Petrochemical analysis

Quality control of petroleum products

Metrohm

Metrohm ...

- is the global market leader in titration
- offers a complete portfolio for NIR analysis, in addition to all of the methods of ion analysis – titration, voltammetry, and ion chromatography
- is a Swiss company and manufactures exclusively in Switzerland
- grants a 3-year instrument warranty and a 10-year warranty on chemical suppressors for ion chromatography
- supports you with unparalleled application expertise
- offers you more than 1600 applications free of charge
- supports you with dependable on-site service worldwide
- is not listed on the stock exchange, but is owned by a foundation
- takes a sustainable approach to corporate management, putting the interests of customers and employees ahead of maximizing profit

Metrohm – customized analysis for the petrochemical industry

A demanding industry

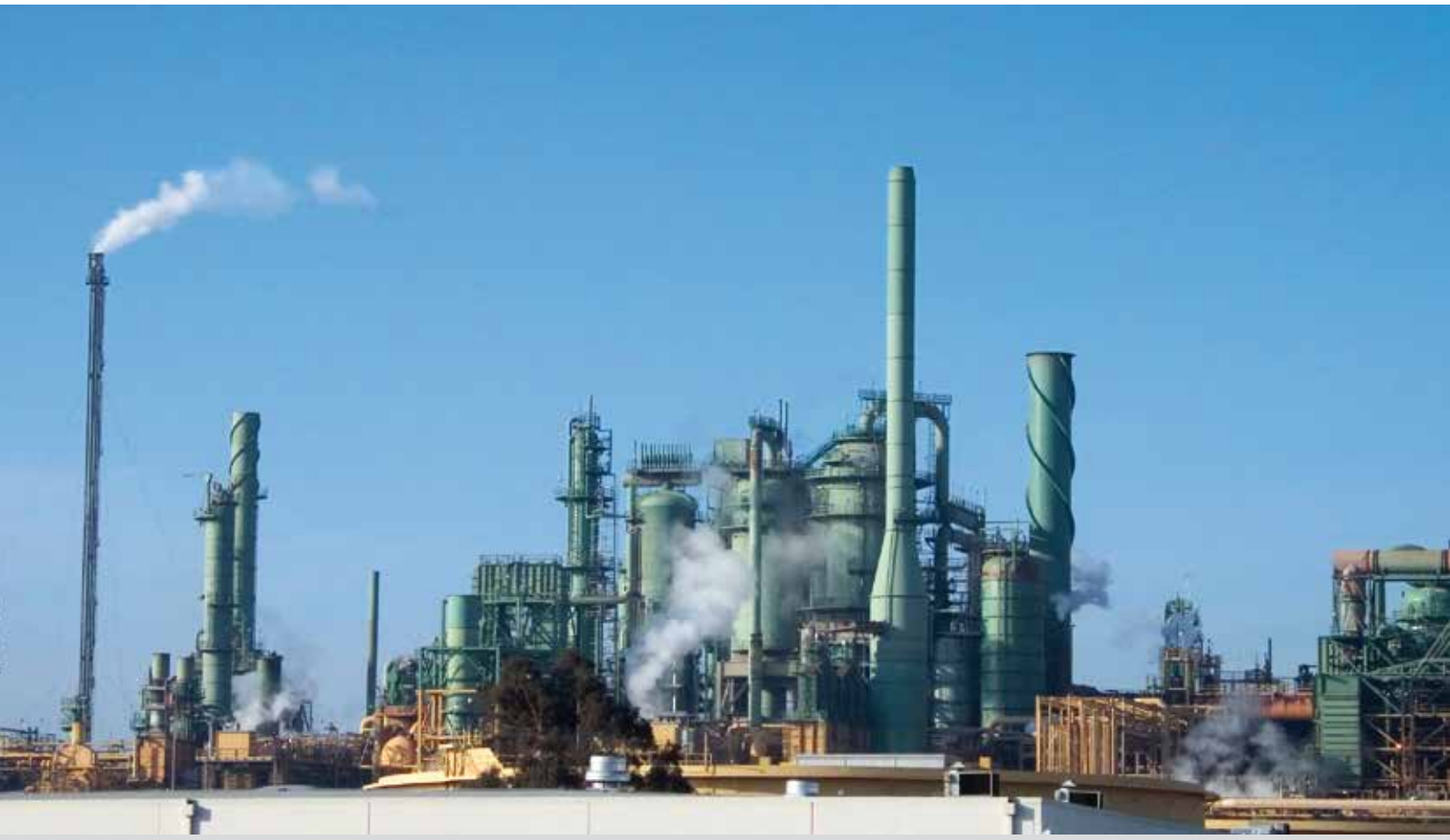
Crude oil is a highly complex mixture of hydrocarbons and other compounds that through desalting, destillation and conversion is transformed into higher quality hydrocarbons. This refining is demanding and requires precise and reliable analysis.

As a leading manufacturer of instruments for chemical analysis, we are quite aware of these challenges. We offer you state-of-the-art instruments and systems for monitoring and optimizing the quality of a wide variety of petrochemical products with the required accuracy not only in your laboratory but also in process.

You can count on our support

Not only do we provide you with the right instrumentation but with complete solutions for the particular task at hand. Your partners at Metrohm are experienced professionals who help you with customized application support and service.

On the following pages, discover the solutions Metrohm offers the petrochemical industry to ensure the quality and safety of your products.



Analysis of petroleum products

Formation of crude oil deposits

According to current knowledge our oil reserves originated during the Jurassic and Cretaceous periods (200 to 65 million years ago) from microbial flora and fauna living in the seas. While some of the dead organic residues were directly mineralized, i.e., decomposed, the other part sank to the seabed. There the material was covered by other marine deposits and formed a sludge with very fine rock material that slowly converted to crude oil under the prevailing biogeochemical conditions of increased pressure and salinity. Due to its lower density the crude oil migrated upwards through fine cracks in the rock layers until it accumulated under impermeable covering rocks and thus formed the oil deposits we know today. Sometimes above-ground oil deposits were formed that already allowed our forefathers to use crude oil for heating and lighting, building, or lubrication.

«Lubricant» of the global economy

Nowadays crude oil, which consists of at least 500 different components, is processed by distillation and refining to produce liquefied gas, gasoline, diesel, heating fuel, and lubricants as well as a large variety of other products. As the «lubricant» of the global economy, crude oil is omnipresent. It covers approximately 40% of our energy demand and is used in the chemical industry for the production of plastics, textiles, dyes, cosmetics, fertilizers, detergents, building materials, and pharmaceuticals.

Standards for quality control

The importance of petroleum products is reflected by the large number of standards relating to them. Metrohm as a leading manufacturer of instruments for analysis offers long-standing application know-how for the quality assurance of petroleum products.

Selected standards from petrochemical analysis

Parameters	Standard	Matrix	Method	Page
Base number	DIN ISO 3771	Petroleum products	Potentiometric titration	6
	ASTM D 4739	Petroleum products Lubricants		
	ASTM D 2896	Petroleum products		
Nitrogenous bases	UOP269	Petroleum distillates	Potentiometric titration	
Acid and base number	ASTM D 974	Petroleum products	Colorimetric titration	
	ASTM D 664	Petroleum products	Potentiometric titration	
Acid number	DIN EN 12634	Petroleum products Lubricants	Potentiometric titration	
Acid number and naphthenic acids	UOP565	Petroleum products Petroleum distillates	Potentiometric titration	
Mercaptan sulfur	ISO 3012	Light and middle distillate fuels, moderately volatile distillates, kerosene	Potentiometric titration	8
	ASTM D 3227	Automotive fuel, kerosene		
H_2S	ASTM D 2420	Liquefied petroleum gas (LPG)		
H_2S, mercaptan sulfur	UOP163	Petroleum products		
Alkalinity, H_2S, mercaptans	UOP209	Used alkaline petroleum products		
H_2S, mercaptan sulfur, carbonyl sulfide	UOP212	Gaseous hydrocarbons Liquefied petroleum gas (LPG)		
Saponification value	ASTM D 94	Petroleum products	Potentiometric titration	9
	DIN 51559	Petroleum, insulating oil	Colorimetric titration	

Parameters	Standard	Matrix	Method	Page
Bromine number	ISO 3839	Petroleum distillates, alkenes	Potentiometric titration	10
	ASTM D 1159	Petroleum distillates Aliphatic alkenes		
	ASTM D 5776	Aromatic hydrocarbons		
Bromine number and bromine index	UOP304	Hydrocarbons	Potentiometric titration	
Bromine index	ASTM D 1492	Aromatic hydrocarbons	Coulometric titration	
	ASTM D 2710	Petroleum hydrocarbons	Potentiometric titration	
Hydroxyl number	ASTM E 1899	Aliphatic and cyclic hydrocarbons	Potentiometric titration	10
	DIN 53240	Resins, raw materials for varnishes, primary alcohols, glycols, fats		
Organic chlorine content	ASTM D 4929	Crude oil	Potentiometric titration	11
Organic, inorganic and total chlorine content	UOP588	Hydrocarbons		
Salinity	ASTM D 6470	Crude oil	Potentiometric titration	11
Water content	ISO 12937	Petroleum products	Coulometric KFT	12
	ISO 10337	Crude oil	Coulometric KFT	
	ISO 10336	Crude oil	Volumetric KFT	
	ISO 6296	Petroleum products	Volumetric KFT	
	DIN 51777-1/2	Petroleum hydrocarbons Solvents	Coulometric KFT[a] Volumetric KFT	
	ASTM D 4377	Crude oil	Volumetric KFT	
	ASTM D 4928	Crude oil	Coulometric KFT	
	ASTM E 1064	Crude oil, lubricating oil, solvents	Coulometric KFT	
	ASTM D 1364	Highly volatile solvents	Volumetric KFT	
	ASTM D 890	Turpentine	Azeotropic distillation, KFT	
	ASTM E 203	General	Volumetric KFT	
	ISO 10101	Natural gas	Coulometric KFT	14
	DIN 51869	Gaseous fuels, gases		
Oxidation stability	EN 14112	Fatty acid methyl esters (B100)	Oxidation stability	16
	EN 15751	Fatty acid methyl esters and diesel fuel blends		
	DIN EN 16568	Fatty acid methyl esters and diesel fuel blends		
Inorganic chloride and sulfate	ASTM D 7319 ASTM D 7328 DIN EN 15492	Ethanol as a blending component	Ion chromatography	18
Free and total glycerol content[b]	ASTM D 7591	Biodiesel blends	Ion chromatography	18
Halogens and sulfur	ASTM D 7359	Aromatic hydrocarbons	Combustion IC	22
	UOP 991	Halogens in liquid organics		
Sulfur and heavy metals	–	Gasoline, ethanol	Voltammetry	24
Various parameters (RON, CEN, etc.): Qualitative analysis Quantitative analysis	 ASTM E 1790 ASTM E 1655	Crude and petroleum as well as numerous petroleum products	Near-infrared spectroscopy	28
Parameters that can be determined by wet chemistry and spectroscopy	Process-dependent specifications	Petroleum products	Process analysis	30

