Measurements of Nitrogen Solubility in Hydrogen for Hydrogen Liquefaction Absorber Design

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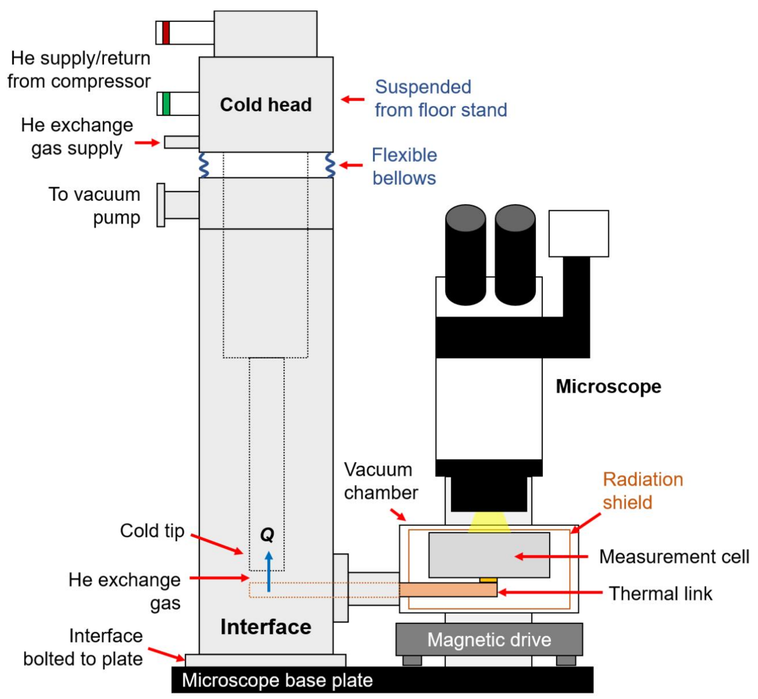
FUTURE ENERGY EXPORTS
Cooperative Research Centre

Introduction

Hydrogen is poised to become a critical carbon-free energy vector. However, transporting this fuel is usually only economically viable where a sufficiently high energy density can be achieved. One method of increasing energy density is to *liquefy* the hydrogen, which can deliver a high-purity, easily re-gasified stream to the end user.

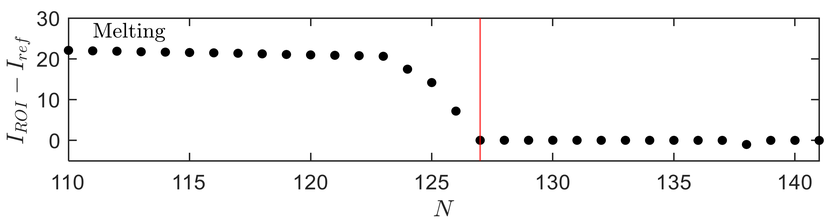
When liquefying H_2 (which requires cooling to ~ 20 K), contaminants present in the hydrogen feed can freeze-out and form a solid. These solids can cause many operational hazards including blockages of heat exchangers and deactivation of *ortho-para* conversion catalysts. Impurities must be removed (*via* adsorption) so that their concentration is below their solubility in the hydrogen stream at the process *T* and *p*. Accurate measurements of this solubility are thus essential for LH_2 plant design.

