Electronic Supplementary Information

Deoxygenation-enhanced chemical looping gasification: A new pathway to produce hydrogen from biomass

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1. CLG and DE-CLBG

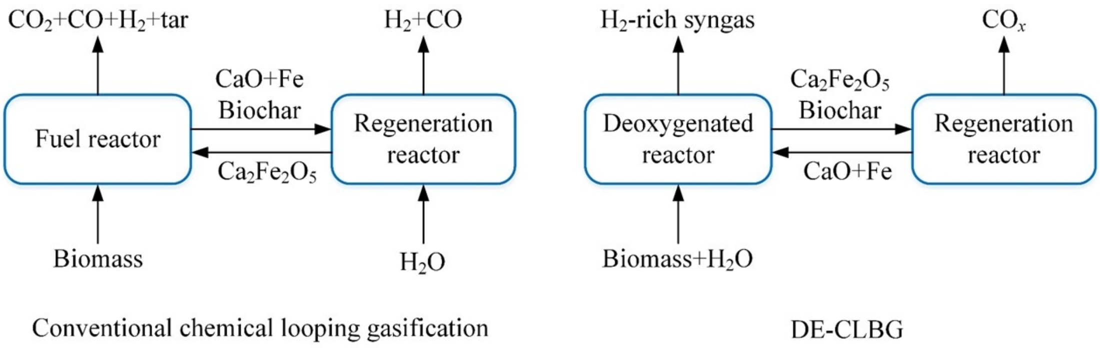

Fig. S1. Comparisons of conventional chemical looping gasification and DE-CLBG.

For conventional chemical looping gasification of biomass, the oxygen carrier provides lattice oxygen with syngas production, in which the oxygen carrier is reduced during biomass gasification. For the regeneration stage, the OC is oxidized with the achievement of H_2O splitting; while for DE-CLBG, the redox looping is exactly reverse to the conventional chemical looping gasification. Specifically, the deoxidizer is oxidized ($Fe^0 \rightarrow Fe^{3+}$) during deoxygenated gasification stage due to the existence of steam, and the deoxidizer is reduced at the regeneration stage, accomplishing the deoxygenated looping ($Fe^{3+} \rightarrow Fe^0$).