[a]Karl Fischer titration, [b]for details see brochure on biofuel analysis

Thermometric titration, corrosion, and service

The table above lists, amongst others, some standards for determining the acid and base number. Thermometric titration is an interesting alternative. For details, see page 9 of this brochure.

Pages 26 and 27 cover corrosion research and the Metrohm Autolab potentiostats and galvanostats used in this area. The extensive services offered by Metrohm Service are detailed on pages 36 and 37.

Separate brochure for biofuel analysis

An additional brochure is available for the analysis of biodiesel and bioethanol. This can be downloaded in PDF format at:

biofuels.metrohm.com

Determination of acid and base numbers

Potentiometric titration with the Solvotrode easyClean

The base number is a sum parameter for alkaline components. These include primary organic and inorganic amino compounds. However, salts of weak acids, basic salts of polycarboxylic acids, a number of heavy metal salts, and detergents are also determined. The base number indicates how many basic components, expressed as mg KOH, are contained in 1 g of sample. This determination is used for the immediate detection of product changes during use.

With the acid number, acidic components are measured as a sum parameter. It includes acids and salts with pK_s values < 9 and indicates how many mg KOH are required to neutralize 1 g of sample. The acid number reveals changes during the use of the product.

Both parameters are determined by potentiometric titration in nonaqueous solvents or solvent mixtures. Titrimetric determinations can be completely automated – from the addition of solvents to the reproducible cleaning of the electrode. Oil samples can even be weighed in fully automatically by the 864 Robotic Balance Sample Processor before titration. This guarantees complete traceability.

The Solvotrode easyClean is a combined pH glass electrode that was especially developed for this application. The easyClean ground-joint diaphragm can be easily cleaned even of strong contamination. The electrostatic shielding of the electrolyte compartment also ensures a low-noise measuring signal.

Solvotrode easyClean

Determination of acid and base number according to ASTM D 974 (photometric titration)

The acid and base number may also be determined by photometric titration with color indication of the equivalence point according to ASTM D 974. For this application, Metrohm offers the Optrode, a new sensor for photometric titration. It is 100% solvent resistant thanks to the glass shaft. Another key advantage of the Optrode is its capacity for automation.

Optrode

Standard	Parameter	Titrant	Solvents	Electrode (reference electrolyte)
ASTM D 4739	Base number	HCl in isopropanol	Chloroform, toluene, isopropanol, water	Solvotrode easyClean (LiCl in EtOH)
ASTM D 2896	Base number > 300 mg KOH/g	Perchloric acid in glacial acetic acid	Glacial acetic acid, xylene	Solvotrode special
ISO 3771	Base number	Perchloric acid in glacial acetic acid	Toluene, glacial acetic acid, acetone	Solvotrode easyClean (LiCl in EtOH)
ASTM D 664	Acid number	KOH in isopropanol	Toluene, isopropanol, water (lubricants), isopropanol (biodiesel)	Solvotrode easyClean (LiCl in EtOH)
DIN EN 12634	Acid number	KOH or TMAH[a]	Dimethyl sulfoxide, isopropanol, toluene	Solvotrode easyClean (LiCl in EtOH)
UOP565	Acid number and naphthenic acids	KOH in isopropanol	Toluene, isopropanol, water	Solvotrode easyClean (LiCl in EtOH)
ASTM D 974	Acid number	KOH in isopropanol	Toluene, isopropanol, water	Optrode
ASTM D 974	Base number	KOH in isopropanol	Toluene, isopropanol, water	Optrode

[a] Tetramethylammonium hydroxide

864 Robotic Balance Sample Processor (with 843 Pump Station (peristaltic)) for TAN/TBN determination

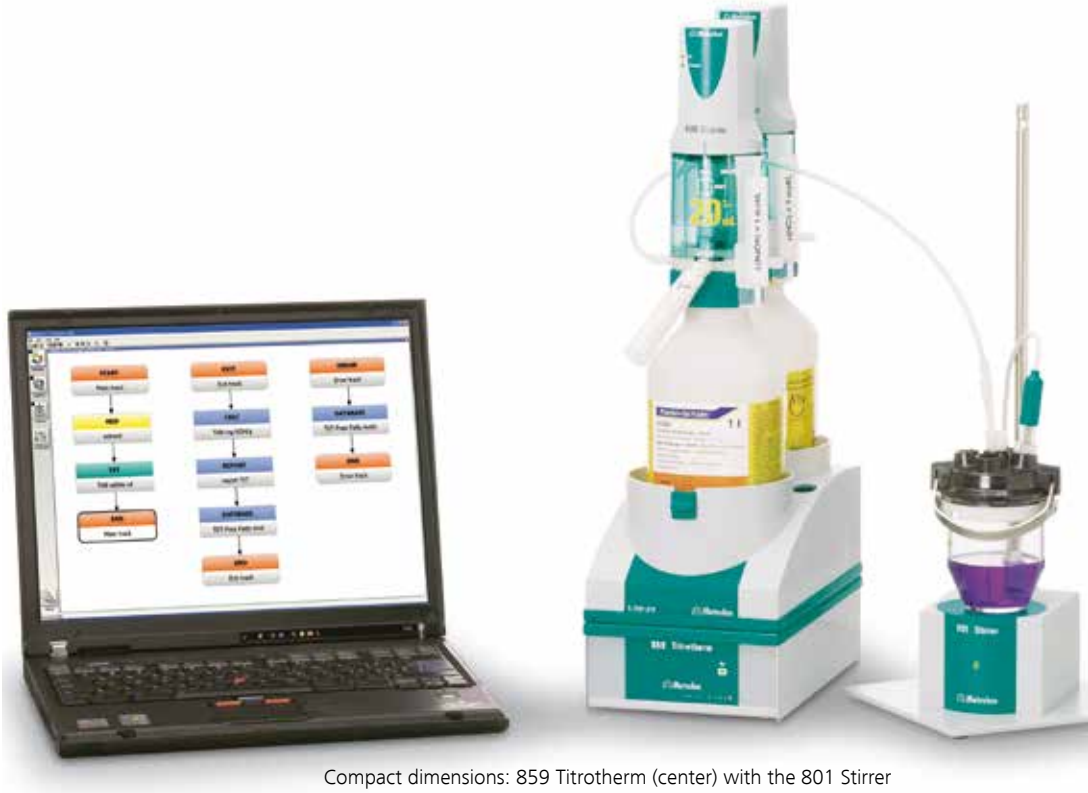
Sulfur and sulfur compounds determined by potentiometric titration with the Ag Titrode

Sulfur compounds in petroleum products not only have an unpleasant odor, they are also environmentally damaging and promote corrosion. For determining hydrogen sulfide and mercaptans in liquid hydrocarbons (gasoline, kerosene, naphtha, and similar distillates), the sample is titrated with silver nitrate solution, whereby silver sulfide (Ag_2S) and silver mercaptide are produced. Two pronounced potential jumps occur. The first endpoint corresponds to hydrogen sulfide (H_2S), the second to the mercaptans. The indicator electrode for the titration is the Ag-Titrode with Ag_2S coating. Since both H_2S and mercaptans are oxidized by atmospheric oxygen and the arising oxidation products cannot be determined titrimetrically, work must be carried out under nitrogen atmosphere.

Gaseous sulfur compounds can also be determined with this procedure. For this purpose, they are absorbed in an alkaline solution. The first two absorption vessels contain KOH or NaOH (for H_2S and mercaptans), the third contains ethanolic monoethanolamine (for carbonyl sulfide).

The results are expressed in mg/kg (ppm) hydrogen sulfide and/or mercaptan sulfur.

The Ag-Titrode is a maintenance-free combined Ag-ring electrode. During titration, it references the constant pH value of the sample: therefore, the diaphragm, which is used on other sensors, is no longer required.



Compact dimensions: 859 Titrotherm (center) with the 801 Stirrer

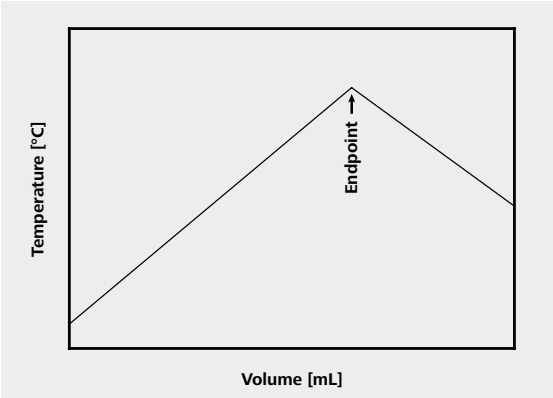
Thermometric titration: the ideal complement to potentiometric titration

Thermometric titration is a determination method suitable for a broad range of applications. It substitutes potentiometric titration, particularly when potentiometric electrodes are not suitable for the application at hand. The only prerequisite for thermometric titration is an adequately large temperature change in the sample solution.

