Nano-trap Catalysts for Reducing Methane Emissions in Shipping Vessels

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Introduction

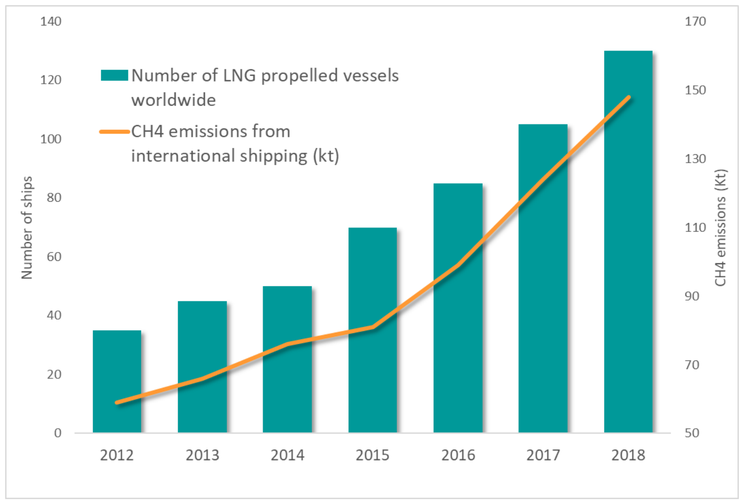
Shipping is a major source of **greenhouse gas emissions**

More and more ships are **using LNG** as an alternative fuel

LNG **minimises NO_x, SO_x and CO_2** emissions

Releases unburnt methane into the atmosphere

As the number of LNG-powered ships has increased so have methane emissions produced from international shipping.[1,2]

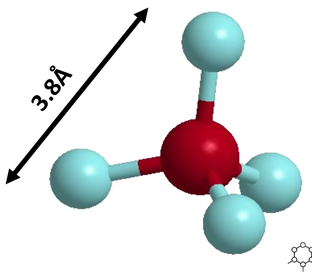


Proposed methane slip abatement methods

	Maintains engine efficiency	Does not produce CO_2	Reduce methane slip	Re-use Methane
In-cylinder methods	✗	✓	✓	✗
Total Oxidation Catalysts	✓	✗	✓	✗
Methane capture catalysts	✓	✓	✓	✓

Methane Capture Catalysts

Metal Organic Frameworks (MOFs) are promising candidates for methane capture materials with advantageous features such as:

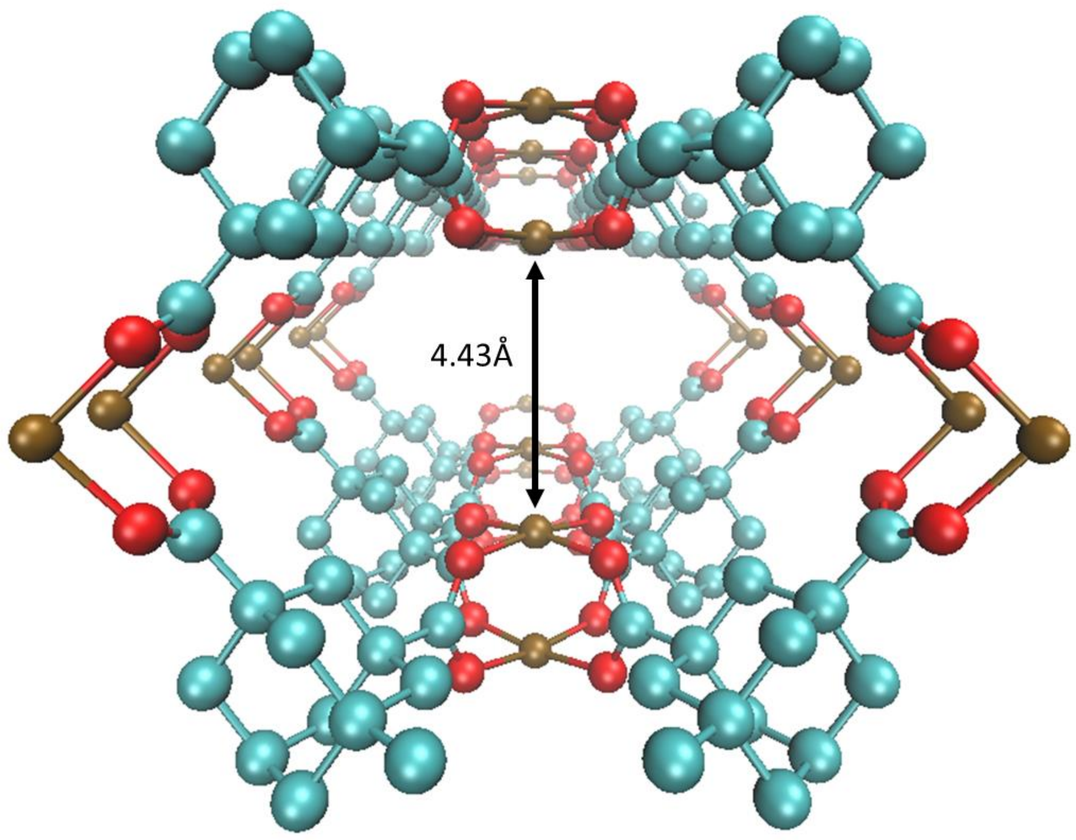


- **Lage surface area**
- **Tuneable pore sizes**
- **Introduce different metal sites**
- **Add functional groups to the framework**

Various MOFS with differing frameworks and metal sites have been investigated for CH_4 capture.

