

Research Development & Innovation

Novel Zeolite Adsorbents

for separation of Methane
and Nitrogen for use
in Swing Adsorption
Systems

**UWA technology
licensing/ partnering
opportunity**

- **Processing of conventional gas sources**
- **Coal bed methane /coal mine ventilation**
- **Biogas**
- **CH₄/N₂ selectivity of 6 - 8**

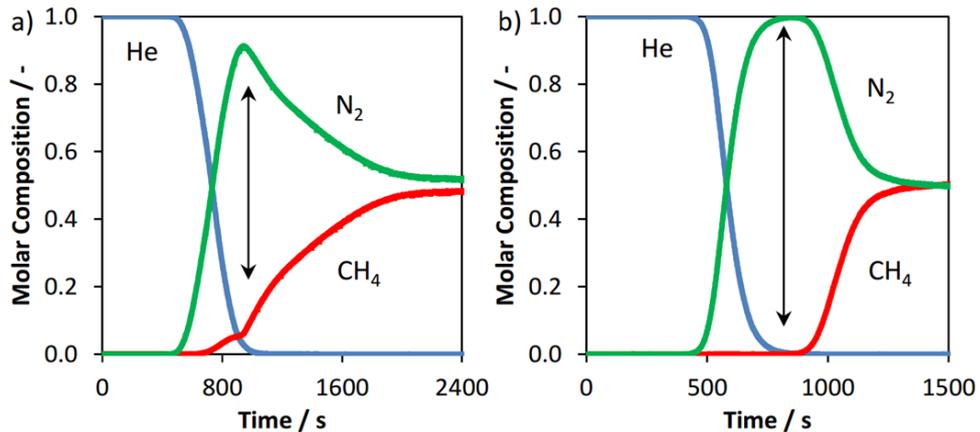


Fig 1: Breakthroughs of an equimolar nitrogen/methane mixture with (a) activated carbon, and (b) ILZ



Fig 2: a) Pressure Swing Adsorption test rig



b) ILZ-1 adsorbent

The Technology

Researchers at the University of Western Australia (UWA) have developed a novel adsorbent for separation of methane and nitrogen, namely ILZ – with a selectivity of 6 -8 (compared to conventional zeolites with a selectivity of 2 and high-spec commercial activated carbons with a selectivity of 3–4). It outperforms all known industrial adsorbents in its ability to separate methane from nitrogen and it is well suited for Swing Adsorption methods (such as Pressure Swing Adsorption and Vacuum Swing Adsorption).

The separation of methane and nitrogen is particularly difficult to achieve due to very similar properties: both are inert gases, both are non-polar and they have very similar molecular diameters (3.80 Å vs 3.64 Å).

Figure 1 demonstrates the superior separation power of ILZ compared to a commercial carbon adsorbent (Norit RB3). An adsorption column is pre-filled with inert helium. A 50:50 mix of methane and nitrogen is then fed through the vessel and the composition of effluent gas is measured. In a), nitrogen starts breaking through the carbon column at $t=500$ s, closely followed by the creeping elution of methane, suggesting an ineffective separation. In b) methane was completely captured by the ILZ column before $t=900$ s and a pure nitrogen vent was obtained. The desorption was fully reversible by lowering partial pressures.

Benefits of the Technology

- Reduced costs due to higher selectivity and hence performance of adsorbent
- Lower production cost than currently used carbon adsorbents
- Verified mechanical strength, thermal stability and contamination resistance
- Ability to economically process lower grades of methane streams than before
- Ability to process methane streams with very low concentrations when combined with UWA's Dual Reflux Pressure Swing Adsorption (DR-PSA) technology

State of Development

We have produced several kg of ILZ adsorbent and tested it in UWA's pilot scale DR-PSA apparatus, as shown in Figure 2. With an input feed consisting of 97.4% nitrogen and 2.6% methane, we generated a greenhouse gas (GHG) free nitrogen vent stream (100% purity), thus capturing all of the methane which is can now be added to the product stream rather than being vented to atmosphere. Achieving such an outcome in a single step process has never been achieved before.

Figure 3 below illustrates the performance of the ILZ adsorbent compared with a widely used carbon adsorbent (Norit RB3) in a series of experiments performed on UWA's DR-PSA apparatus.