The advantages of thermometric titration are ease of handling, control via ***tiamo***™ software, and exceptionally short analysis times. Automation is particularly advantageous here, as it saves a great deal of time. The sensor requires no calibration or maintenance and is ideally suited to aggressive sample matrices. There are two versions, one for HF-free and the other for HF-containing aqueous/nonaqueous solutions.

The principle

Every chemical reaction is associated with a change in reaction enthalpy. This results in either an increase (exothermic reaction) or a decrease (endothermic reaction) of the sample solution temperature. The titrant added reacts with the analyte and thereby changes the temperature in the reaction solution. A bend in the temperature curve indicates the endpoint when all analyte has reacted and allows the calculation of the analyte concentration.



Temperature curve of an exothermic titration

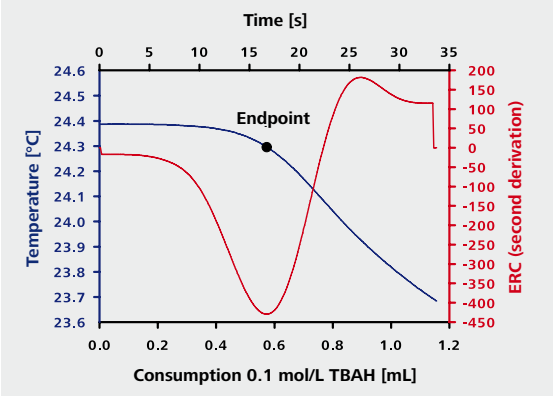
Thermoprobe: a unique sensor for a variety of thermometric titrations

Total acid number and total base number (TAN and TBN)

The total acid number (TAN) indicates how much base is required to neutralize the acids contained in an oil sample. It is given in milligrams of KOH per gram of oil. The TAN is a measure of the acidity of the oil, i.e., the amount of acidic compounds. It is indicative of processes such as oxidation, depletion of additives, or the introduction of acids.

The total base number (TBN) indicates the capacity of a sample to neutralize acids, also measured in milligrams of KOH per gram of oil. The higher the TBN, the higher the amount of acid that can be neutralized. The TBN contains important information about the quality and characteristics of the sample.

The TAN and TBN are generally determined using potentiometric titration. The associated electrode maintenance can be avoided by using thermometric titration. Contamination and matrix influences do not impair the sensor. It also works without rehydration. In comparison to potentiometric titration, thermometric titration is approximately three times faster and can be fully automated.



TAN determination for a synthetic oil sample

Saponification value

The saponification value (SV) primarily serves to determine the proportion of fatty acid esters in the sample. The fatty acid esters are cleaved by boiling in KOH, a process that produces the salts of the fatty acids and the corresponding alcohol, for example, glycerol. The method is not specific since acidic sample constituents consume KOH and in doing so increase the saponification value. The titrant employed is c(HCl) = 0.5 mol/L in isopropanol. The SN indicates how many mg KOH are consumed by 1 g sample under the test conditions.

Bromine number and bromine index

The bromine number (BN) and the bromine index (BI) indicate the proportion of unsaturated compounds (usually C-C double bonds) in petroleum products. Here, the double bond is cleaved by bromine addition. The BN indicates how many g of bromine (Br_2) are bound by 100 g of sample.

The method is used for the following products:

- Distillates with a boiling point below 327 °C (620 °F) and a volume percentage of at least 90% of compounds that are lighter than 2-methylpropane (included in this are fuels with and without lead additions, kerosene, and gas oils).
- Commercial alkenes (mixtures of aliphatic monoalkenes) with a bromine number from 95 to 165.
- Propenes (trimers and tetramers), butene trimers, mixtures of nonenes, octenes, and heptenes.

The BI indicates how many mg of bromine (Br_2) are bound by 100 g of sample. The method is used for «alkene-free» hydrocarbons with a boiling point below 288 °C (550 °F) and a bromine index of between 100 and 1000. For products with a bromine index of > 1000, the bromine number should be used.

Method	Samples	Titrant	Solvents	Electrode
Bromine number [g Br_2/100 g]	Automotive fuels, kerosene, gas oils, propene, butenes, heptenes, octenes, nonenes	c(bromide/bromate solution) = 0.08333 mol/L	Glacial acetic acid, trichloroethane, methanol	Double Pt wire electrode
Bromine index [mg Br_2/100 g]	Alkene-free hydrocarbons	c(bromide/bromate solution) = 0.00333 mol/L	Glacial acetic acid, trichloroethane, methanol	Double Pt wire electrode

Hydroxyl number

The hydroxyl number (OHN) indicates the number of mg KOH corresponding to the hydroxyl groups in 1 g sample. The most frequently described method for determining the hydroxyl number is conversion of the sample with acetic acid anhydride in pyridine with subsequent titration of the released acetic acid. The one-hour boiling under reflux, the difficulty in automating the process and particularly the use of the health-hazardous pyridine are serious disadvantages.

An alternative is offered by the considerably simpler and more easily automated method according to ASTM E 1899. Primary and secondary hydroxyl groups are converted with toluene-4-sulfonyl-isocyanate (TSI) into an acid carbamate, which is then titrated with the strong base tetrabutylammonium hydroxide (TBAH) in a non-aqueous medium. The method is especially suitable for neutral raffinates. Acidic products can falsely indicate values that are too high. In the same way products that contain bases can show values that are too low due to neutralization of the carbamate formed.

In comparison to the formerly used 1-hour boiling under reflux, this automated procedure saves time and is more convenient, and reproducible, as it guarantees that every sample is treated in exactly the same way.

Chloride and organically bound chlorine

Organically bound chlorine present in petroleum products is decomposed at high temperatures and forms hydrochloric acid. This is highly corrosive and can cause damage, for example, to the distillation columns.

Before measurement, the sample is freed of sulfur compounds and inorganic chlorides by distillation and subsequent washing as described in ASTM D 4929. The organically bound chlorine is converted to NaCl with metallic sodium in toluene. After extraction into the aqueous phase, the NaCl is titrated potentiometrically with the Ag-Titrode.

Water determination according to Karl Fischer

Water occurs as a contaminant in virtually all petroleum products. It reduces lubricant properties, promotes microbial oil degradation, leads to sludge formation in the tank, and promotes corrosion of ferrous and nonferrous metals. While water boils and contributes to a partial degreasing at higher temperatures, temperatures below freezing point lead to the formation of ice crystals and a rapid decrease in lubricity. In addition, insulating and transformer oils used in high-voltage engineering become electrically conducting and are therefore rendered useless in the presence of water.

Therefore, it is very important to know the water content of petroleum products. Karl Fischer titration, owing to its excellent reproducibility and accuracy as well as its ease of use, numbers amongst the most important water determination methods and accordingly figures in numerous international standards. Measurement can be performed using volumetric or coulometric Karl Fischer titration. Because of the low water content in petroleum products, KF coulometry is usually applied.

Aliphatic and aromatic petroleum components

Water determination in these products is simple. They usually contain only a small amount of water, therefore coulometric Karl Fischer titration is used. If volumetric titration needs to be carried out, reagents with a low titer must be used. For long-chain hydrocarbons, the addition of a solubility promoter (propanol, decanol, or chloroform) is recommended. In the rare case of interferences by double bonds, one-component reagents should be used.

Hydraulics, insulation, transformer and turbine oils

In these oils the water content is almost always determined coulometrically using a diaphragm cell. Due to the poor solubility in methanol, solubility promoters must be used (chloroform or trichloroethylene). Since these products have very low water contents, it is very important to achieve a low and constant drift value.

Engine oils, lubricating oils, and lubricating greases

The additives frequently present in these oil samples can react with KF reagents and falsify the result. In a KF drying oven, a stream of dry carrier gas transfers the expelled water into the titration cell. Since the sample itself does not come into contact with the KF reagent, interfering side reactions and matrix effects can be excluded. The correct heating temperature lies below the decomposition temperature of the sample and is determined in preliminary tests.

Turpentine and its distillation products

After addition of toluene or xylene, the water contained in these products is transferred through azeotropic distillation by a stream of dry carrier gas to the titration cell where it is determined by Karl Fischer titration.

KF Evaporator

860 KF Thermoprep with 851 Titrando

Petroleum (crude oil, heavy oil)

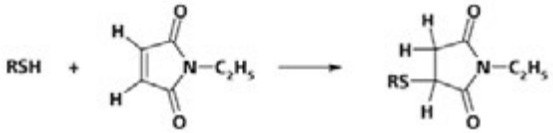
Water is not homogeneously distributed in these products, which means that the petroleum samples must be homogenized before analysis, for example, with the Polytron PT 1300D. Furthermore, crude and heavy oils contain tars that can seriously contaminate electrodes and titration cells. Reagents must therefore be exchanged regularly and the titration cells must be cleaned frequently. To ensure that the sample completely dissolves, solubility promoters are added to the methanol:

- Crude oil (in general): 10 mL methanol + 10 mL chloroform + 10 mL toluene
- Heavy oil: 10 mL methanol + 10 mL chloroform + 20 mL toluene

Fuels

Fuels contain mercaptans which are oxidized by iodine and thus falsely indicate a water content that is too high. The problem is dealt with by adding N-ethylmaleimide, which causes the SH groups of the mercaptan to add to the double bond of the N-ethylmaleimide.

Another option is the separate determination of the mercaptan component by potentiometric titration with silver nitrate. The result of the water determination reduced by this amount corresponds to the actual water content of the sample (1 ppm mercaptan sulfur corresponds to approx. 0.5 ppm water). Normally the water content in fuels is determined by coulometric titration. With volumetric titration, a solubility promoter must be added to the methanol.



