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Review

Progress in oxygen carrier development of methane-based chemical-looping reforming: A review

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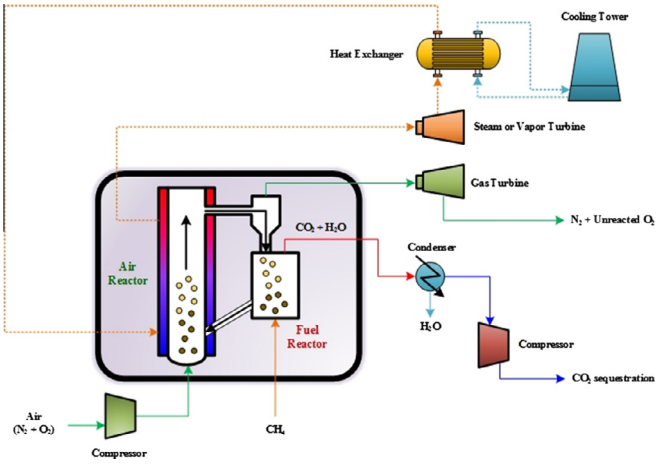
HIGHLIGHTS

- Partial oxidation of CH_4 (POM) possesses advantages over steam reforming of CH_4.
- Applying chemical-looping combustion concept can resolve the drawbacks of POM.
- The appropriate selection of oxygen carrier becomes a critical issue for POM.
- The use of steam or CO_2 to replace air remains to be a great challenge.
- Perovskites using lattice oxygen for syngas production showed prominent results.

GRAPHICAL ABSTRACT



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ABSTRACT

This work comprehensively reviews the recent advances for chemical-looping reforming of CH_4 (CLR) technology, which breaks down the traditional CH_4 reforming process (including steam and dry reforming) into two separate half-steps, namely CH_4 oxidation and replenishment of oxygen carrier (OC) with appropriate oxidizing agents. In order to steer the conversion of CH_4 toward partial oxidation (POM) for synthesis gas (H_2 + CO) production rather than total oxidation for producing CO_2 and H_2O, the appropriate selection of OC becomes a critical issue. Moreover, instead of the commonly used air to re-oxidize the oxygen-depleted OC after reaction with CH_4, steam and CO_2 have been proposed as two alternatives, opening up the opportunities to produce extra H_2 and CO. However, owing to much weaker oxidization ability of steam and CO_2 than air, the low oxidation degree and slow oxidation rate seem to remain as challenges. Furthermore, the resistance of OC to attrition, agglomeration and carbon deposition is also of great importance. In these regards, the latest major milestones are compiled.

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Abbreviations: AR, air reactor; CFB, circulating fluidized bed; CLC, chemical-looping combustion; CL-DRM, chemical-looping dry reforming of methane; CLOU, chemical-looping oxygen uncoupling; CL-POM, chemical-looping partial oxidation of methane; CLR, chemical-looping reforming; CL-SRM, chemical-looping steam reforming of methane; COG, coke oven gas; CSR, carbon dioxide splitting reaction; DRM, dry reforming of methane; FR, fuel reactor; GTL, gas-to-liquid; OC, oxygen carrier; OSC, oxygen storage capacity; POM, partial oxidation of methane; SRM, steam reforming of methane; TGA, thermo-gravimetric analyzer; TPR, temperature-programmed reduction; WGS, water–gas shift; WSR, water splitting reaction; YSZ, yttrium-stabilized zirconia.

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