Enhanced oil recovery

CSIRO's enhanced oil recovery technologies are maximising oil production efficiency from existing fields in order to sustain oil supplies for Australia's energy future.

In Australia, production from existing oil fields is in decline and the replacement rate from new discoveries is not sufficient to offset the depletion rate. Improving the productivity of known oilfields will play a critical role in sustaining oil supply from mature fields and will help to further secure Australia's energy supplies for the future.

Enhanced oil recovery (EOR) techniques allow the extraction of additional oil from the reservoir. The International Energy Agency estimates that EOR techniques can increase the recovery factor of oil by an additional 40 per cent after primary and secondary oil recovery methods have been used.

Based on our multidisciplinary skills in reservoir characterisation, petrophysics and world-leading polymer chemistry, CSIRO is working on new technologies to influence the oil production of known oilfields through improved and enhanced methods.

High resolution phase-contrast X-ray CT image of a porous sand pack, showing grain surfaces, (brown), pore water (white) and gas bubbles (blue).

Expertise

CSIRO has extensive research and technical experience in reservoir characterisation, modelling and oil recovery, and is using these capabilities to explore the potential of EOR.

We have developed expertise in the following areas:

PETROPHYSICAL CHARACTERISATION OF RESERVOIRS

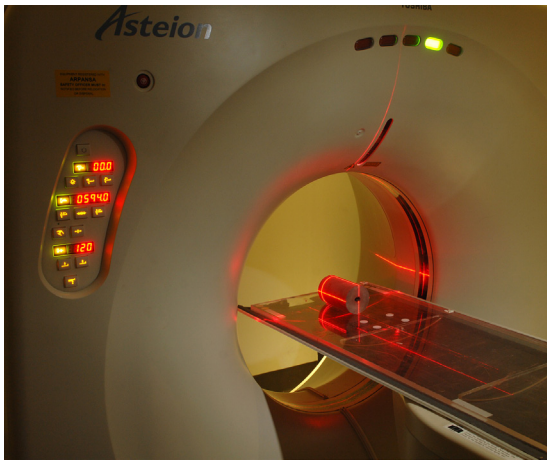
Our Petrophysics laboratory is equipped for a full range of measurements: Nuclear Magnetic Resonance (NMR) spectrometer, X-ray Computed Tomography (CT) scanner, 4-terminal resistivity and resistivity index system, dielectric analysers, helium porosimeter/permeameter and core flooding systems. Techniques like NMR and core flooding improve our understanding of the behaviour of reservoir rocks during the oil recovery process and help to evaluate alternative EOR procedures.

FLUID CHARACTERISATION

CSIRO has a dedicated fluid characterisation laboratory for measuring density, viscosity and interfacial tension (IFT) of reservoir fluids under elevated temperatures. Our IFT cell can work under reservoir conditions of pressures and temperatures of up to 10,000 psi and 170°C, and can also be used to measure fluid–rock contact angles under reservoir conditions. The laboratory is also equipped with UV-Vis, fluorescence and FT-IR spectrophotometers that can be used to quantify oil in produced fluid mixtures during coreflooding experiments.

PORE SCALE IMAGING AND MODELLING

CSIRO uses high resolution X-ray CT and synchrotron imaging to reveal the micron- to centimetre-scale features of rock samples, including the pore geometry and interconnectivity which determine how fluids will flow through rock. We use NMR and dielectric spectroscopy to evaluate the wettability of the pore surfaces. This indicates the preference for fluid to adhere to the rock or to flow. These rock properties affect the viability of a reservoir and its suitability for EOR.



X-ray scanning of rock core prior to core flood experiments.

OILFIELD CHEMISTRY

In order to develop novel molecules for EOR several key areas are required, from small molecule synthesis, macromolecular design, surfactant chemistry through to expertise in reservoir applications. CSIRO possesses expertise in all of these areas and can develop and apply enabling molecules for EOR. Our research is at the frontier of physics, chemistry and engineering, and we can deliver a coordinated approach to molecular design, synthesis, characterisation and application. In addition, CSIRO also has significant capability in the physio-chemical characterisation of materials, including methods to study phase behaviour of surfactant-polymer systems and surface and interfacial properties, as well as a strong background in the development of materials for oilfield applications.

HYDRODYNAMICS AND RESERVOIR COMPARTMENTALISATION

The hydrodynamics team characterises, quantifies and predicts hydrodynamic response in a producing reservoir. Oil field compartmentalisation, fault and top seal properties, and the impacts of depletion are addressed, to understand fluid flow and optimise EOR techniques.

