RCCS_PC PHOTO RIG (UK4.5)

Photocatalysis Reactor and Photoelectrochemical Rigs

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Edinburgh, United Kingdom

Operated by

Description

Two facilities have been built to perform the photocatalytic and photoelectrochemical reduction of CO_2. The photocatalysis reduction of CO_2 for gas or liquid phases is performed under UV (365 nm) and visible light source (optical fibre with tuneable light intensity, 50-150 mW cm^{-2}). The gas phase reactor is made of stainless steel with a quartz window on top of the reactor and is connected to a gas chromatograph (GC) for product analysis. The customised reactor allows the placement of samples in the form of powder, thin film or mesh. The humidity throughout the experiment is monitored with a humidity sensor. The reacting temperature can be varied between room temperature to 80 °C, whereas the flow of CO_2 can be varied between 0.07-8 mL min^{-1}.

The liquid phase reactor, which can be pressurise up to 5 bar, has a similar feature as the gas phase. The products obtained can be analysed using GC or Nuclear Magnetic Resonance (NMR). The customised liquid phase reactor can also be used for other photocatalytic reaction in liquid phase, such as photocatalysis of propylene oxide to cyclic carbonates, and is fitted with a solar simulator. Photoeletrochemical rig is used for photoelectrochemical reduction of CO_2 and other form of photoelectrochemical reactions and analysis. The electrochemical workstations (AutoLab PGSTAT 302N and Chi660E), which allow a voltage range of +/- 10 V and current range of +/- 250 mA connected can be used to for material fabrication (electrodeposition and anodization), electrochemical testing, such as chronoamperometry, cyclic voltammetry, electrochemical impedance spectroscopy (EIS). The customised membraneless photoelectrochemical reactor is available for photoelectrocatalytic reduction of CO_2 testing.

Scientific Environment

The Research Centre for Carbon Solutions (RCCS) at Heriot-Watt University, is an interdisciplinary world-leading engineering centre, inspiring and delivering innovation for the wider deployment of technologies needed to meet necessary carbon targets. The RCCS occupy over 350 m^2, across ten separate and interlinked laboratories, with dedicated high-end analytical research instruments and many bespoke in-house designed systems and rigs for advanced research and process development dedicated to research into Carbon Capture, Storage, Transport and Utilisation, in addition to facilitating several projects in the fields of Low Carbon System and Negative Emission Technologies. Along with facilitating our core research activities, the RCCS welcomes Academic and Industrial collaborators, and offers external contract analysis services.

State of the Art

CCUS Technologies

Use

- Electrochemical and Photochemical Conversion of CO2
- CO2 Conversion to Solid Carbonates

Research Fields

- Chemistry/Geochemistry
- Material science
- Modelling
- Engineering

Scale of Facility

- Lab Scale

Research Facility Contact

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Website

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A gas phase CO_2 photoreduction rig consisting of a photodifferential photoreactor fitted with a variable optical fibre irradiance light source (365, 400 – 500 nm filters or full spectrum). The reactor temperature is controlled across the range 25-80°C, and is fitted with an inline humidity saturator (temperature controlled 25–50°C). A four channel gas mixing system is controlled by Bronkhorst mass flow controllers and allow precise control of gas flow, from very low flow (0.07 - 0.7 $ml.min^{-1}$) to intermediate flow (0.16 - 8 $ml.min^{-1}$). Gas chromatography or mass spectrometry detectors analysis the photoreduction products.
A photoelectrochemical rig controlled by a Autolab PGSTAT 302N electrochemical workstation and/or a CHI660E electrochemical workstataion, which allow a voltage range of +/- 10V and a controlled current range of +/-250mA or +/-2A.

Quality Control / Quality Assurance (QA)

Quality Commitment

Equipment calibrated and validated by qualified staff using recognised industry standard techniques

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Facility Availability

Unit of Access (UA)
Day

Availability Per Year (in UA)
Up to 10 days per year

Forms of Access
In Person, Contract Research, Cooperative Research

Present Facility State of Access
Fully Accessible

Average Duration of a Typical Access
1 UA (day)

Number of External Users for Typical Access
n/a

Operational or Other Constraints

Specific Risks
Specialist research equipment will require qualified facility staff to operate, therefore access depending on resource and staff availability. A risk assessment will be required prior to any work taking place in the facility. All external visitors will undergo a safety induction and be provided with written safety instructions.

Legal Issues
n/a

Selected Publications

2019 - 1 Jul In : Faraday Discussions. 215, p. 329-344.
A microfluidic photoelectrochemical cell for solar-driven CO2 conversion into liquid fuels with CuO-based photocathodes.
Kalamaras, E., Belekoukia, M., Tan, J. Z. Y., Xuan, J., Maroto-Valer, M. M. & Andresen, J. M.

