ANALYZER
HIDEN ISOCHEMA NEWSLETTER
ISSUE 09
SPRING 2020

HIDEN ISOCHEMA

Tackling air pollution

Are porous materials part of the solution?

Air pollution is a global problem, adversely affecting both human health and the earth's climate. Pollutants can take many forms, including particulates, greenhouse gases and toxic species such as CO, SO_x and NO_x.

Air quality could be improved by lowering overall emissions, but investigating new ways of removing contaminants from significant point sources, such as fossil fuel power plants, is also important.

In this edition, we look at some recent examples of work by Hiden Isochema customers who are seeking to develop new porous adsorbents to tackle this global problem.

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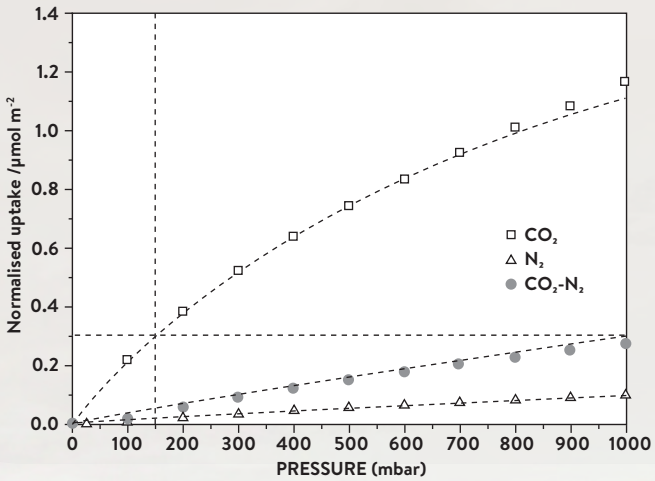
One promising option, particularly for removing CO_2 from flue gas, is physical adsorption using porous materials. This has the potential to significantly lower the energy consumption of CO_2 capture, compared to existing technology such as amine scrubbing using aqueous alkanolamine absorbents.

Other contaminants, however, are also emitted from common sources such as pulverized coal-fired power plants, and these include SO_x, NO_x and Hg. Removing any of these species from gas released into the atmosphere is important in the fight against the continued degradation of our air quality, particularly in highly populated areas.

Carbon capture by xerogels

Researchers at the University of Strathclyde (UK) recently reported the synthesis and characterization of four selected melamine-resorcinol-formaldehyde xerogels.[1] Such resin-based carbon xerogels have potential applications as solid adsorbents with readily tuneable properties for processes including carbon capture and sour gas sweetening.

In this study, carbon dioxide adsorption uptake, kinetics, cyclic stability and selectivity over other gases present in pre- and post-combustion carbon capture scenarios, was measured using **IGA analyzers**. Pure gas adsorption-desorption isotherms were measured using an **IGA-001** and mixed gas isotherms measured with an **IGA-003**. The gas sorption isotherms were also used to evaluate the enthalpy and entropy of CO_2 adsorption for the respective xerogel samples, and for Ideal Adsorbed Solution Theory (IAST) calculations of selectivity, which were correlated with the experimental mixed gas isotherms.



Adsorption isotherms for single component gases (CO_2 and N_2) and a binary mixture (15% CO_2:85% N_2) on a melamine-resorcinol-formaldehyde xerogel, measured at 60 °C

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Hierarchical porous carbon nanocomposites

The synthesis and characterization of a hierarchically structured porous carbon nanocomposite with four length scales was recently described by researchers at the Slovenian National Institute of Chemistry.[2] The unique material, comprising zeolite nanocrystals embedded in the walls of the microcellular carbon foams, has pores at the ultramicro, micro, meso and macroporous scales, enhanced CO_2 adsorption capacity, and a low regeneration cost.

An **IMI-HTP** was used to measure CO_2 and N_2 adsorption isotherms and thermal desorption profiles. The isotherms show enhanced CO_2 adsorption capacity compared to the individual zeolite and carbon foam, whilst the thermal desorption measurements show that the desorption kinetics are rapid at a relatively low regeneration temperature of 150 °C.

References:

[1] I. A. Principe and A. J. Fletcher, Adsorption, 2020. DOI: 10.1007/s10450-020-00203-w

[2] M. Mazaj, M. Bjelica, E. Žagar, N. Z. Logar and S. Kovačič, ChemSusChem, 2020. DOI: 10.1002/cssc.201903116

[3] M. Mohamedali, H. Ibrahim and A. Henni, Microporous and Mesoporous Materials, 2020. DOI: 10.1016j.micromeso.2019.109916

[4] M. M. Lozinska, D. N. Miller, S. Brandani and P. A. Wright, Journal of Materials Chemistry A, 2020. DOI: 10.1039/c9ta09783j

"Hiden Isochema has a well-earned reputation for designing and developing high-end sorption instruments to accurately characterize the uptake of a wide range of species by materials for practical applications."