2. Effect of D/B mass ratios on the product distribution

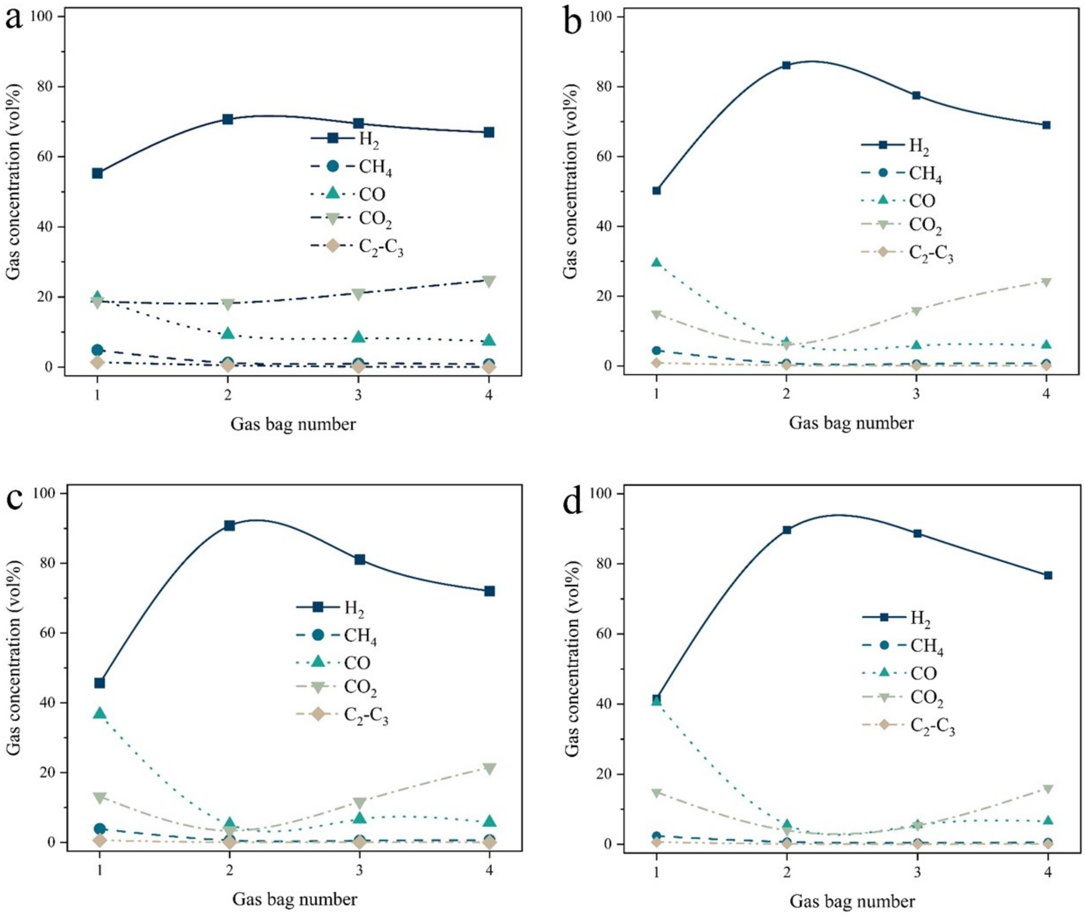

Fig. S2. Effect of D/B mass ratios on gas concentrations: (a) D/B=0, (b) D/B=0.1, (c) D/B=0.2, and (d) D/B=0.3. (Deoxygenation temperature: 680°C, water injecting velocity: 0.010 mL/min).