2019 - 4 Sep , In : ChemSusChem.
Novel Raspberry-like Microspheres of Core-shell Cr2O3/TiO2 Nanoparticles for CO2 Photoreduction.
Tan, J. Z. Y., Xia, F. & Maroto-Valer, M. M.

2019 - 1 Jul, In : Faraday Discussions. 215, p. 407-421.
Photo-generation of cyclic carbonates using hyper-branched Ru-TiO2.
Gavrielides, S., Tan, J. Z. Y., Sanchez Fernandez, E. & Maroto-Valer, M. M.

2019 - 16 Jul, In : RSC Advances. 9, 38, p. 21660-21666.
Systematic study of TiO2/ZnO mixed metal oxides for CO2 photoreduction.
Thompson, W. A., Olivo, A., Zanardo, D., Cruciani, G., Menegazzo, F., Signoretto, M. & Maroto-Valer, M. M.

2018 - 10 Jul, In : Applied Catalysis B: Environmental.
Systematic study of sol-gel parameters on TiO2 coating for CO2 photoreduction.
Thompson, W. A., Perier, C. & Maroto-Valer, M. M.

CCUS Projects

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2019-2022 -EU-funded CCUS projects - ACT

PrISMa

Process-Informed design of tailor-made Sorbent Materials for energy efficient carbon capture, This project tailor-makes novel materials that yield optimal carbon capture solutions for a range of different CO2 sources and CO2 use/destinations. Of particular interest to this proposal is then capture materials optimised for CO2 conversion.

2017-2020 -EU-funded CCUS projects - ACT

ALIGN-CCUS

The project's aim is to support the quick and cost-effective deployment of CCUS, enabling Europe's industrial and power sectors to be part of a low-carbon future while remaining economically viable.

2016-2021 -EU-funded CCUS projects - ERC

MILEPOST

MILEPOST-Microscale Processes Governing Global Sustainability. The project will transform our ability to analyse and predict the behaviour of a wide range of pore-scale processes governing the macroscopic behaviour of complex subsurface systems and open up new horizons for science in other areas, e.g porosity controlled in polymers and bioprinting.

2016-2020 -EU-funded CCUS projects - RFCS

PROMOTEE

This EU-Research Fund for Coal & Steel (RFCS) project is aiming at the development of novel porous carbon materials for energy and environmental applications using low value coal-derived liquids as the carbon precursors.

2017-2019 -Other CCUS Projects - EPSRC

Low carbon jet fuel through integration of novel technologies for co-valorisation of CO2 and biomass.

2016-2020 -Other CCUS Projects - EPSRC

Novel adsorbents applied to integrated energy-efficient industrial CO2 capture.

2014-2022 -Other CCUS Projects - EPSRC

CRITICAT

Centre for Doctoral Training in Critical Resource Catalysis.

2013-2020 -Other CCUS Projects - EPSRC

Solar fuels via engineering innovation

2013-2017 -Other CCUS Projects - EPSRC

CO2 injection and storage - Short and long-term behaviour at different spatial scales.

2016-2019 -Main/major non-CCUS projects - Innovate UK

Next Generation Green Data Centres for Environmental and Business Sustainability.

Figures

Photocatalysis reduction rig.

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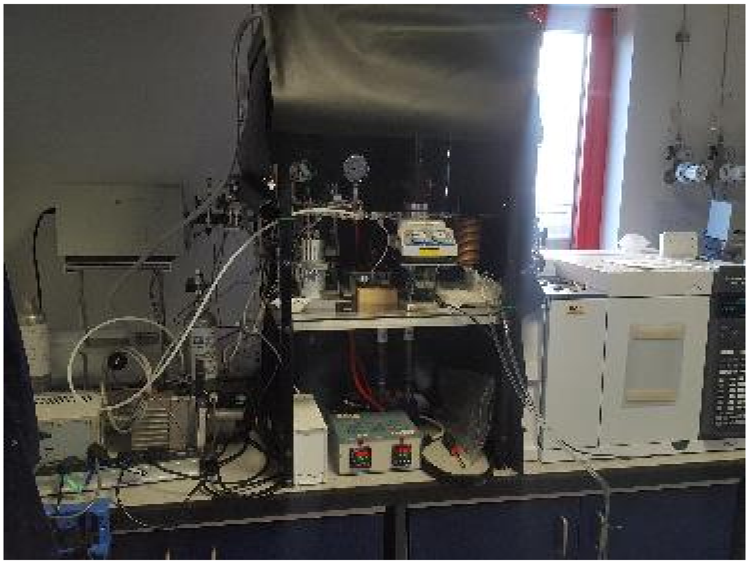

Photoelectrochemical rig .