Nanoscale Studies of Confined and Interfacial Compressed Fluids

Syringe Pump Application Note AN33

Using a Teledyne ISCO Syringe Pump

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Introduction

Fluid-solid interactions control the properties of geofluids, including: water, alkanes, carbon dioxide, etc. To better understand fluid migration through porous rock formations and fluid reservoir processes, a nanoscale quantitative understanding of fluid-mineral interactions is needed, which can be obtained from combined excess sorption and neutron scattering experiments. The adsorbed phase model, developed by our group, calculates mean density and volume of the sorption phase of fluids in narrow pores, quantities of interest for theoretical analysis, and computer modeling that have been inaccessible hitherto.

Currently, our confined fluids research includes the study of carbon dioxide interactions with cap- and reservoir rocks for geologic carbon storage applications. We are also interested in hydrocarbon – mineral interactions with respect to tight shale gas production and enhanced oil recovery processes.

Precise automated fluid delivery to the neutron pressure sample cells is key for effective use of precious instrument time at neutron scattering facilities.

Experimental Procedure

In a typical neutron scattering experiment, the sample is placed inside a pressure cell with neutron transparent windows and contacted with the compressed fluid at different conditions of pressure (P) and temperature (T). For each P, T condition, pressure and thermal equilibrium are established before measuring the neutron signal. After completion of the neutron measurement (typically 2-3 hrs), the next P,T set-point is dialed in and another neutron curve taken. Analysis of the data sets yields information about the structure of the sorption phase along the sorption isotherm.

We used a Teledyne ISCO syringe pump for automated measurements of neutron scattering data along isotherms and isochors. The model 260 HLf pump is suitable for CO_2 and hydrocarbons, and is used in constant pressure mode. Typical temperature and pressure ranges studied in our sorption experiments are 20-150 ^{o}C and 0-500 bars. Fluid flow rates are rather small due to the small volumes of the high-pressure cells and setups. Figure 1 shows the setup of the pressure system for neutron measurements. Repeated fluid flushing and evacuation of the entire system before the measurement removes water traces that may be present in the tubing. The neutron pressure cell is thermostated to ±0.01 K, all tubing is $^{1}/_{16}$ inch stainless steel capillary. Fluid delivery is entirely controlled by the ISCO pump. The setup is kept as simple as possible to facilitate easy and fast assembly at neutron beam lines. The RS232 port, in conjunction with the LabView driver provided by Teledyne ISCO, is used to synchronize the syringe pump with the neutron instrument control PC and allow continuous measurements.

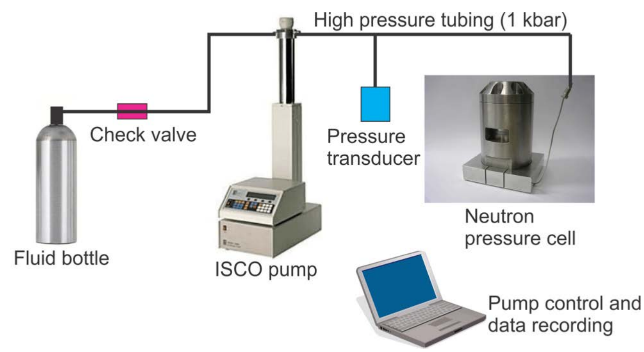

Figure 1: Schematic of experimental setup

Reference

1. J. F. Ankner, L. M. Anovitz, J. L. Banuelos, J. F. Browning, J. R. Carmichael, D. R. Cole, G. Rother, D. J. Wesolowski. “High-pressure cell for neutron reflectometry of supercritical and subcritical fluids at solid interfaces”, Rev. Sci. Instrum. 83, 045108 (2012).

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Product model names have been updated in this document to reflect current pump offerings.

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