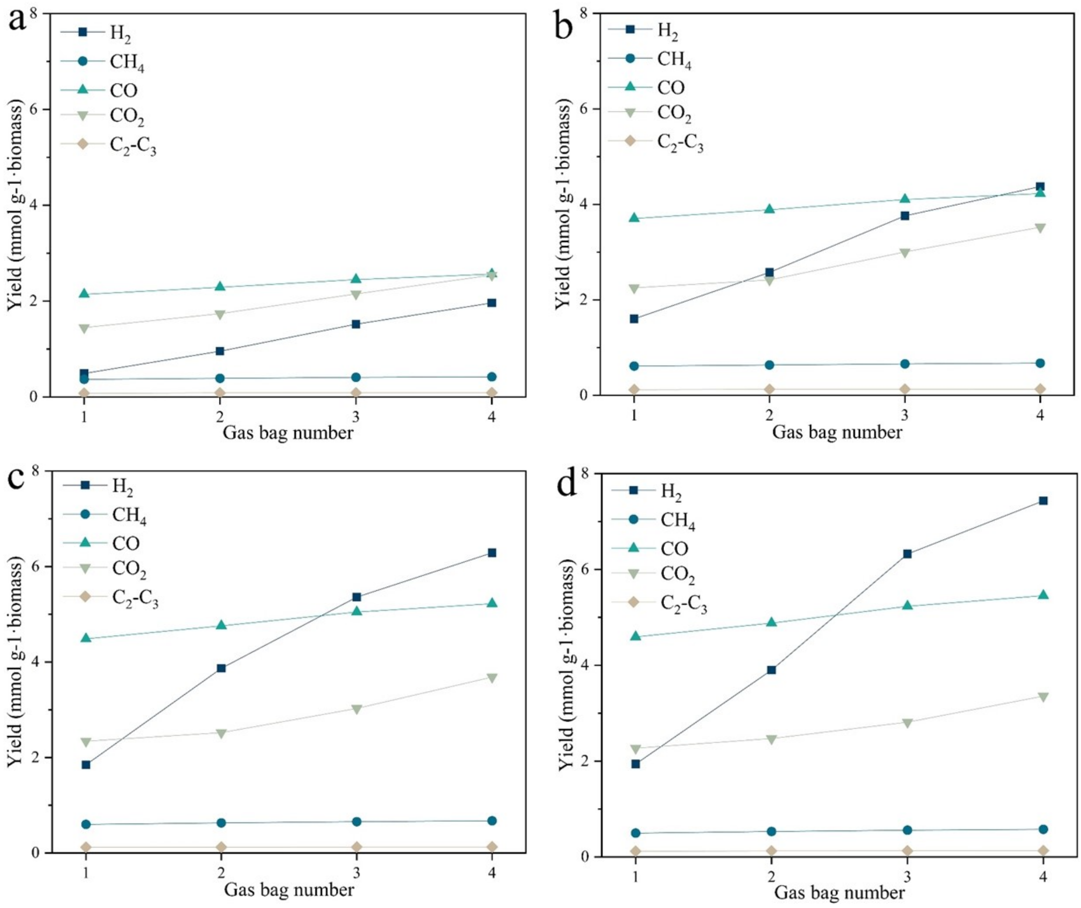

Fig. S3. Effect of D/B mass ratios on gas yields: (a) D/B=0, (b) D/B=0.1, (c) D/B=0.2, and (d) D/B=0.3. (Deoxygenation temperature: 680°C, water injecting velocity: 0.010 mL/min).

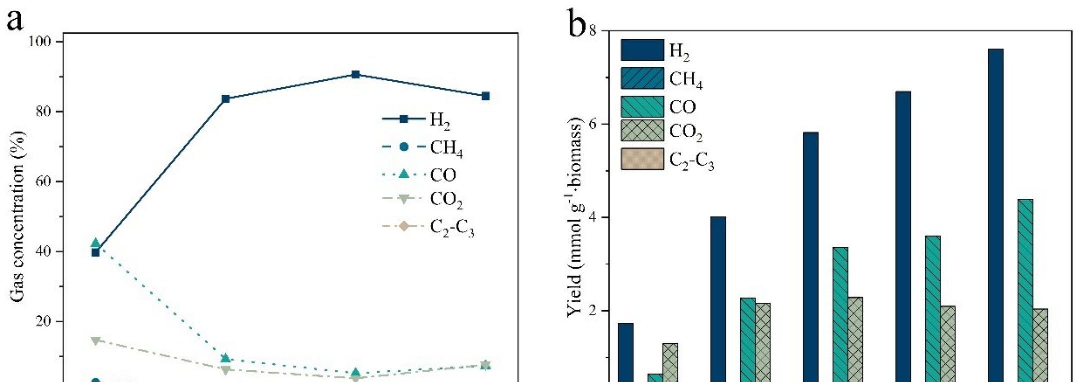

Fig. S4. (a) gas concentration on D/B=0.4 condition, and (b) gas yields with different D/B ratios.

It can be seen that the yields of H_2 and CO under D/B=0.4 increased by 13.50% and 21.48%, respectively, compared with that of D/B=0.3. Moreover, the highest hydrogen concentration reaches 90.66% during the third gas bag collection. However, it is to be noted that the excessively high content of deoxidizer addition may result in the incomplete reduction of the deoxidizer during regeneration stage, owing to limited amount of biochar left. Therefore, D/B=0.3 would be a suitable selection. To sum up, both the yields of H_2 and CO were promoted with the increase in the D/B mass ratio.

