PETRO
PETROLEUM RESEARCH

Tracer Analyses Laboratories – chemical (non-radioactive) tracers

•Radioactive and non-radioactive (chemical) tracers used in studies of fluid flow in oil reservoirs are analysed in this laboratory. Several thousands of samples are analysed annually, - the majority being chemical tracers. This pamphlet will only cover equipment used for chemical tracer analysis

METHODS

The analyses are mainly based on gas and liquid chromatography separation. Concentration levels down to the low ppt-range are reached.

LABORATORY INSTRUMENTATION

Various analytical methods are available in our laboratories:

- 4 GC-MS (various ionization principles)
- 1 GC-MS-MS
- Several GCs with various detectors (ECD, FID, ELCD, PFPD)
- Several HPLCs with various detectors UV, fluorescense/diode array, electrochemical).
- 3 ATD (automatic thermal desorber)

ANALYSIS OF WATER TRACERS

Non-radioactive tracers for injected water in oil and geothermal reservoirs include various non-reactive anions and polyfluorinated aromatic carboxylic acids (FBAs). In addition, a new class of proprietary non-radioactive tracers have recently been qualified for high-temperature reservoirs.They are organic anions at pH > ~4.5. Water tracers are analysed with HPLC or, after derivatization, with GC-MS or GC-MS-MS. The latter reduces potential background disturbances greatly.

ANALYSIS OF GAS TRACERS

Non-radioactive tracers for injected gas include perfluorinated cyclic hydrocarbons (PFCs), SF_6 and others. For lower concentrations (ppt-range) the gas tracers are best analysed with GC-MS which gives a more certain qualitative identification and a more sensitive quantitative determination.

Relatively high (ppb-range) concentrations of gas tracers in natural gas are easily analysed directly with GC-ECD.

The Automatic Thermal Desorption unit (ATD) is used in combination with the capillary absorption sampler tubes (CATS) that selectively absorb and concentrate PFC gas tracers from natural gas samples. It is connected to a GC-MS. The ATD automatically releases the gas tracer into the GC-MS, and 42 samples can be analysed automatically in one load. Software is available to analyse and compare the results from the different samples in various graphical presentations.

The equipment is used both for routine analyses and for research purposes.

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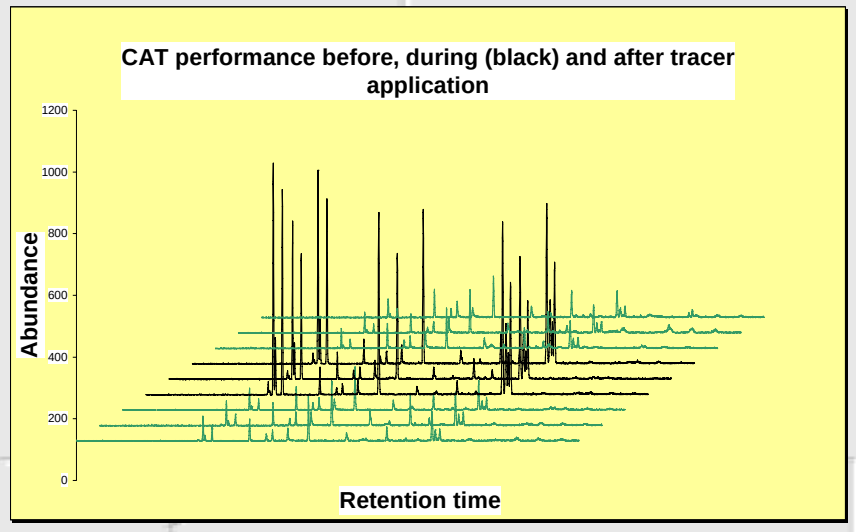

Gas chromatograms of PFC tracers from a CATS tube

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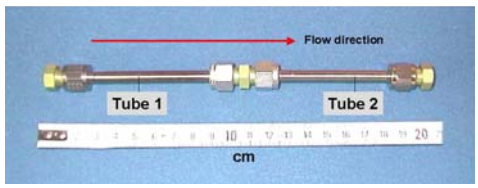
GC-MS with ATD for gas tracer analyses where CATS technology is applied



Capillary absorption tube (CATS) sampler, - two in series to ensure quantitative sorption for PFC-tracers

Pressurized gas tracer sampling cylinder with volume of 500 ml and typical pressure of 30-60 bar previously used for PFC-tracers and presently used for SF4 and radiolabelled hydrocarbons

ON-LINE IN-STREAM ANALYSIS

Today, all tracer analysis is carried out in a well-managed and clean laboratory environment. It is, however, a research and development goal to be able to analyse tracer concentrations directly in the produced fluid streams at the production site. This requires robust methods and ruggidized instrumentation. For the time being, we pursue two main lines of development:

- Separation in test separator and analysis with GC/ECD for gas tracers
- Separation in test separator and analysis by laser-induced fluorescence spectrometry for water tracers

ON-GOING R&D

- We are seriously studying the potential for the use of HPLC-MS-MS in detection of non-radioactive water tracers. This will be a general method also for tracers that cannot easily be derivatized and evaporized into a gas chromatograph.
- We develop now an instrumentation for analysis of fluorescent tracer molecules which is based on laser excitation in the UV-range followed by spectroscopy analysis of the fluorescent light at higher wavelengths. This method has potential for on-line analysis.
- We are looking into the concept of Molecular Imprinted Polymers (MIPs) to to investigate the possibility to tailormake detection methods for each individual tracer molecule.