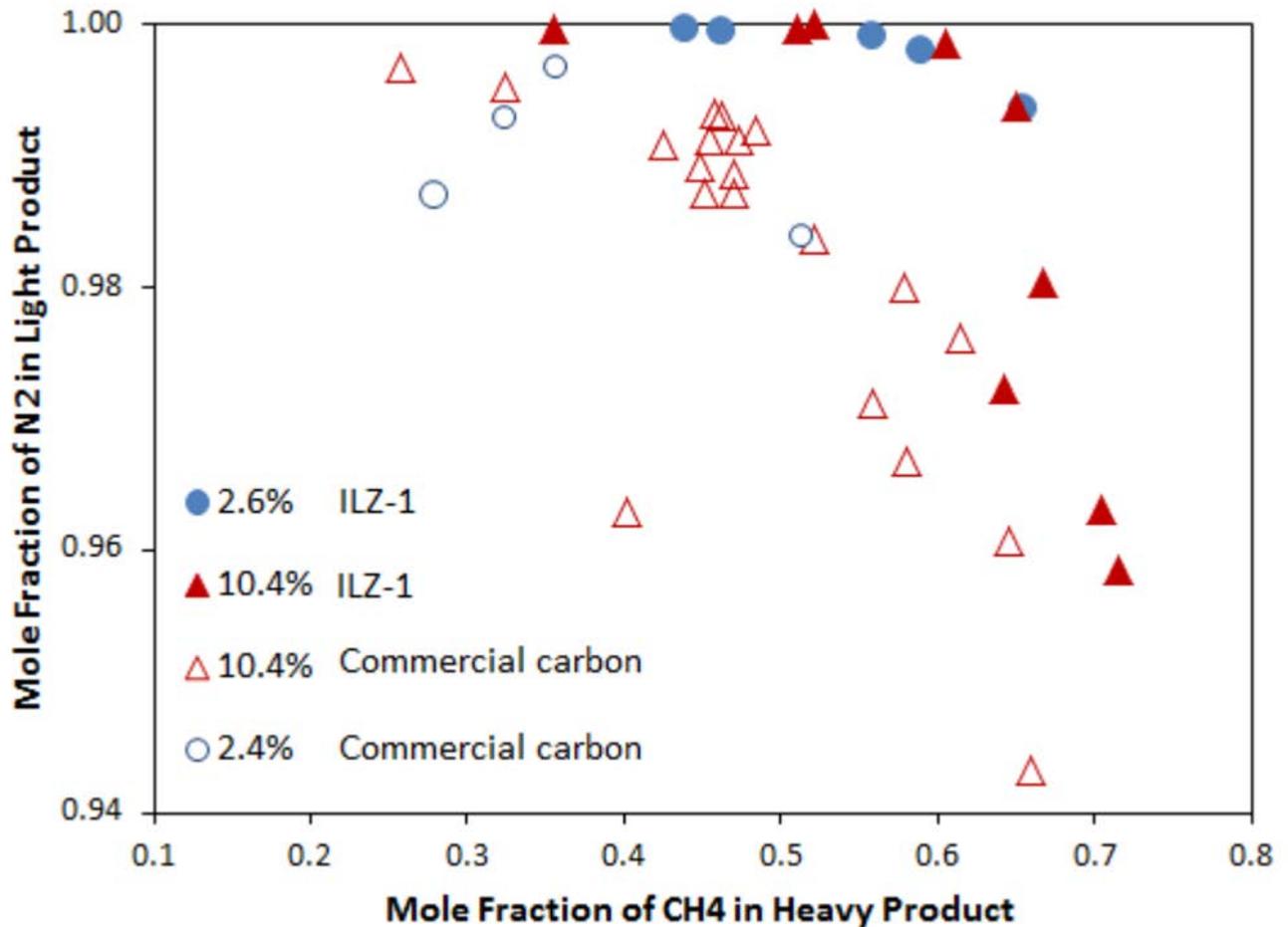


Fig 3: Separation performance of ILZ-1 adsorbent (solid symbols) vs. commercial carbon adsorbent (hollow symbols) obtained in a series of DR-PSA experiments. The CH₄ molar fraction of the feed gas is given in the legend.

Commercial Opportunity

UWA is seeking expressions of interest from industry for manufacturing and sale of the zeolite adsorbent under licence. We believe that there is a significant market for the adsorbent, especially in those countries with the largest coal bed methane reserves, such as China, Russia and Canada. This technology has the potential to substantially reduce greenhouse gas emissions, and our choice of industry partner will be strongly influenced by the ability to realise this potential.

The Research Team

Prof. Eric May – Chevron Chair in Gas Process Engineering
Dr Kevin Li – ARC DECRA Research Fellow.

The University of Western Australia

UWA is a research-intensive university ranked 96th in the world (Shanghai Jiao Tong University's internationally recognised Academic Ranking of World Universities – August 2016), and one of the internationally recognised Australian Group of Eight Universities.