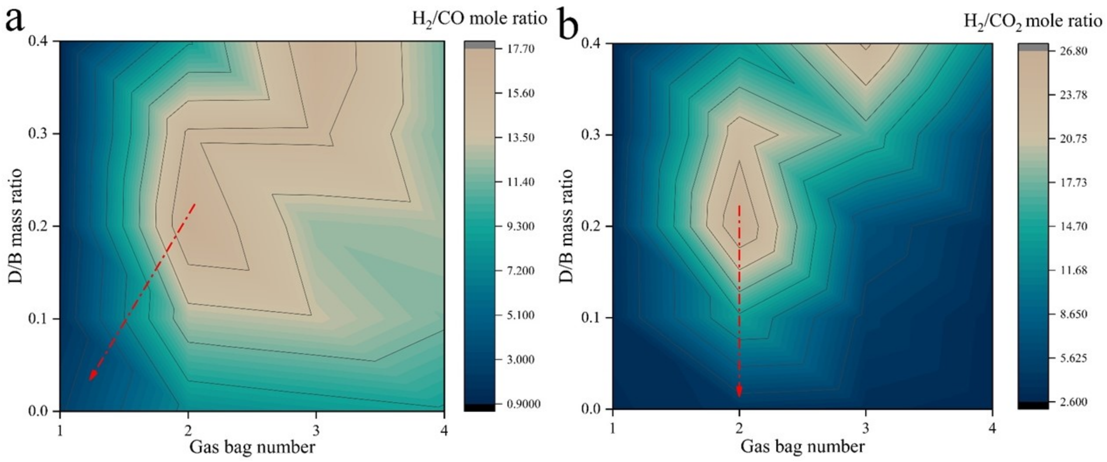

Fig. S5. Effects of different D/B mass ratios on the a) H2/CO ratio; b) H2/CO2 ratio during gasification.

3. Effect of deoxygenation temperature on the product distribution

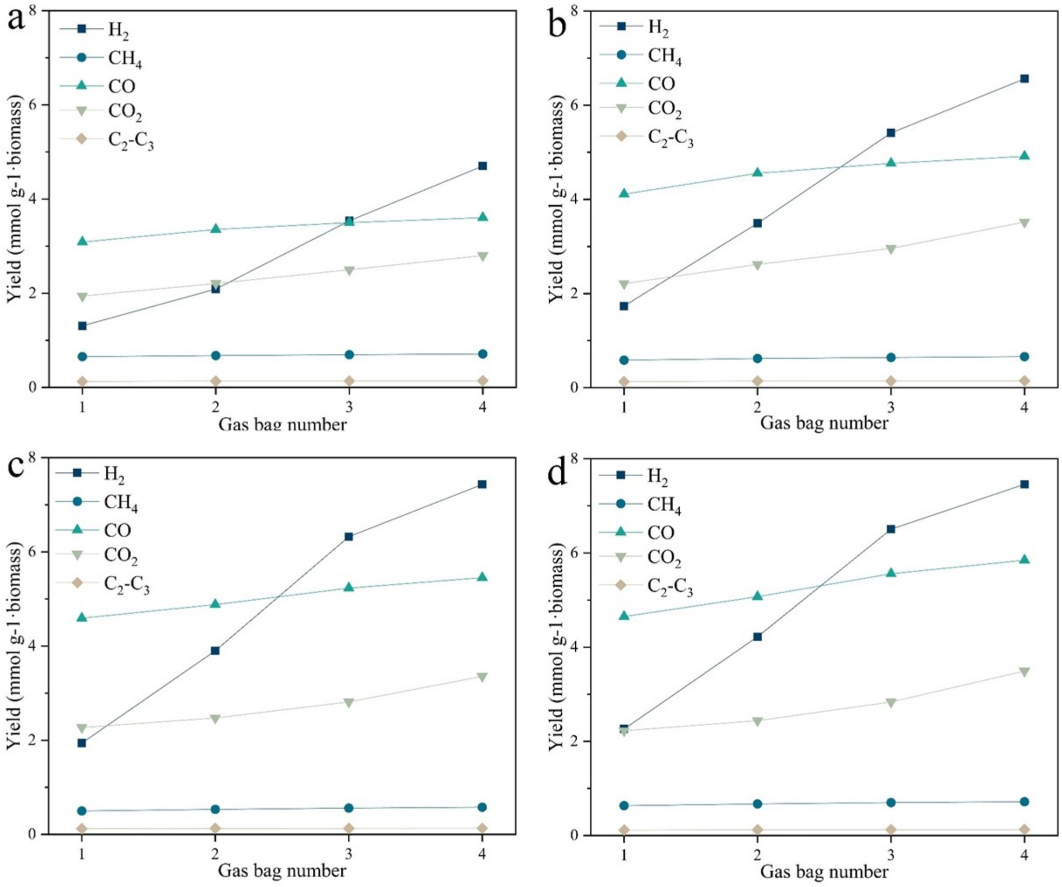

Fig. S6. Effect of deoxygenation temperature on gas yields: (a) 620℃, (b) 650℃, (c) 680℃, and (d) 710℃. (D/B=0.3, water injecting velocity: 0.010 mL/min).