Currently MOF ATC-Cu,[3] displays the highest CH_4 adsorption ability of 64.96cm^3g^{-1} at 298 K and 1 bar.

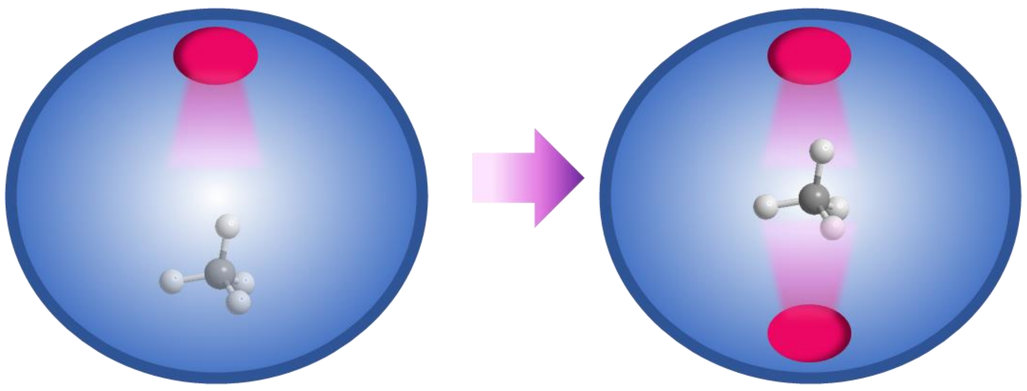
ATC-Cu MOF



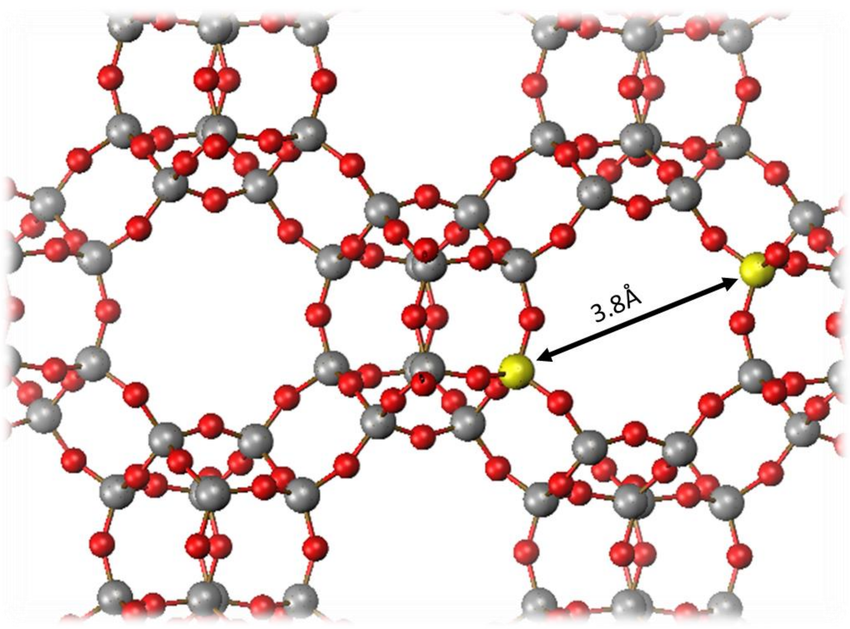
ATC-Cu MOF[3] is based on the H_4ATC (1,3,5,7-adamantane tetracarboxylic acid) ligand acting as a 4 coordinated tetrahedral linker connecting Cu paddle-wheel secondary building units.

The MOF contains 3D rectangular channels of dimensions 4.43 x 5.39Å where the proximity of the 2 copper sites mediates a 'nano-trap' for methane.

Key features of methane capture catalyst



- ○ **Unsaturated metal centre**
- ★ **Di-metal centre for enhanced binding**
- ○ **Appropriate pore size**
- ○ **Alkyl groups within the pore**



Chabazite framework with isomorphous substitution could lead to di-copper sites.

Further possibilities of introducing other metals such as Co could create redox sites for oxidation to methanol.

References

[1] Fourth IMO GHG Study 2020 Full Report

[2] Statista. (2021). Number of liquified natural gas-propelled (LNG) vessels worldwide from 2010 to 2020 with a forecast through 2027 https://www.statista.com/statistics/1096072/trend-in-projected-global-supply-and-demand-for-lng-fueled-vessels/ (accessed: June 13, 2024)

[3] Z. Niu *et al*, *Angew. Chem. Int. Ed.*, 2019, 58, 10138–10141.

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