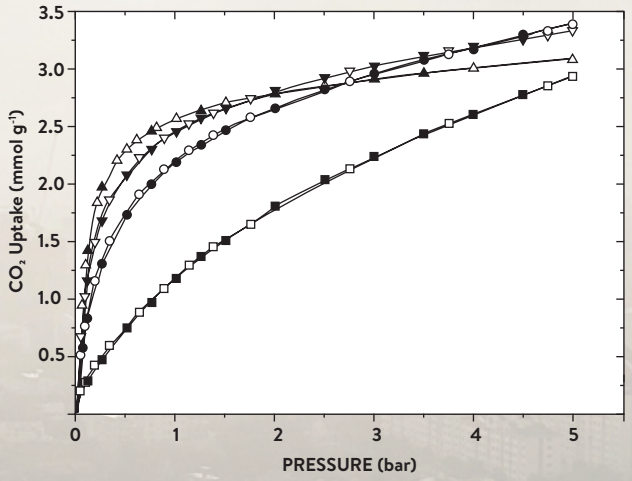
Dr Mark Roper, Sales & Marketing Director, Hiden Isochema

Ionic liquid–silica composites

A study from the University of Regina (Canada) reported the characterization of two imidazolium-based ionic liquids immobilized on mesoporous silica supports MCM-41 and SBA-15.[3] An **IGA-003** was used to measure CO_2 sorption isotherms and kinetics at a range of temperatures and pressures to 10 bar. The best performing composite ionic liquid–silica sorbents show enhanced CO_2 sorption capacity compared to the pure silica samples at moderate pressures, which is assigned to an acid-base solvation mechanism.

The CO_2 sorption kinetics for the composite materials are slightly slower than for the pure silicas, but significantly faster than for the corresponding bulk ionic liquids, indicating that such composite materials may offer a practical compromise for post-combustion carbon capture applications.

Zeolites as pressure swing adsorbents for carbon capture



CO_2 adsorption and desorption isotherms for four cation-exchanged L zeolite samples, measured at 25 °C

Reproduced from Reference [4] with permission from The Royal Society of Chemistry

A joint study between the Universities of Edinburgh and St. Andrews (UK) reported modification of zeolites L and Y by internal cation exchange.[4] An **IGA-001** was used to measure high resolution CO_2 adsorption-desorption isotherms to 5 bar for the six samples synthesized. The sorption isotherms were used to determine Henry's law constants and isosteric heats of adsorption, as well as CO_2 adsorption capacity. The isotherm results are considered in relation to the position of the cations determined from X-ray diffraction, with the extra-framework cations effectively "hidden" from the pores and consequently significantly decreased Henry's law constants.

The authors comment that the ability to modify the CO_2 isotherm shape for low silica zeolites is potentially significant for the design of practical pressure swing adsorbents for CO_2 capture applications, as the working capacity of the adsorbent may be increased without the need for industrially costly high vacuum processes.

Hiden achieves benchmark environmental accreditation

We are proud to announce we have been awarded ISO 14001 accreditation for our environmental management system.

nqa.
ISO 14001
ENVIRONMENTAL MANAGEMENT

This accreditation, which is widely acknowledged as a benchmark for organizations taking a responsible approach to environmental issues, represents the latest achievement as we continue to minimize the environmental impact of our activities.

Recent investment at Hiden's headquarters in Warrington, England, has included installation of solar panels and electric vehicle charging points, as well as implementation of new energy efficient heating and lighting systems.

Across the Hiden group, product development aims to increase the energy efficiency of our products, whilst we continue to implement modern solutions to reduce the carbon footprint of our transport and travel activities.

Follow us on Twitter **@HidenIsochema** for our latest updates, research, materials science and anything else we find interesting!

Discovering more. Seeing more.

DATE	CONFERENCE	LOCATION
12-15 July	**FEZA 2020**	Brighton, UK
12-17 July	**ICOM 12th International Congress on Membranes and Membrane Processes**	London, UK
20-23 September	**MOF 2020**	Dresden, Germany
1-7 November	**MH2020**	Perth, Australia
15-20 November	**AIChE Fall Meeting**	San Francisco, USA
30 Nov-Dec 2	**13th Brazilian Meeting on Adsorption EBA 13**	Fortaleza, Brazil

Dates are subject to change, please confirm details with event organizers.

PUBLICATION ROUND-UP

Vapor Diffusion in Polymers

Macroscopic modelling of water uptake behaviour of PEDOT:PSS films

L. Zhanshayeva, V. Favaron and G. Lubineau

ACS Omega, 2020. DOI: 10.1021/acsomega.9b02866

Researchers in the Composite and Heterogeneous Material Analysis and Simulation (COHMAS) Laboratory at KAUST, Saudi Arabia, used experimentally determined vapor sorption kinetics to model the interaction of water with conductive polymer films. This interaction is an important factor in determining the mechanical and electrical properties of the films. Kinetic data, measured using an **IGAsorp-CT**, were studied at a range of temperature and humidity conditions up to 80 %RH / 80 °C for PEDOT:PSS films of various thickness, with and without treatment by ethylene glycol. The kinetic data was well described by a combined reaction-diffusion model including solubility, diffusivity and reaction rate terms.

Adsorption Chillers

Molecular insight into fluorocarbon adsorption in pore expanded metal-organic framework analogues

J. Zheng, D. Barpaga, B. A. Trump, M. Shetty, Y. Fan, P. Bhattacharya, J. J. Jenks, C.-Y. Su, C. M. Brown, G. Maurin, B. P. McGrail and R. K. Motkuri

Journal of the American Chemical Society, 2020. DOI: 10.1021/jacs.9b11963

A collaborative study led by Pacific Northwest National Laboratory (USA) recently reported the detailed characterization of metal-organic framework analogues, specifically developed as sorbents for refrigerant gases. These sorbents have potential applications in adsorption-based cooling systems, which offer significant energy efficiencies compared to traditional mechanical compressors. An **IGA-003** was used to measure sorption isotherms and kinetics for fluorocarbon R134a, chosen as a model hydrofluorocarbon refrigerant, on pure Ni-MOF-74 and the pore-engineered analogues. The R134a sorption uptakes at pressures above 5 bar and corresponding working capacities were shown to be significantly enhanced for the best performing sorbents.

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