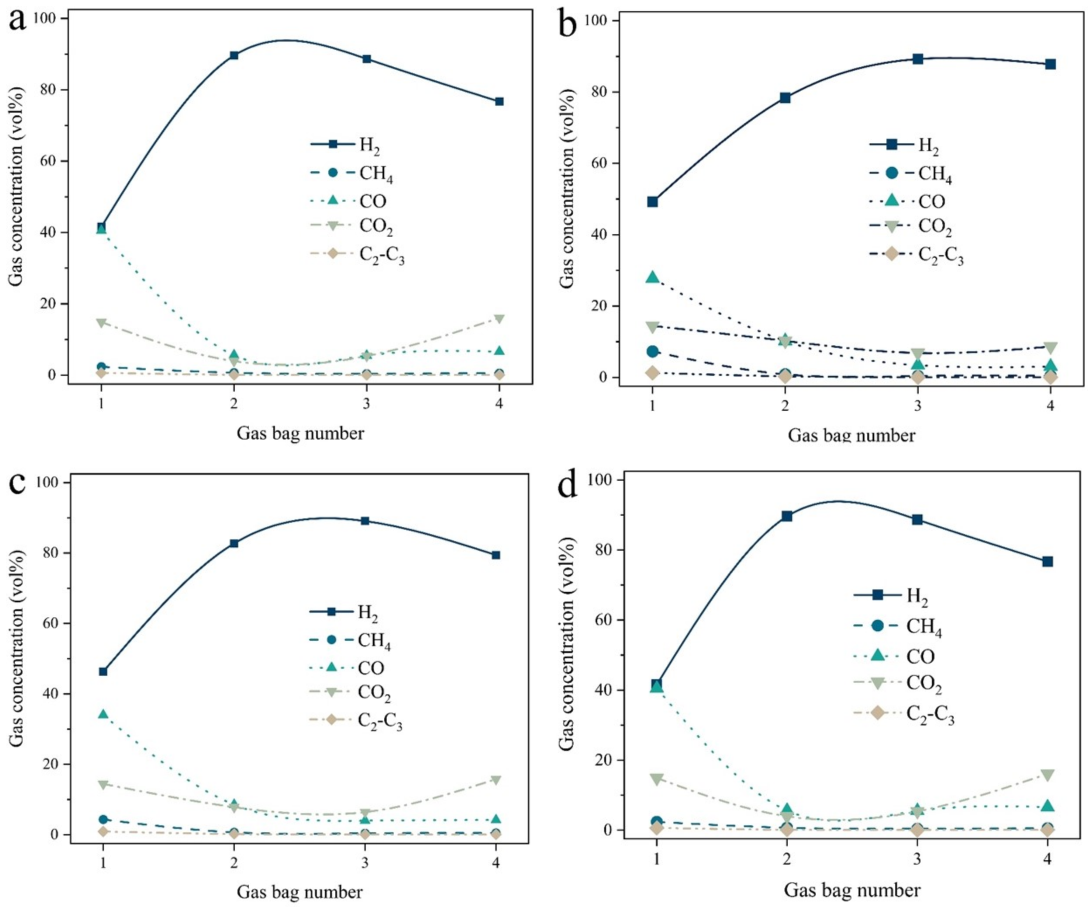

Fig. S7. Effect of deoxygenation temperature on gas concentrations: (a) 620℃, (b) 650℃, (c) 680℃, and (d) 710℃. (D/B=0.3, water injecting velocity: 0.010 mL/min).

