energy, boosting energy generation from renewable sources and CO_2 capture, are not sufficient to limit the CO_2 concentration in the atmosphere to the desired levels. In fact, the adoption of new solutions capable of removing CO_2 from the atmosphere, referred to as "negative emission technologies (NETs)", will be necessary in the near future. The increasing interest to find innovative solutions that allow reaching below zero CO_2 emissions has recently led to the celebration of the first International Conference on Negative CO_2 Emissions held at Chalmers University of Technology (Sweden) [4]. According to predictions by the United Nations Intergovernmental Panel on Climate Change (IPCC), CO_2 emissions should peak by 2020 and then decrease to negative values by the end of the

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