Reaction of a mercaptan with N-ethylmaleimide

Mobile water determination with the 899 Coulometer

The water content of instable or hygroscopic samples should be immediately determined. Often, the nearest laboratory is too far away and there there might be no socket around to plug in a power cord either. The compact 899 Coulometer was designed with this scenario in mind. It can be powered by an optional Power Box which contains a set of rechargeable batteries and enables mobile measurements at any conceivable location.

899 Coulometer and optional Power Box for mobile water determinations far away from any power supply

Water as a contaminant in liquefied gases

Water is a contaminant in fuels and its concentration should be as low as possible. Water promotes corrosion and it leads to undesired reactions in the fuel. In the case of liquefied gases, also known as LPG, Liquefied Petroleum Gas, the challenge lies in the sample measurement and the associated phase transition from liquid to gas: In the sample cylinder, an equilibrium is reached between the liquid and gas phase. Depending on the sample, the water content in the gas phase can be several times higher than that of the liquid phase. Therefore, defined sampling is very important to ensure accurate and reproducible results.

875 KF Gas Analyzer – a few technical details

In the 875 KF Gas Analyzer, defined sampling is achieved by using a vaporization unit downstream of the sampling module. This rapidly vaporizes the sample and all the water contained within it. An inlet filter for separation of particles, an oil filter and a mass flow controller (MFC) are also integrated in the instrument: They guarantee precise measurement of the gas flow, even in samples contaminated with oil or stabilizers. For every gas, the MFC is calibrated once using a balance.

Trace determination thanks to coulometry

Thanks to the proven KF coulometer, the water content of liquefied and permanent gases can be determined to an extremely precise and accurate level – even for samples with a very low water content.

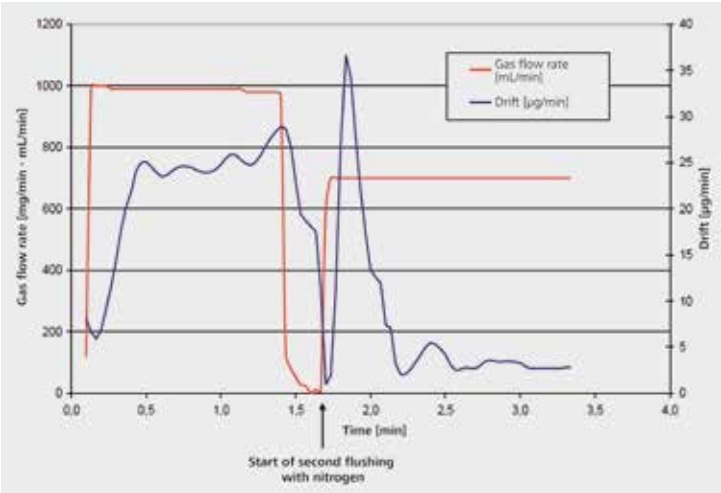
Precise, robust, and fully automatic

The 875 KF Gas Analyzer is designed for routine analysis in the laboratory. The system consists of an operating unit and an analysis module, which is equipped with a base plate to convey the gas and a cell for the water determination. The control and database software ***tiamo***™ controls the magnetic valves, which take care of the fully automatic measurement process.

The 875 KF Gas Analyzer with operating unit and analysis module. An integrated vaporizer, four magnetic valves, and the control and database software ***tiamo***™ enable fully automatic and highly sensitive coulometric water determination in both liquefied and permanent gases.

Water content in natural and liquefied gas

For transport purposes, natural gas is often liquefied to reduce its volume and allow it to be transported without pipelines. Freshly obtained natural gas contains water vapor as a contaminant. This would freeze when the natural gas is compressed and block the valves. Water also lowers the calorific value. Therefore, natural gas is purified and dried before transport. The natural gas drying process can be conveniently monitored with the 875 KF Gas Analyzer. Other applications include determination of the water content in liquefied gas with main components propane and butane as well as in other short-chain hydrocarbons (e.g., according to ISO 10101, DIN 51869).



Typical progress of the gas flow and drift curve when determining the water content in propene. When the sample is introduced, the gas flow begins and the drift increases due to the water content.

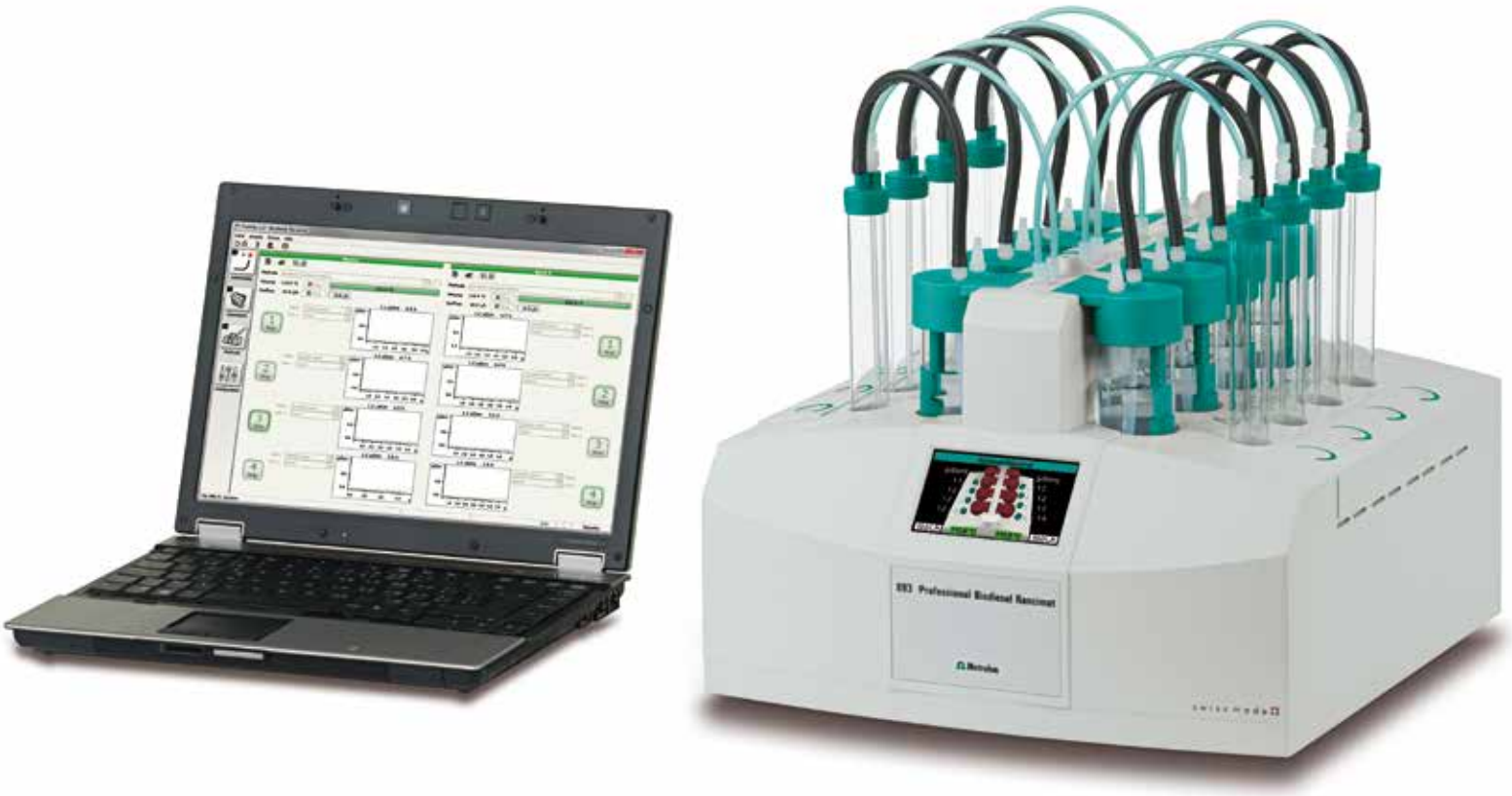
Oxidation stability

If stored in such a way that air has access, petroleum undergoes oxidizing reactions whose reaction products can cause problems in combustion engines. Polymeric, poorly soluble compounds in particular lead to deposits in and blockages of the fuel injector systems. The aging behavior (oxidation stability) is therefore a very important property of petroleum products.

To quantitatively determine the oxidation stability using the Rancimat method, air is passed through the sample at an elevated temperature to bring about artificial aging. During this process, long-chain organic molecules are oxidized by oxygen, whereby highly volatile organic substances form in addition to insoluble polymer compounds. The former are driven out by the air flow, absorbed in water and detected there by measuring the conductivity. The time until formation of these decomposition products occurs is referred to as the induction time or the Oil Stability Index (OSI) and characterizes the resistance of the sample towards oxidative aging processes, i.e., the oxidation stability.

893 Professional Biodiesel Rancimat

The 893 Professional Biodiesel Rancimat enables simple and reliable determination of oxidation stability in petroleum products and biodiesel. Up to eight samples can be measured simultaneously. The instrument is controlled via a PC; the computer software records the measurement curves, automatically evaluating them and calculating the result.



Important applications

Biodiesel and biodiesel blends

Biodiesel (FAME, fatty acid methyl esters) is usually produced from oilseeds by transesterification with methanol. It is being added more and more to mineral diesel as a blending component. Vegetable oils and methyl esters of fatty acids are relatively unstable under storage conditions since they are oxidized by atmospheric oxygen. Just as with oxidation of petroleum, polymer compounds can be formed that can cause damage to engines. For this reason, oxidation stability is an important quality criterion for biodiesel and vegetable oils that must be monitored regularly during production according to EN 14112. The corresponding method for biodiesel blends is described in EN 15751 and EN 16568. The addition of suitable antioxidants slows down the oxidation process. The 893 Professional Biodiesel Rancimat also enables the effectiveness of antioxidants to be determined.