4. Effect of water injecting velocity on the product distribution

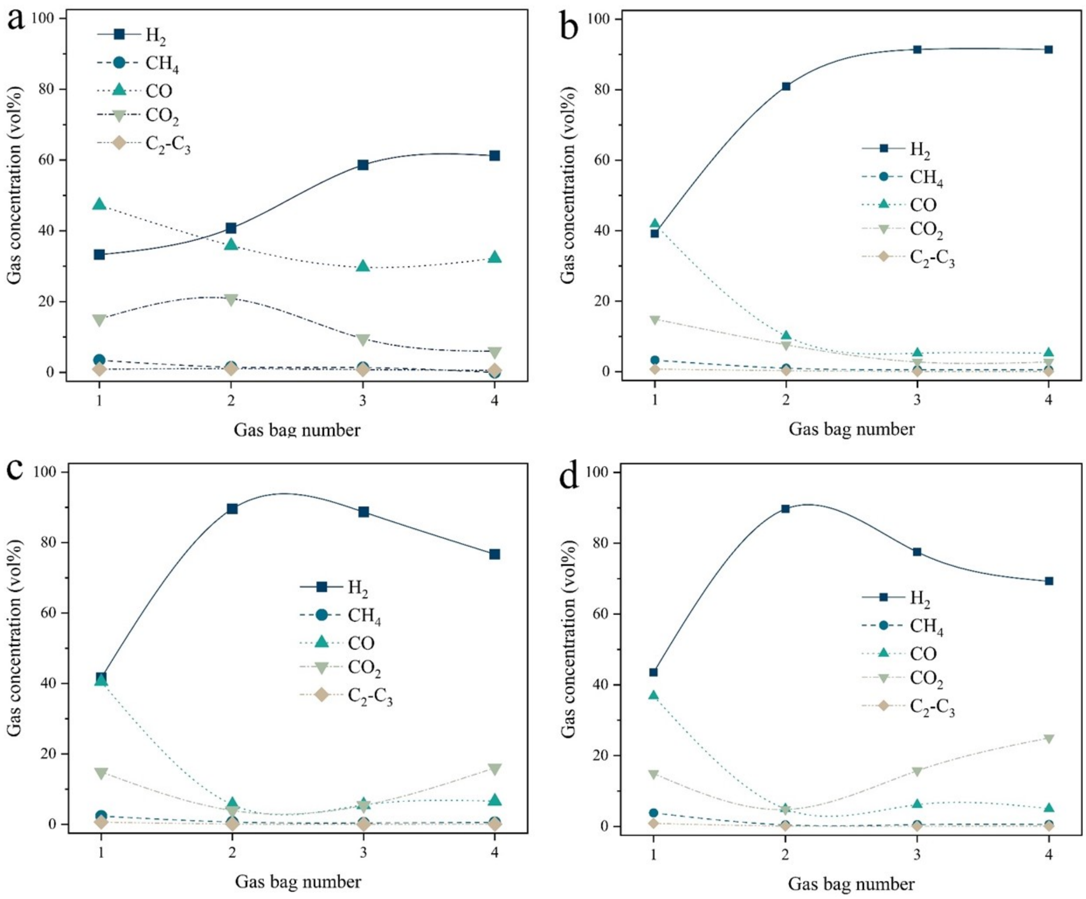

Fig. S8. Effect of water injecting velocity on gas concentrations: (a) 0 mL/min (b) 0.005 mL/min, (c) 0.010 mL/min, and (d) 0.015 mL/min. (D/B=0.3, deoxygenation temperature: 0.010 mL/min).