SURFACE CHEMISTRY AND COLLOID SCIENCE

We employ core skills in surface chemistry to understand interfacial interactions in solid–liquid (e.g. water–rock) and liquid–liquid (e.g. emulsion) systems in model reservoir/recovery environments. This is supported by capabilities in X-ray photoelectron spectroscopy, atomic force microscopy, surface mass spectrometry and polymer and surfactant synthetic chemistry.

PETROLEUM MICROBIOLOGY AND GENOMICS

Researchers are exploring the use of bioinformatics to gain information on gene pools of microbial communities within petroleum reservoirs.

NEAR WELLBORE FLOW AND PRODUCTION ENGINEERING

CSIRO has developed the Near Wellbore Reservoir Characterisation Tool (NWRCT), a system capable of automatically linking reservoir and hydraulic simulators. This allows analysis of production profiles in production and injection wells, and optimisation of the design of well completions to maximise productivity and recovery factors at reservoir/field level.

CORE FLOODING MONITORED BY X-RAY CT

The core flooding facility is capable of providing real-time monitoring of fluid flow in cores under reservoir pressures and temperatures using X-Ray CT. This unique setup allows us to capture the flooding process in reservoirs and provide some essential parameters for reservoir modelling. It also provides a better understanding of the fluid–fluid and fluid–rock interaction during the oil recovery process.

RAPID POLYMER SCREENING TECHNIQUES

CSIRO has an extensive range of high throughput and combined methods for synthesis, characterisation, and evaluation of new polymer gels and surfactants. This enables the rapid development of new materials that can effect fluid flow within reservoirs, using high throughput evaluation to explore a large experimental space.

Facilities

CSIRO has specialised laboratories and equipment to characterise fluid–rock interactions, these include:

- core flooding rig
- petrophysics laboratory
- robotic synthesis and characterisation for developing libraries of target materials
- PressurePlot™ hydrodynamics software
- X-ray CT scanning equipment
- iVEC: high performance computing and scientific visualisation
- HP differential scanning calorimetry (DSC)
- high temperature rheology
- small angle x-ray scattering (SAXS)
- expertise in synchrotron techniques (via the Australian Synchrotron).

Applying the capability

CSIRO is using its capabilities to determine the feasibility of the following EOR technologies.

MICROBIAL ENHANCED OIL RECOVERY

Microbially enhanced oil recovery (MEOR) involves the use of microbes in petroleum reservoirs to enhance the amount of oil that can be produced. The microbes use hydrocarbons as a food source and either occur naturally in the reservoirs or are introduced.

In MEOR systems, the microbial activity changes the physical/chemical properties of crude oils to stimulate oil–water–rock interactions that improve oil recovery.

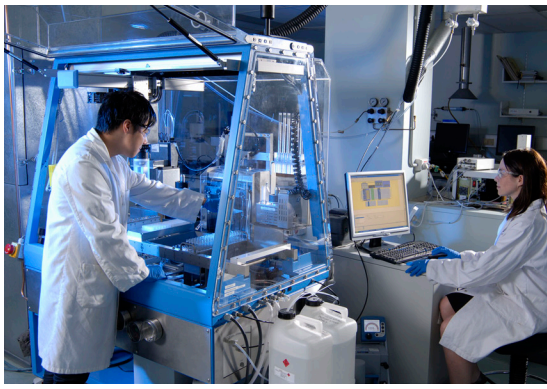
We are currently improving our MEOR strategy through characterisation of microbial communities in petroleum reservoirs.

GAS INJECTION METHODS

Gas injection methods can potentially be employed to improve recovery of hydrocarbons. In the case of carbon dioxide, there is also benefit in sequestering a gas that otherwise contaminates the natural gas product, or is emitted as a greenhouse gas.

'SMART WATER'

'Smart water' involves altering the chemical composition of the waterflood to enhance oil recovery. The water–rock and water–oil electrochemical interactions of 'smart water' favours the movement of hydrocarbons trapped at the pore scale through short range surface forces or capillarity.



Materials library synthesis using Chemspeed robotic synthesis platform within the CSIRO High Throughput Centre.

Collaborating with CSIRO

CSIRO's EOR research encompasses both academic and commercial partnerships of diverse types. Please contact us to investigate collaborative opportunities in this area.

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