Ultra-low-sulfur diesel fuel

As a result of environmental protection concerns and technical requirements for motor vehicle manufacturers, ultra-low-sulfur diesel fuel is appearing more and more on the market. This mineral diesel fuel with a sulfur content of at most 10 ppm (EU) or 15 ppm (USA) is oxidized considerably more easily than the formerly used diesel fuels with a higher sulfur content. This means that oxidation stability has also become an important parameter for fuel production. The 893 Professional Biodiesel Rancimat enables easy assessment of oxidation stability.

Biologically easily degradable lubricating oils

Biologically easily degradable lubricants can also be manufactured from natural fat and oils. Like the raw material, these products are also susceptible to oxidation.

Light fuel oil

Alongside other methods, the Rancimat method is also used for assessing the oxidation stability of light fuel oil. In order to accelerate the reaction, metallic copper is added to the fuel oil sample to act as a catalyst.

Ion chromatographic analyses

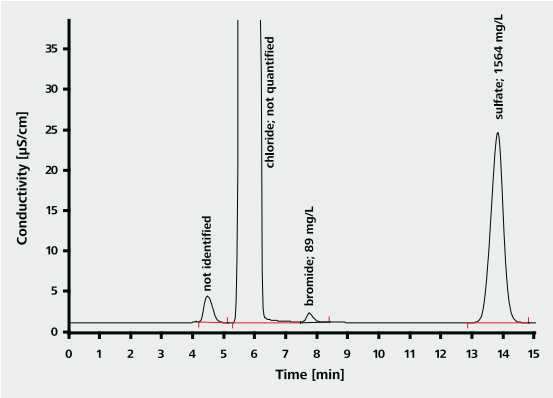
The quality assurance of petroleum products involves numerous applications of ion chromatography in which inorganic and low-molecular organic ions are determined in fuels, lubricating oils, gas-washing solutions, and the so-called «produced water» that is a by-product of crude oil drilling.

Anions and cations in «produced water»

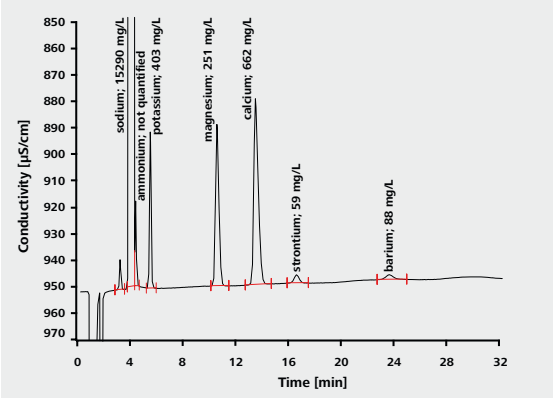
During oil and gas production, large quantities of «produced water» are transported to the surface. In addition to oil drops and dissolved organic components, «produced water» contains large amounts of inorganic cations such as calcium, magnesium, barium, and strontium as well as anions such as carbonate, bromide, and sulfate. The resulting salts can cause scaling and ultimately block the piping. For this reason, the determination of inorganic components is of essential importance, not least for the correct dosing of scale inhibitors.

Robust analyzers

Since determinations occur not only on-shore, but also off-shore, as for example on drilling rigs, robust analyzers that do not need to be serviced frequently are required. This is offered by the 930 Compact IC Flex in combination with the 919 IC Autosampler plus. The system can also be equipped with Metrohm's patented Inline Dialysis system. The intelligent MagIC Net chromatography software assumes control of the device, the data management and the system monitoring, and can, if necessary, be configured as «One-button IC» for shift personnel.



Anions in «produced water»; column: Metrosep A Supp 4 - 250/4.0; eluent: 1.8 mmol/L Na_2CO_3, 1.7 mmol/L $NaHCO_3$, 1.0 mL/min; sample volume: 20 µL; sample 1:20 diluted



Cations in «produced water»; column: Metrosep C 4 - 150/4.0; eluent: 3.0 mmol/L oxalic acid, 3% acetonitrile, 0.9 mL/min; sample volume: 10 µL; sample dilution 1:100

930 Compact IC Flex in combination with 919 IC Autosampler plus, optionally equipped with Inline Dialysis

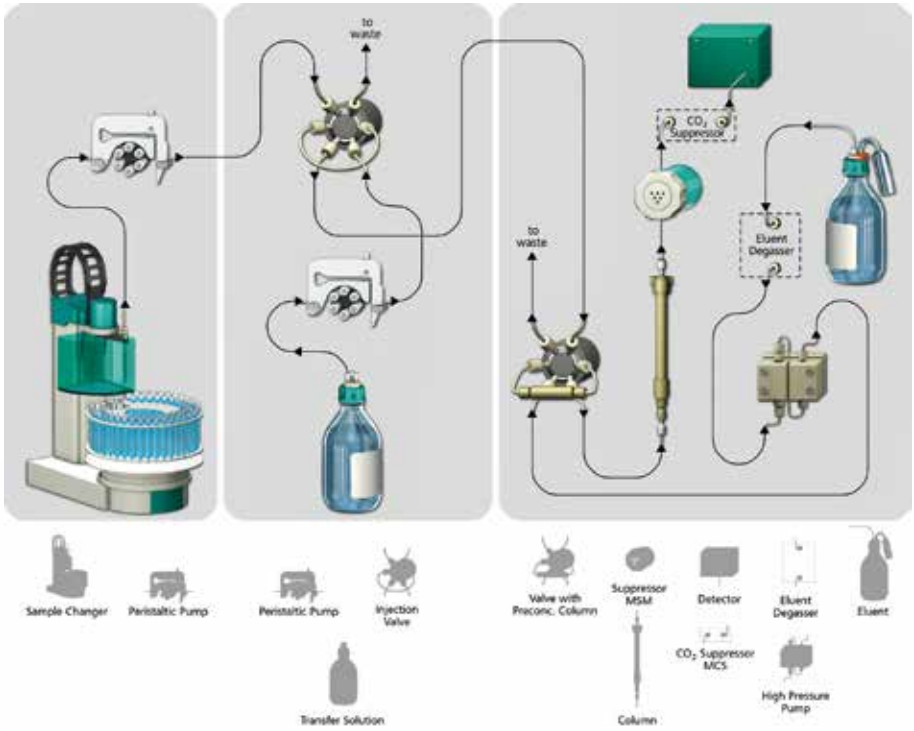
Anions in gasoline-ethanol blends

The use of energy from renewable sources and the associated reduction of greenhouse gases is one of the most pressing goals of our modern industrial society. Ethanol manufactured from waste and renewable plant material, which can be mixed with conventional gasoline in any proportion, is regarded as one of the most promising alternatives. Contaminants in the form of inorganic salts, however, impair engine performance, which is why international standards now specify the chloride and sulfate content of gasoline-ethanol blends in particular.

Additional IC applications for petrochemistry
• Halogens and sulfur in liquefied natural gas (LNG) and liquefied petroleum gas (LPG)
• Halogens, sulfur, and organic acids in crude oil, gasoline, kerosene, heating oil, and coal (ASTM D 7359)
• Sulfur compounds in amine absorbers (HSS, Heat Stable Salts)
• Amines in various matrices from refineries and petrochemical operations
• Anions, cations, and amines in process and waste water samples and absorption solutions
• Alkali, alkaline earth and transition metals as well as anions in cooling liquids, e.g., monoethyleneglycol «MEG» (ASTM E 2469)
• Anions in emulsions from drilling oils
• Anions and cations in biofuels and fuel blends
• Anions, cations, and organic acids in water which is used for the fracking process

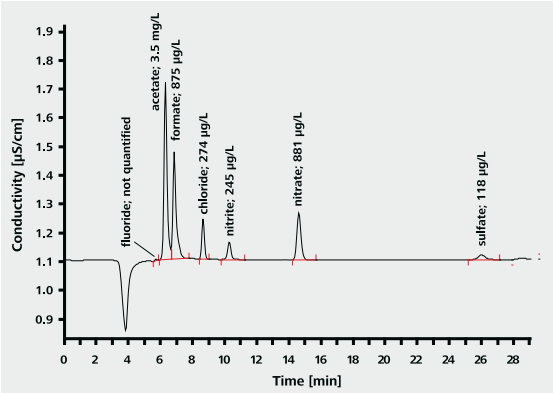
Simple matrix elimination

The anions to be determined are freed from the interfering fuel matrix by Metrohm Inline Matrix Elimination. For this purpose, the fuel is injected directly onto a high-capacity preconcentration column. While the anions are retained on the column, the fuel matrix is removed from the preconcentration column using a rinsing solution. Then, the anions are eluted onto the analytical column. This method allows the additional determination of acetate and formate.