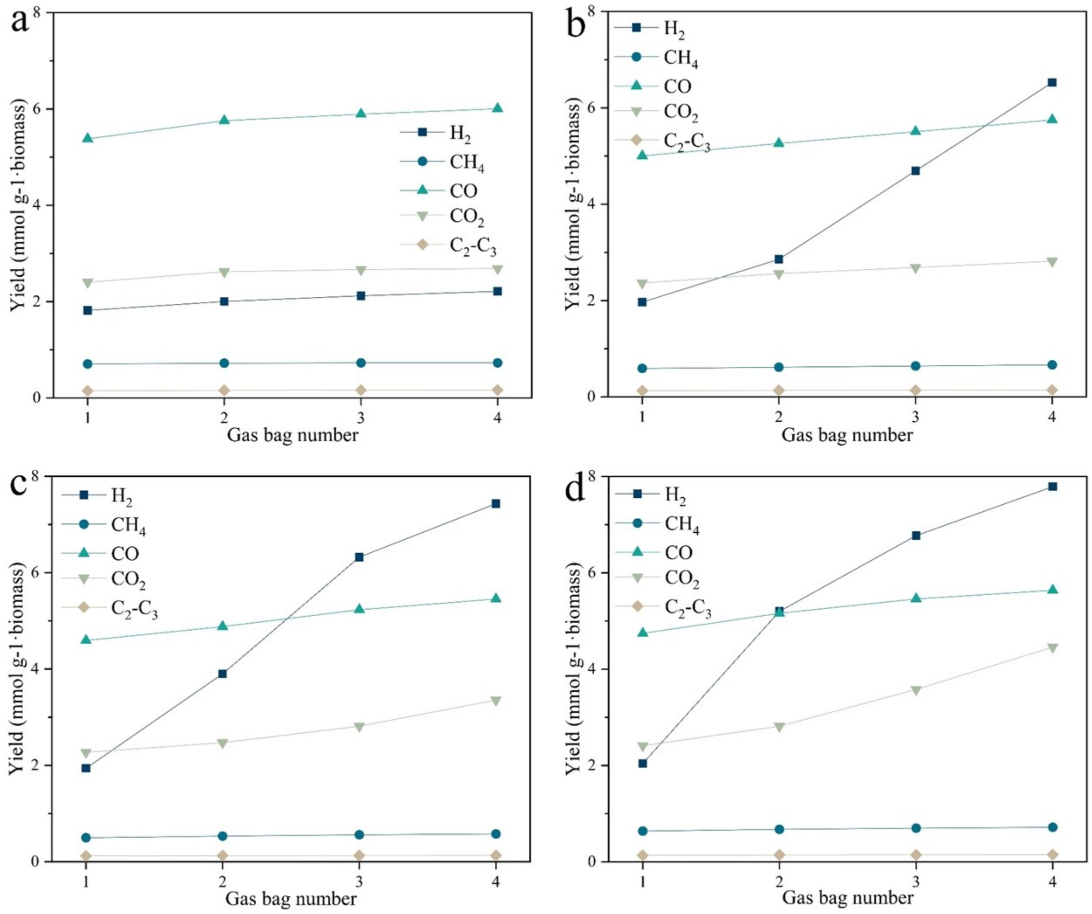

Fig. S9. Effect of water injecting velocity on gas yields: (a) 0 mL/min (b) 0.005 mL/min, (c) 0.010 mL/min, and (d) 0.015 mL/min. (D/B=0.3, deoxygenation temperature: 0.010 mL/min).