References

Conference presentation 30 May 2016 at DECHEMA - 12th International Conference on the Fundamentals of Adsorption: "Ionic liquidic zeolites for methane capture from low grade sources"

While not dealing with the ILZ adsorbent, the following publications illustrate UWA's expertise in the design of DR-PSA systems:

"Demonstration and Optimisation of the Four Dual-Reflux Pressure Swing Adsorption Configurations", Separation and Purification Technology, (2016).

"Non-isothermal numerical simulations of dual reflux pressure swing adsorption cycles for separating N₂ + CH₄", Chemical Engineering Journal, 292 (2016).

"Capture of low grade methane from nitrogen gas using dual-reflux pressure swing adsorption", Chemical Engineering Journal, 281 (2015). Intellectual Property protection Patent protection has been applied for.

Awards



Further Information

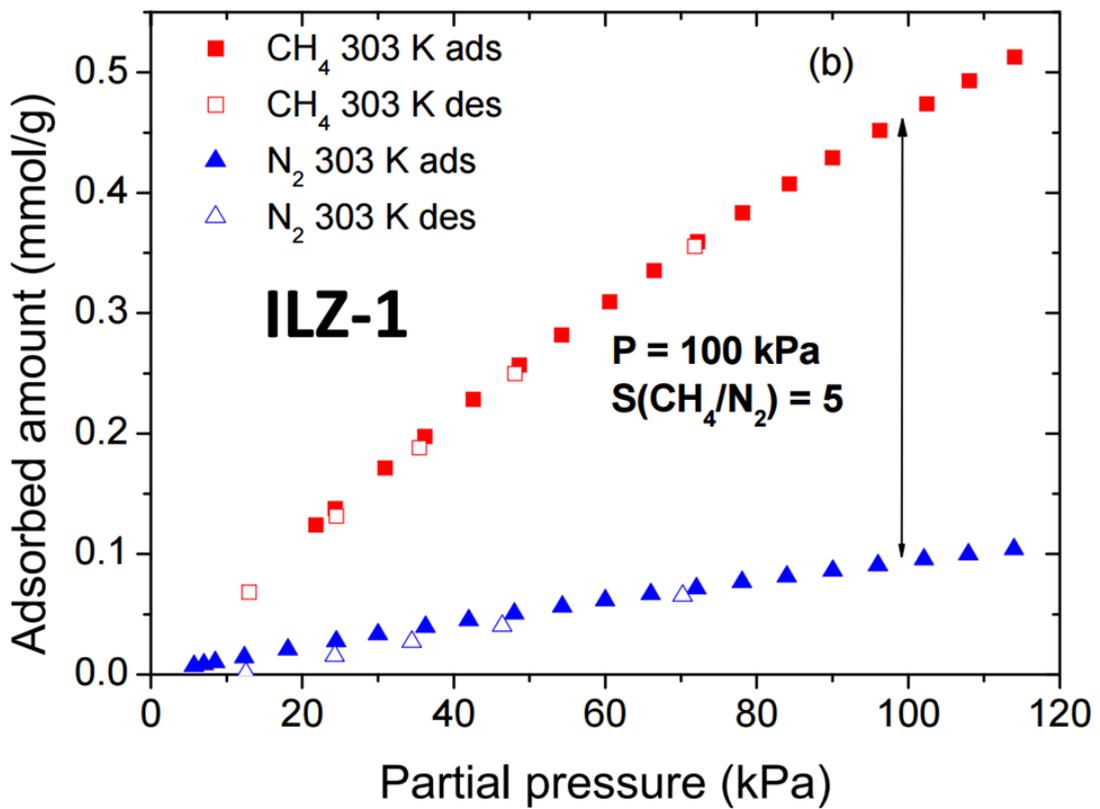
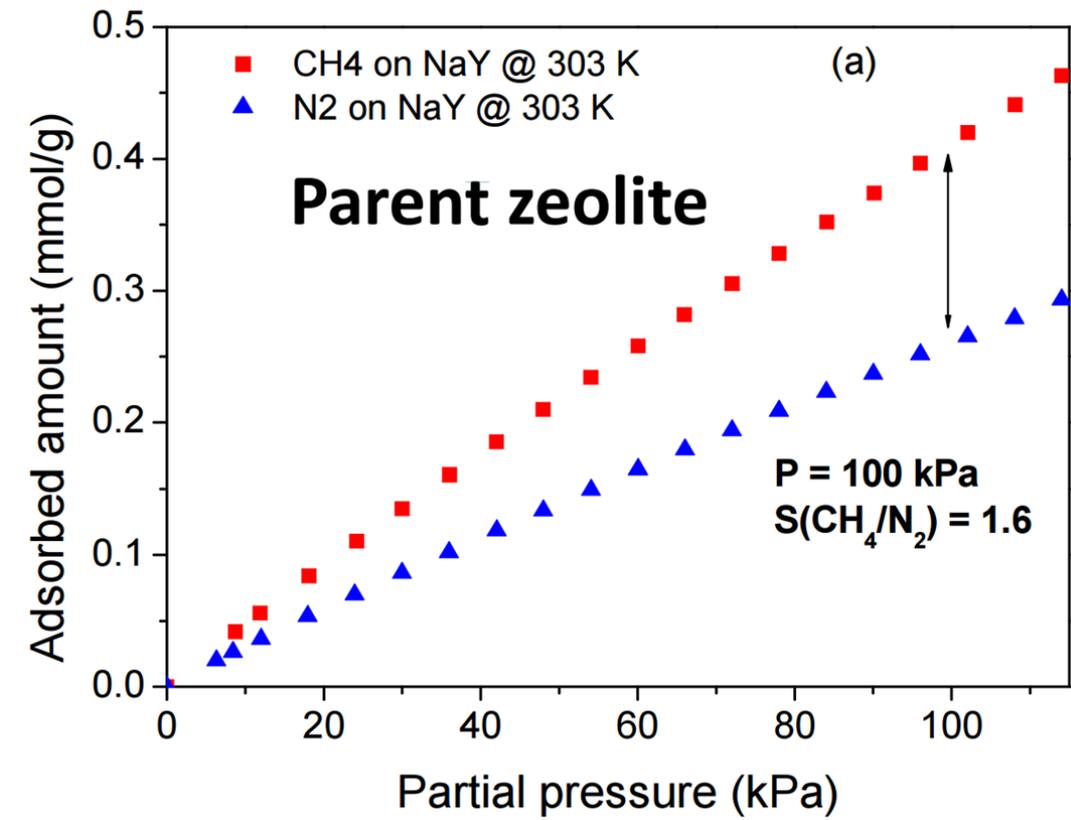
Commercial correspondence to:

Tom Schnepple
Research Development and Innovation
E: tom.schnepple@uwa.edu.au
T: +61 8 6488 1520

Technical correspondence to:

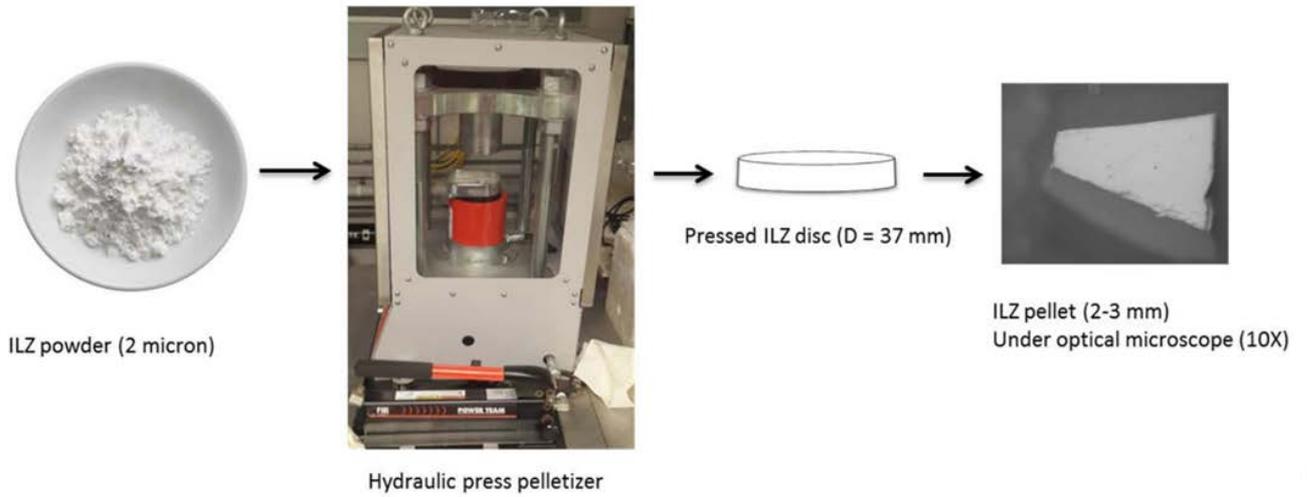
Professor Eric May
Chevron Chair in Gas Process Engineering
School of Mechanical and Chemical Engineering
E: eric.may@uwa.edu.au

Appendix - Single component isotherms



- Calculated CH₄ /N₂ selectivity increased by 300%
- CH₄ capacity increased by 15%

Appendix – Adsorbent preparation



Experimental setup