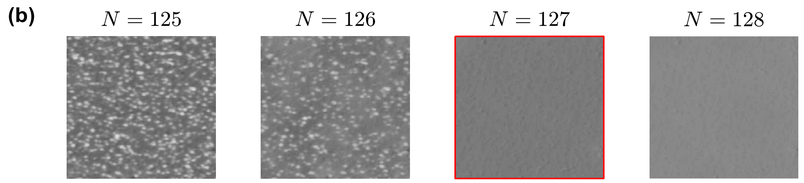
Apparatus



Method

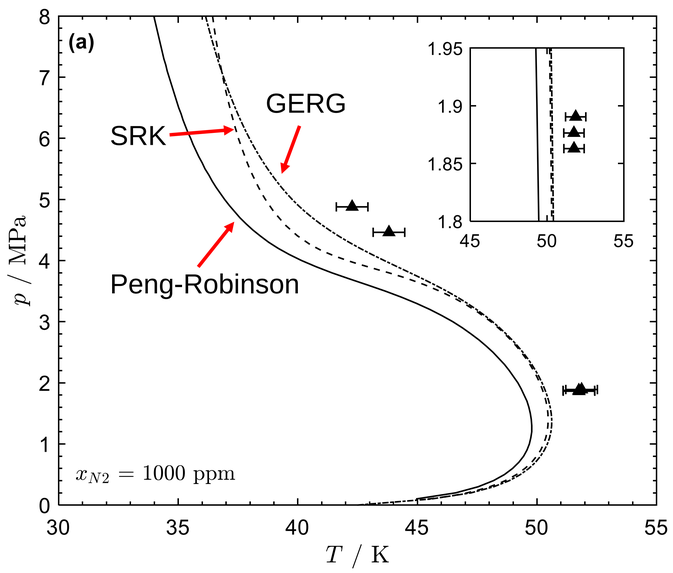
The solubility of 0.1% N_2 in fluid hydrogen was measured optically. “stepped” melting experiments were employed to measure the solubility at two pressures: 2 and 4.7 MPa. Image subtraction was used to identify the temperature step on which melting occurred.





N_2 solids No N_2 solids

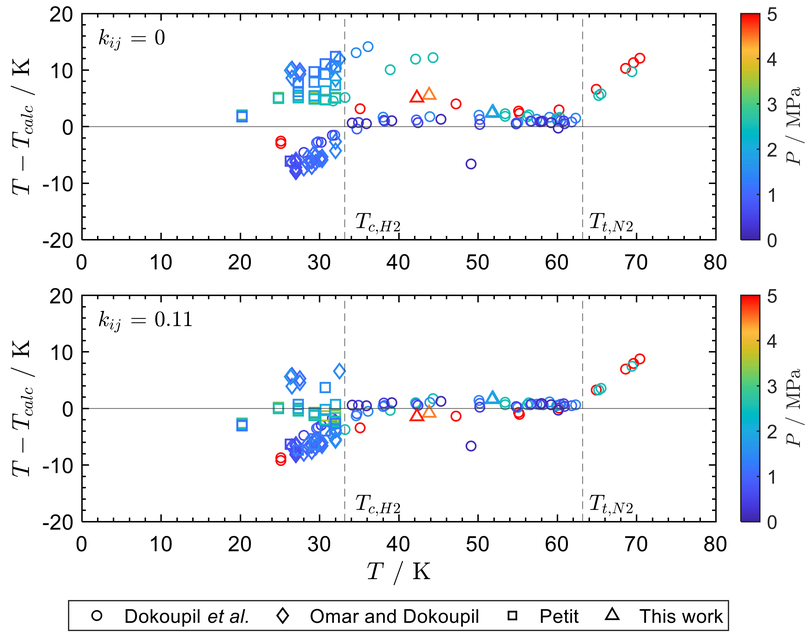
Results



The measured melting temperatures lie significantly to the right of the thermodynamic models. Solid formation can occur at temperatures **up to 5 K above the predicted value**.

Discussion & Modelling

The data measured in this work alongside that from the literature was used to improve the performance of thermodynamic models by tuning the N_2-H_2 binary interaction parameter for SFE.



Tuning the binary interaction parameter improved the **associated RMS error in the overall dataset by 67%.** In future, we will extend our measurement technique to LH_2 temperatures to resolve the remaining scatter in the literature data.

Conclusions

A new apparatus was developed for solubility measurements of nitrogen in fluid hydrogen. The results, alongside those of the literature, were used to significantly improve the predictions of the thermodynamic models implemented in ThermoFAST. This work directly informs the maximum allowable concentration of any contaminant nitrogen in a hydrogen stream which is to be liquefied.