5. Characterizations

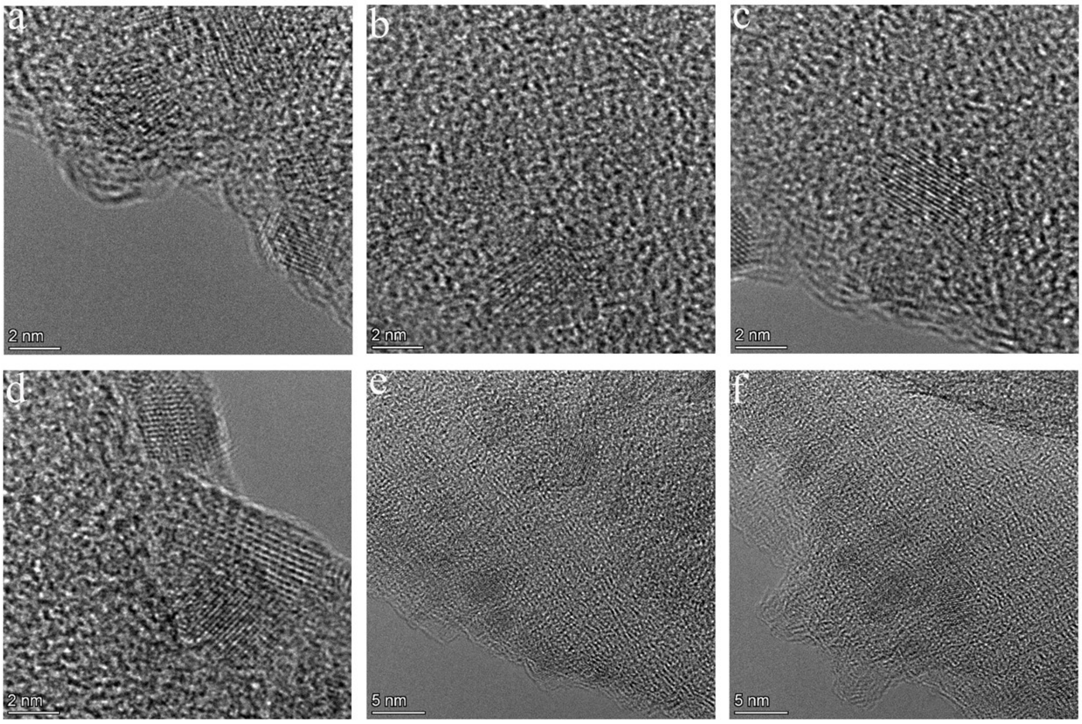

Fig. S10. The TEM images of the deoxidizer after 10 minutes' deoxygenated gasification (D/B mass ratio at 0.3, water injecting velocity at 0.010 mL/min, gasification temperature at 680℃).

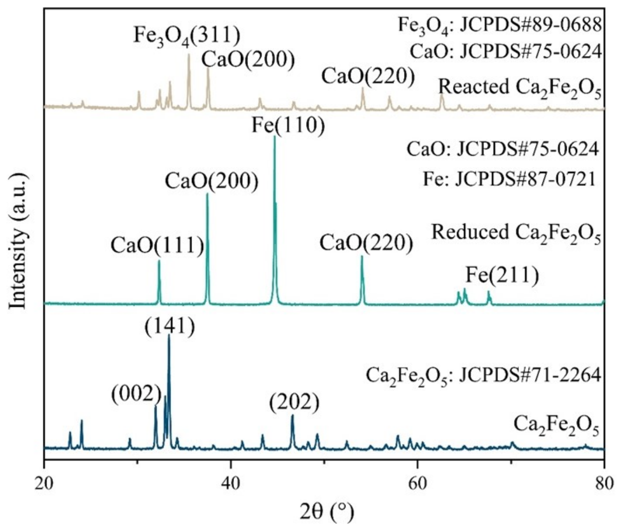

Fig. S11. The XRD patterns of $Ca_2Fe_2O_5$, reduced $Ca_2Fe_2O_5$, and reacted $Ca_2Fe_2O_5$.

6. Biochar conversion

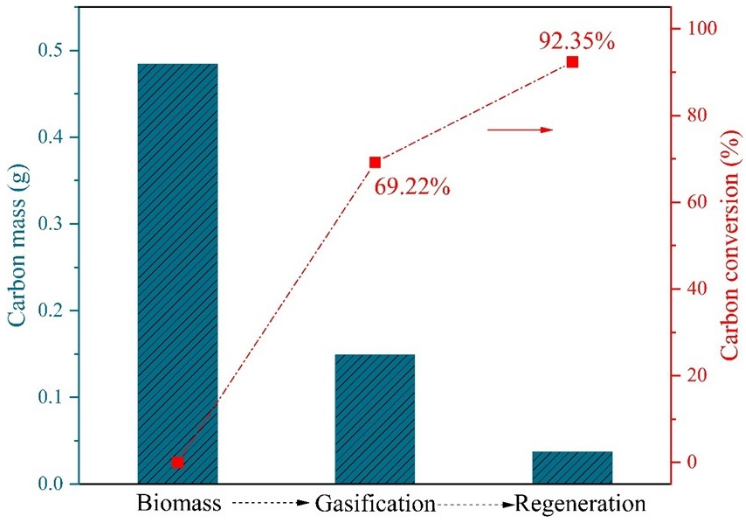

Fig. S12. Carbon mass and conversion during DE-CLBG process.