Schematic representation of Metrohm Inline Matrix Elimination

Anion system with Metrohm Inline Matrix Elimination



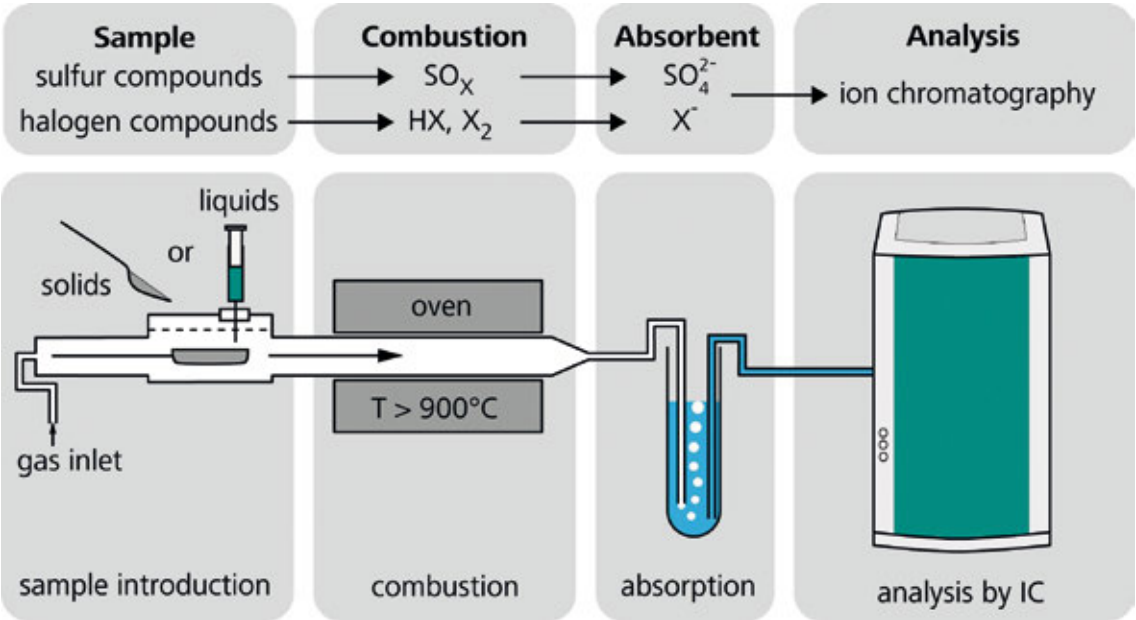
Anions in an E85 gasoline-ethanol blend (85% ethanol, 15% gasoline); column: Metrosep A Supp 7 - 250/4.0; eluent: 3.6 mmol/L Na_2CO_3, 7.5% acetone, 0.8 mL/min; column temperature: 45 °C; sample volume: 10 µL; matrix elimination: transfer solution 7.5% acetone, sample enrichment with Metrosep A PCC 1 HC/4.0

Combustion ion chromatography

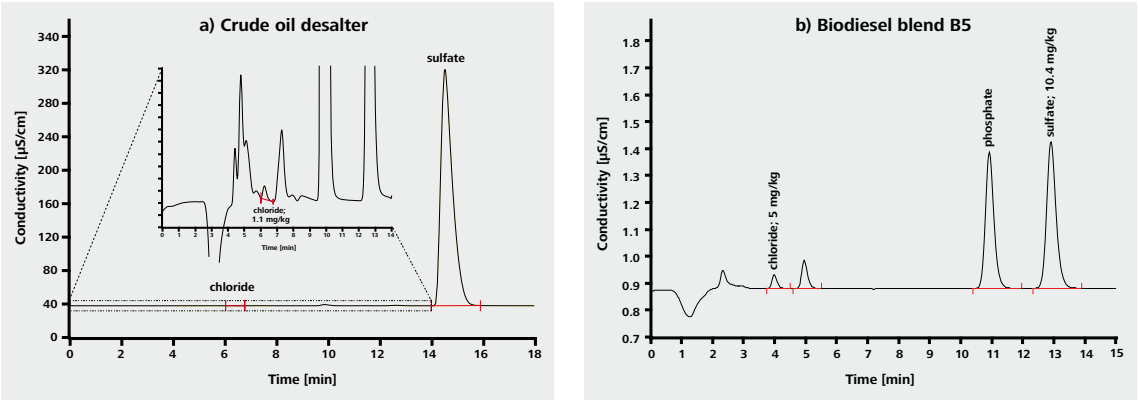
The burning of sulfur-containing fuels leads to the emission of air-polluting sulfur oxides into the atmosphere. Furthermore, high sulfur concentrations have an adverse effect on the ease of ignition of fuels and their stability during storage. Halogen concentrations in the refinery process must also be analyzed due to the corrosion risk. As a result, a fast and reliable method for determining the halogen and sulfur contents is required.

Combustion IC enables the sulfur and halogen content in combustible solids, liquids, and gases to be determined by combining combustion digestion (pyrolysis) with subsequent ion chromatography. It can be fully automated and excels in its high sample throughput, large measuring range, and excellent precision and accuracy.

The Combustion Ion Chromatography system includes an 930 Compact IC Flex, a 920 Absorber Module, and a Combustion Module from Analytik Jena equipped with Autosampler MMS 5000.



In combustion digestion (pyrolysis), sulfur compounds are converted into sulfur dioxide, and halogen compounds are converted into hydrogen halides and elemental halogens. These gaseous combustion products are fed into an oxidizing absorption solution and detected as sulfate and halide by way of the ion chromatography that follows.



Determination of the chlorine and sulfur content by Combustion IC in a) crude oil desalter output sample and b) B5 biodiesel blend; column: Metrosep A Supp 5 - 150/4.0; eluent: 3.2 mmol/L Na_2CO_3, 1.0 mmol/L $NaHCO_3$, 0.7 mL/min; column temperature: 30 °C; sample volume: 100 µL

Voltammetry

Voltammetric trace analysis is used for determining electrochemically active substances. These can be inorganic or organic ions or even neutral organic compounds. Voltammetry is often used for supplementing and validating spectroscopic methods and is characterized by a minimum amount of equipment, comparably low investment and operating costs, short analysis times, and a high accuracy and sensitivity. In addition, unlike spectroscopic methods, voltammetry can distinguish between different oxidation states of metal ions as well as between free and bound metal ions. This is referred to as speciation analysis.

Broad application range

Voltammetric measurements can be carried out both in aqueous solutions and in organic solvents. Heavy metal determinations are usually carried out in aqueous solutions after digestion of the sample.

Voltammetry is particularly well-suited to laboratories in which only a few parameters need to be monitored in combination with a moderate sample throughput. It is frequently used for special applications which cannot be performed using other techniques or only with a great deal of effort.

797 VA Computrace

The 797 VA Computrace is a modern measuring stand for use in voltammetric and polarographic determinations. The analyses can be easily automated by adding Dosinos and a sample changer.

Some application examples

Elemental sulfur in gasoline

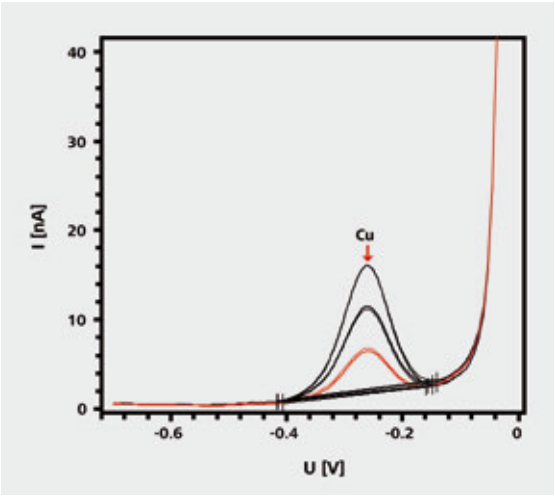
The total sulfur content in petroleum products is widely defined by law and is therefore routinely controlled. It is also of interest to see in which form the sulfur is actually present. By using voltammetry, the proportion of elemental sulfur can be determined directly and simply. In this way, inferences can be drawn about the influence of gasoline on corrosion processes, for example, regarding sensors in the fuel tank.

Copper in ethanol

Ethanol is increasingly used in gasoline as a blending component. Contaminants can cause problems in the engine. For example, traces of copper catalyze the oxidation of hydrocarbons. As a consequence, polymer compounds can form which can lead to deposits and blockages in the fuel system. Using voltammetry, copper can be measured without any sample preparation in pure ethanol or ethanol-gasoline blends (E85, 85% ethanol + 15% gasoline) in the range between 2 µg/kg and 500 µg/kg.

Heavy metals in petroleum products

The determination of heavy metals in petroleum products by voltammetry is usually carried out after digestion. The samples are mineralized by microwave digestion or combusted. Alternatively, the metal ions can be determined after extraction with a mineral acid.



Voltammetric determination of copper

Corrosion

Corrosion – a universal problem
All industries which work with materials that are susceptible to corrosion have to fight this form of electrochemical decay. Contact and pitting corrosion are particularly problematic: they have a negative impact on the mechanical properties of the material without causing obvious changes.

Petrochemistry – an easy target for corrosion
Corrosion is common in the petrochemical industry, particularly in the areas of production, transport, and refinery. The chemical composition of the raw materials, high pressure, and high temperature along with the use of salt water all promote corrosion.

Electrochemistry in corrosion research
Corrosion not only leads to increased production costs, it also represents a constant danger for man and machine. To prevent it, it is essential to have an in-depth understanding of the corrosion process. As corrosion is an electrochemical process, it is best described using electrochemical methods. These are described in depth in numerous specialist publications as well as many international standards.

Linear polarization and impedance spectroscopy
Metrohm Autolab offers a complete product range for investigating the corrosion properties of materials, both for pure and applied research. A common feature of all methods is that they relate to the interface between the material and the corrosive environment and that they can be easily adapted to suit the analytical problem in question. The measuring instruments from Metrohm Autolab use a variety of different electrochemical methods, primarily linear polarization and electrochemical impedance spectroscopy (EIS).

Fast, accurate and standard-compliant: PGSTAT204
Together with the FRA32M impedance analyzer module and the ASTM-compliant 1 L corrosion cell, the Autolab PGSTAT204 is ideal for carrying out fast and accurate corrosion measurements.

The Autolab PGSTAT204 and corrosion cell for corrosion research

Fuels change the corrosion behavior

The corrosion resistance of storage tanks, process lines, and pipelines is a key material prerequisite for the storage and transport of fuels. Fuel-conveying materials, in particular, can suffer considerable damage due to stress corrosion cracking (SCC) and microbial-induced corrosion (MIC). In comparison to fossil fuels, biodiesel exhibits a higher risk of corrosion.

