

Green Promoters for Sustainable Energy Storage

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Zeolitic ice are promising materials for safe and compact energy storage but their wide-scale application is hindered by slow formation kinetics [1]. For the first time, we revealed the role of acidic zeolites such as Y-H to enhance the kinetics and conversion of methane gas hydrates [2]. To further boost the economics of the process, we showed that more hydrophobic zeolites (USY-40) has a superior performance over hydrophilic one (USY-10) to enhance the methane uptake and the kinetics of hydrates formation from seawater at ambient condition. The results showed that gas uptake could reach 40 mmol of gas/mol of water, which is the highest reported under mild conditions using seawater [3]. In this study, we further investigated the effect of another acidic zeolite ((H-SSZ-13) and amino acids (l-tryptophan, l-leucine, and l-methionine) as green kinetic promoters in a novel reactor design to accelerate hydrate formation at 6 MPa.

In non-stirred reactor (NSR), H-SSZ-13 and l-tryptophan showed superior performance over l-leucine and l-methionine. While H-SSZ-13 showed the lowest average t_{90} (time taken for 90% completion of methane uptake) of 286 mins and the highest volumetric capacity of 115 v/v at 283 K, its kinetic performance, along with other promoters, dropped significantly at 293 K. We introduced a new fixed bed reactor (FBR) equipped with light metallic packing filaments (MPF) to increase gas diffusion and thermal conductivity. The combined effect of FBR-MFP reactor with zeolite significantly improved the kinetics overcoming NSR drawbacks. At 293.15 K, H-SSZ-13 acidic zeolite promoter showed superior performance reducing the induction time and t_{90} to 3 and 154 mins, respectively. Furthermore, it exploited 88.6%, and 96% of the sII clathrates volumetric storage capacity at 293 K and 283 K, respectively. Finally, we showed that the synthesized hydrates can be stored at atmospheric pressure for 4 months without a significant methane loss. This multiscale approach is paving the way for scaling up green and economical gas hydrate technology.

References

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