

Experimental report

22/09/2023

Proposal: 7-05-551

Council: 10/2022

Title: Investigation of 20K H₂ physisorption on MOFs: enhanced dormancy and an alternative to alleviate liquid-hydrogen-tank boil-off losses

Research area: Materials

This proposal is a new proposal

Main proposer: Jitae PARK

Experimental team: Minji JUNG
HYUNLIM KIM
taeung PARK
Sung Yeop JUNG
JAEWOO PARK
Jitae PARK

Local contacts: Monica JIMENEZ RUIZ

Samples: C₄₈H₂₆O₁₃Zn₄
C₉₀H₆₀O₁₆Zn₄
MOFs(IRMOF-20(C₂₄H₆O₁₃S₆Zn₄), MIL-53(Al)(C₈H₅AlO₅), MOF-5(C₂₄H₁₂O₁₃Zn₄)), solvent (DCM, dichloromethane, CH₂Cl₂)

Instrument	Requested days	Allocated days	From	To
IN1	6	5	16/05/2023	21/05/2023

Abstract:

This proposal aims to investigate the quantum states of adsorbed H₂ on two different MOFs at boiling temperatures. The understanding of this process can lead to the design of new nanoporous materials that would significantly reduce the boil-off losses caused by large temperature differences of interior & exterior LH₂ and achieve a highly efficient LH₂ tank. In order to overcome boil-off losses, a new approach is proposed that combines two storage technologies (hybrid; liquefaction at 20 K and cryo-adsorption) taking advantage of both systems. In this experiments, the adsorbed quantum translational states on various MOFs as a function of loading and temperature will provide key information on whether the hybrid system (cryo-adsorption at 20 K) can enhance the boiling temperature of H₂ above the critical temperature (20 K < T_b < 40 K) to improve the boil-off loss for an off-board H₂ storage tank. In addition, it will show the possibility of MOFs capacity can exceed the liquid hydrogen capacity. Our proposed work will lead to a fundamental understanding of the microscopic origin of the higher adsorbed capacity than LH₂, and the utilization of an efficient LH₂ storage tank.

Experimental report of the experiment 7-05-551

“Investigation of 20 K H₂ physisorption on metal-organic frameworks: enhanced dormancy and an alternative to alleviate liquid-hydrogen-tank boil-off losses”

Team: Jitae Park, M. Russina, Hyunchul Oh, Jaewoo Park, Hyunlim Kim, Taeung Park, Jung Sung Yeop

Local contact: Jimenez Ruiz Monica

Objectives

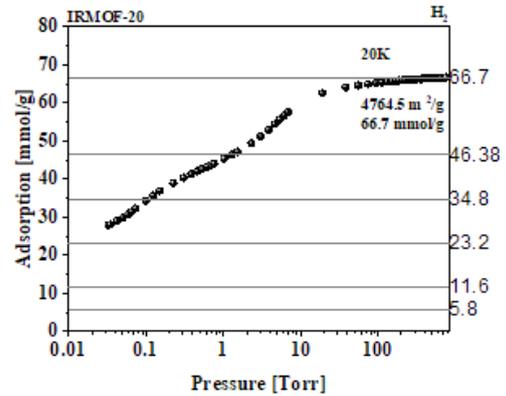
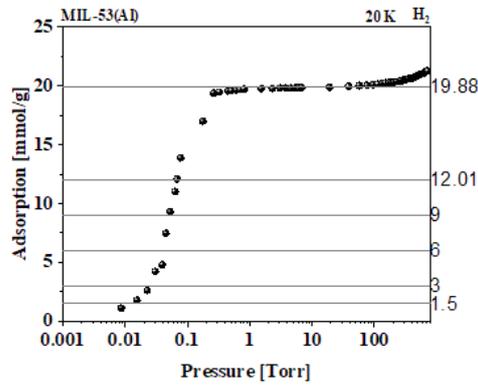
MIL-53 stands out in the realm of metal-organic frameworks (MOFs) due to its remarkable structural flexibility, distinguishing it from traditional inorganic porous materials like zeolites and porous silica. Its architecture comprises metal nodes, commonly chromium or aluminum, interconnected by organic linkers. This MOF exhibits a captivating "breathing" mechanism, enabling it to undergo structural transformations in response to external factors such as temperature, pressure, or guest molecule interactions. These dynamic changes result in variations in pore sizes, rendering MIL-53 highly adaptable for applications in gas adsorption and separation. Scientists have been drawn to its potential in fields ranging from gas storage to catalysis, leveraging its unique pore characteristics for innovative solutions to industrial and environmental challenges. The intrinsic flexibility of MIL-53 holds great promise for the design of advanced materials tailored to specific applications, showcasing its significance in the ever-evolving landscape of porous materials research. However, this has so far been lacking in research. Therefore, we propose to conduct neutron spectroscopy studies to investigate the dynamics of hydrogen isotope.

Achievements (limited 250 words)

For MIL 53(AI), a well-known metal-organic framework recognized for its hydrogen storage capability through reversible pore size changes during respiration transitions, we conducted experiments to measure hydrogen adsorption at various temperatures and rates, considering monolayer coverage. The data collected is presently undergoing analysis. The primary objective of this investigation is to assess the presence and strength of the signal peak, approximately at 14.6 meV. This signal serves as an indicator of the hydrogen phase and its adsorption strength, shedding light on the impact of the porous material's pore volume on hydrogen adsorption capacity.

1. Initial background isotherm measurements

The loading amounts of gases are decided by using various temperature isotherms. The amount of loading gas is decided based on two factors, the first is the ratio of monolayer and the second is the maximum amount of adsorption.



2. Plot results (raw data)