The material-fuel interface (substratum)

Electrochemical methods allow you to easily and conveniently determine the corrosion resistance of various materials in contact with fuels. The Autolab PGSTAT100N potentiostat/galvanostat together with the FRA2 impedance analyzer module is a powerful analysis system with several preprogrammed methods. It allows you to effectively detect corrosion processes occurring on the conductive material-fuel interface by linear polarization or electrochemical impedance spectroscopy.

The Autolab PGSTAT100N – a potentiostat/galvanostat for carrying out electrochemical determination (max. 100 V compensation voltage) in matrices with low conductivity

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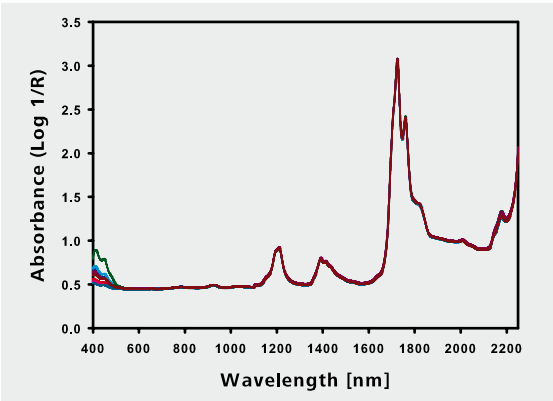
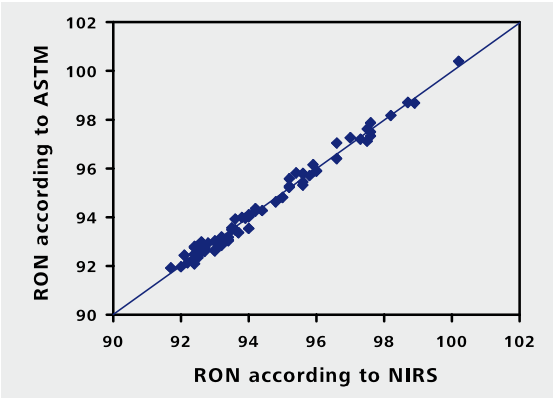
Near-infrared spectroscopy

NIRS – interaction of light and physical matter

Near-infrared spectroscopy (NIRS) is based on the absorption of radiation by matter. Molecular vibrations are induced in the near-infrared region of the electromagnetic spectrum (800–2500 nm) – i.e., from the end of the visible to the mid-infrared (MIR) range. The main absorption bands of the functional groups of chemical substances are located in the MIR range and are very strong. The absorption bands of the harmonics, however, and the combinations of the fundamental molecular vibrations are in the NIR spectral region. They are significantly weaker and allow direct measurement without sample preparation. This enables in-depth insight into the chemical and physical properties of the sample. The strongest overtone absorptions in the NIR range are displayed by OH, CH, NH, and SH compounds. An NIR spectrum is the result of numerous overlapping absorption bands; evaluation is therefore carried out using multivariate chemometric methods.



NIR spectra of diesel fuel samples



Calibration model for quantitative determination of the research octane number (RON). The RON determined according to ASTM D 2699 is plotted against the RON determined by NIRS.

Advantages of NIRS analysis in petrochemistry

Near-infrared spectroscopy has been successfully used in oil refineries for years, as shown by the example of monitoring the blending of a range of fuels. NIRS detects numerous parameters in a single measurement in less than a minute. The cost savings are enormous. Further advantages are:

- short response times and fast quality control
- improved product quality and process optimization
- reduced investment, analysis, and maintenance costs
- accurate and precise measuring results.

From the laboratory to the process

Initially, NIRS analysis was used purely for offline determinations in the laboratory, however, as it matured technically, its potential for use in the harsh process environment was recognized, especially for online and inline monitoring.

The NIRS XDS Rapid Liquid Analyzer can analyze petrochemical samples either offline in the laboratory or atline. The measurement can be made in cuvettes or vials.

Real-time monitoring with NIRS process analyzers

NIRS process analyzers guarantee real-time monitoring of the sample flow in the process and thereby enable optimum product quality.

Robust and versatile

NIRS is an extremely robust and versatile method that is suitable for all sample types, from clear solutions and suspensions through to solids. By selecting a suitable fiber-optic interface, the process analyzer can be perfectly adjusted to suit the required application. Single-Fiber, MicroBundle, and DirectLight/NonContact are available.

NIRS for optimizing refinery processes

In order to refine crude oil and natural gas into diverse petrochemical products, complex processes are required, from crude oil distillation, cracking, and desulfurization to reforming. All these processes rely on NIRS analysis – whether to determine characteristics or the composition of petroleum products.

Where	What		
Crude oil distillation	• API gravity[1] • Density • Distillation of crude oil (TBP[2])	• PIANO[3] • Reid vapor pressure (RVP)	
Cracking and reforming	• API gravity • Distillation analysis[4]	• PIANO • Reid vapor pressure	
Lubricating oil	• Aromatic content • Density • Distillation analysis	• Flash point • Nitrogen • Oil content	• PAH[5] • Pour point • Viscosity
Gasoline blends	• API gravity • Alcohols & ether (MTBE, etc.) • Alkene content • Aromatic content	• Benzene content • Density • Motor octane number (MON) • Octane index number	• Research octane number (RON) • Reid vapor pressure
Diesel blends	• Boiling point • Cetane number • Cloud point • Color	• Cold filter plugging point (CFPP)[6] • Density • FAME[7] content	• Flash point • Pour point • Specific weight • Viscosity
Mobile fuel analysis «On-site testing»	**Diesel** • Cetane number • Density • Distillation analysis	• FAME content • Flash point • Viscosity	**Gasoline** • Alcohols & ether • Aromates • Alkenes • BTX[8] • Density • Octane rating

[1]Degree of density according to the American Petroleum Institute (API)
[2]True Boiling Point distillation
[3]Paraffins, Isoparaffins, Aromatics, Naphthenes, or Olefins (alkenes)
[4]Boiling behavior according to ASTM D 86: verification by NIRS
[5]Polycyclic Aromatic Hydrocarbons
[6]Cold Filter Plugging Point
[7]Fatty Acid Methyl Ester (FAME)
[8]Benzene, Toluene, Xylene

Atline, online, and inline analysis systems from Metrohm Applikon

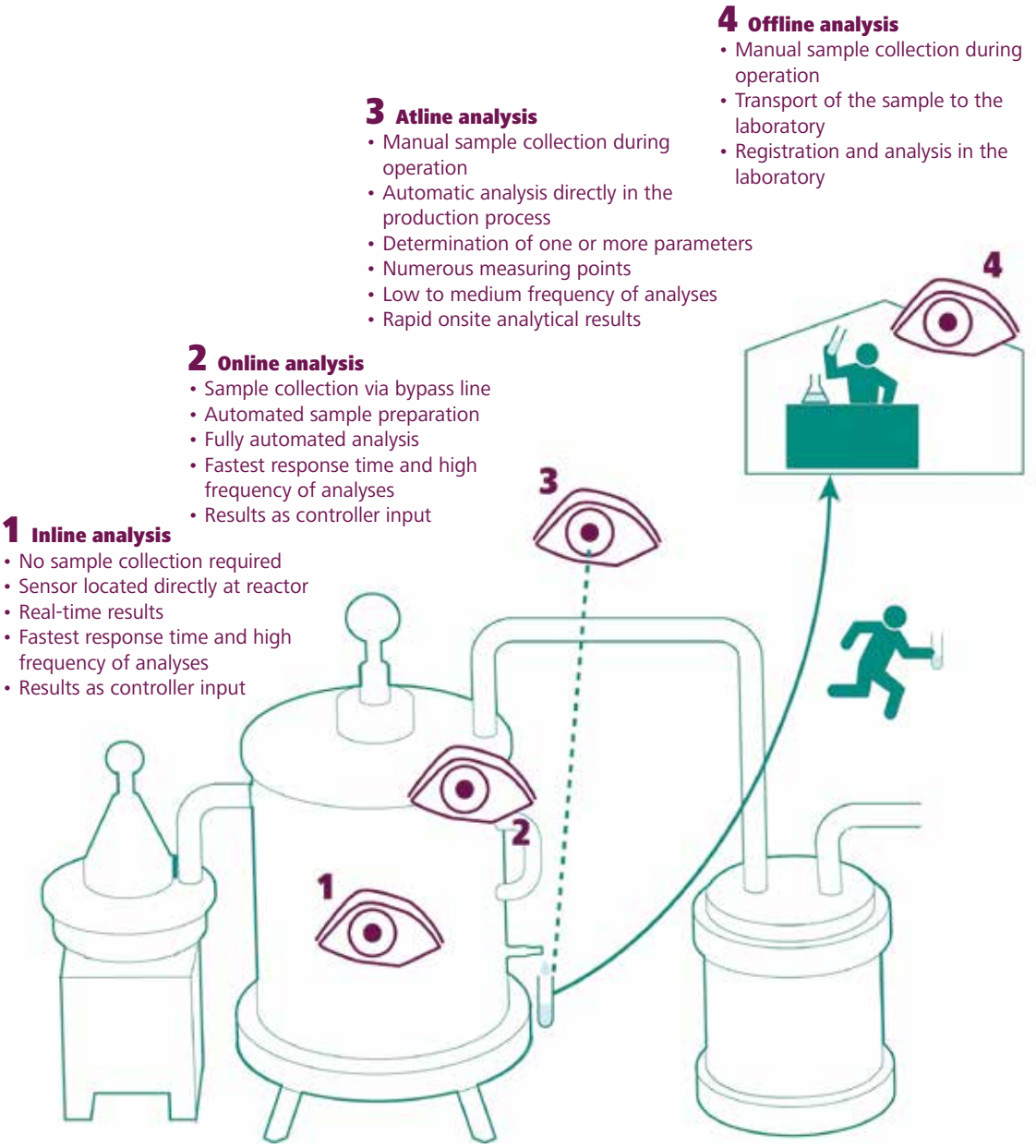
Atline, online, and inline analysis systems from Metrohm Applikon are the preferred solution for process monitoring in a wide range of industries. Reliable analysis results are determined directly in-process with the latest methods of ion analysis and spectroscopy: measurement of pH value, conductivity, redox potential and TOC, as well as titration, Karl-Fischer titration, photometry, ion-selective electrode measurement (dynamic standard addition), ion chromatography, voltammetry, and near-infrared spectroscopy.

Metrohm Applikon is an inline, online, and atline analysis specialist with more than 35 years' experience in the field.

We offer a broad program of process analyzers and sample preparation systems for a large array of applications in a wide number of industries.

Metrohm Applikon – globally present

Metrohm Applikon is part of the Metrohm Group supporting you globally with offices in 45 countries. Our specialists offer you advice during the planning and development of your own custom-designed analysis system, commission the system, and provide professional maintenance and service during routine operations (see pages 36–37).



ProcessLab ADI 2045PL – atline routine analysis in production

The ProcessLab ADI 2045PL is by far the most robust routine system for atline analysis in everyday use in the plant and in control labs. Metrohm Applikon's 35 years experience with online analysis has resulted in a new system for custom-made atline process measurements.

The ProcessLab ADI 2045PL guarantees the highest level of reliable analytical results. The new ProcessLab Manager software offers a user-friendly interface in combination with the well-proven ***tiamo***™ lab software.

Determination of acid and base numbers

The determination of the acid and base numbers is of essential importance for the quality control of petroleum products. The acid number records components that react acidically as a sum parameter and allows conclusions regarding the corrosion of plant or engine components. Over the longer term, petroleum products with high base numbers offer protection from the corrosive influence of any generated acids. By measuring sum parameters, product alterations can also be quickly and directly recorded during use.

The determination of acid and base numbers is carried out automatically in the ProcessLab by potentiometric titration in nonaqueous solvents. Because of its proximity to the process, the analytical results are available within minutes.

Production of standard mixtures with a defined octane rating

The octane rating is a measure of a gasoline's resistance to engine knock. In order to assess the octane rating, the resistance to engine knock of a gasoline sample is determined in comparison with standard mixtures showing a predefined octane rating. The standard mixtures, consisting of n-heptane, isooctane (2,2,4-trimethylpentane), and toluene, must be prepared with the highest accuracy and precision. ProcessLab is ideal for this thanks to its range of options for liquid handling. The automatic production of dilutions and dilution ranges as well as the doping of additives can be carried out easily. The production of test mixtures is precisely documented and the report can be used as a certificate.

In the same way, standard mixtures can also be prepared for measuring cetane numbers with diesel fuels.

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Online and inline process analysis: wet chemistry

Online process analyzers

In the (petro)chemical industry, continuous control of the production process, the quality of the product and the composition of any waste streams is of utmost importance. With the online process analyzers from Metrohm Applikon, this is possible 24 hours a day, 7 days a week. The analyzers are used directly on-site, as close as possible to the process, and run completely stand-alone without operator intervention. The Metrohm Applikon analyzers are based on wet-chemical analysis techniques such as titration, colorimetry, or ion-selective electrode measurements. Analyzers are available for single method, single-stream purposes as well as for complex multiple methods and multiple streams.

Importance of sampling

In online analysis, sampling and sample preparation are at least as important as the analyzer itself. Metrohm Applikon has a lot of expertise in this area and is capable of offering custom-made sampling systems, for example, for pressure reduction, filtering, and degassing.

Powerful interfaces

Analysis alone is of no use for process control, and that is why the analyzers are all equipped with possibilities for digital as well as analog outputs. Results, for example, can be transferred via 4–20 mA outputs, whereas alarms can be transmitted via digital outputs. Digital inputs, in turn, can be used for remote start-stop purposes.

Explosion-proof systems for petrochemistry

In many cases, the IP66-NEMA4 housing of the analyzers will be sufficient. In some cases in the petrochemical industry, however, explosion-proof systems are required. For those circumstances, the ADI 2045TI analyzer is available in a stainless-steel explosion-proof version for Zone I or Zone II according to the European explosive atmosphere directives (ATEX).

ADI 2045TI Online Analyzer

Many of the analysis methods that are used in the laboratory can be transferred to an online analyzer. Typical applications are:

Water content

A very important factor in quality control of the petrochemical industry is the determination of the water content in oil. A water content that is too high has a negative impact on the oil quality. As in the laboratory, Karl Fischer titration (coulometry) is the method of choice for the online determination of the water content in any oil product.

Cuvette module for photometric measurements

Salt in crude oil

Excessive amounts of chloride salts in crude oil result in higher corrosion rates in refining units and have a detrimental effect on the catalysts used. Desalting techniques are well established, but continuous monitoring of the salt content is needed for process control and cost reduction. With the ADI 2045TI equipped with special heavy duty sample valves, the salt content can be monitored by measuring the conductivity or by titration. After each analysis, the measurement vessel is cleaned and a blank measurement is performed before the next sample is taken. For this type of application, the analyzers are configured in an explosion-proof housing.

Sampling system for determining the water content in hydrocarbons

Hydrogen sulfide and mercaptan determination

Sulfur compounds in oil and oil products cause corrosion and pose an environmental hazard. Determination of H2S as well as mercaptans is done by titration with silver nitrate using a sulfide-coated silver electrode serving as the indicator electrode.

TBC in styrene

In styrene production, the addition of 4-tert-butylcatechol (TBC) as a stabilizer is critical to prevent the styrene from polymerization during storage and transport. TBC levels need to be maintained above 10–15 mg/L. The problem is that the TBC concentration in styrene will slowly decrease in the presence of oxygen. By using an ADI 2045TI with colorimetric technique, TBC levels can be monitored continuously to maintain the concentration at the proper level.

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Online and inline process analysis: NIRS

NIRS – from the laboratory to the process
With progressive technological development, NIRS has increasingly established itself as an in-process technology. Just a few decades ago, many users were put off by the range of information combined in a spectrum: the spectra were considered unclear and were hard to interpret using classical methods. This view changed dramatically with the arrival of powerful computers. The enormous potential of NIR spectroscopy was recognized, particularly for process applications.

Several parameters – with just one measurement
Today, NIRS is a robust and extremely versatile method, which enables simultaneous, real-time monitoring of diverse process parameters with just one measurement. Fiber-optic data transfer means that the measuring instrument and measuring cell can be spatially separated – even by hundreds of meters if required. This is a huge advantage, especially in environments with high explosion protection requirements, such as petrochemistry.

Numerous measuring points – with just a single instrument
Metrohm process analyzers are real multitaskers: 4 or even 9 measuring points can be connected (multiplexing) to a single measuring instrument.

NIRS: the key to process understanding
To optimize a process, you need to understand it. You need to know as much as possible about it and this is only possible when you are in the middle of the action.

NIRS is in the thick of it. Everything is available at a glance, in a matter of seconds, thanks to sensitive sensors which are directly atline or inline. There is no need for complex finals checks. NIRS is also nondestructive, and requires no sample preparation.

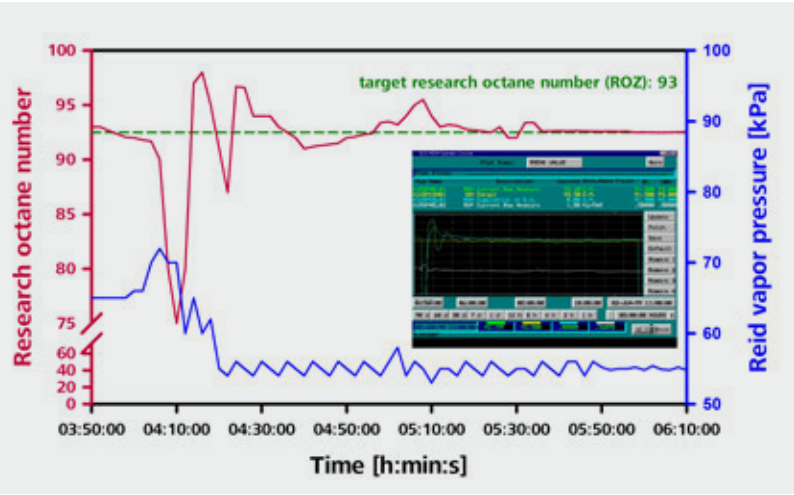
Real-time monitoring of the sample stream
NIRS is now an essential part of process control in petrochemistry. The key properties of petroleum products can be tracked directly in-process, whether it be the water content, flash point, or cold filter plugging point. The same applies to the chemical composition of the petroleum product during fractionation: from aromatics, alcohol, and ether to BTEX or FAME content in biodiesel, the composition can be determined in a matter of seconds.

Key characteristics such as the octane rating, cetane or hydroxyl number are also easy to track live. The same applies to physical parameters such as density, viscosity, or vapor pressure.

The NIRS XDS Process Analyzer (left) and the NIRS Analyzer PRO allow real-time analysis within seconds from process flows or batch reactors.

Blending process: straightforward with NIRS

During the blending process, different fractions of the crude oil distillation are mixed together so as to produce the ready-to-sell diesel or gasoline grades. This is most economical when it is carried out in process systems that work online and can be automated. The endpoint of the blending process is reached when the required fuel specifications are achieved. Key characteristics which indicate the progress of the blending process are the cetane number for diesel blends and one of the octane ratings for gasoline blends. NIRS sensors located directly in the process enable the entire process to be controlled and ensure a high-quality end product. Additional parameters can also be monitored in parallel and inline depending on the application.



Process image of the Research Octane Number (RON) and Reid vapor pressure control parameters determined during the blending process of gasoline using NIRS. Both parameters can be tracked simultaneously via the live view on the control panel (the black/green section between the two trend curves).

Service you can rely on: Metrohm Quality Service

Reliable measurement results during the entire lifetime of the instrument

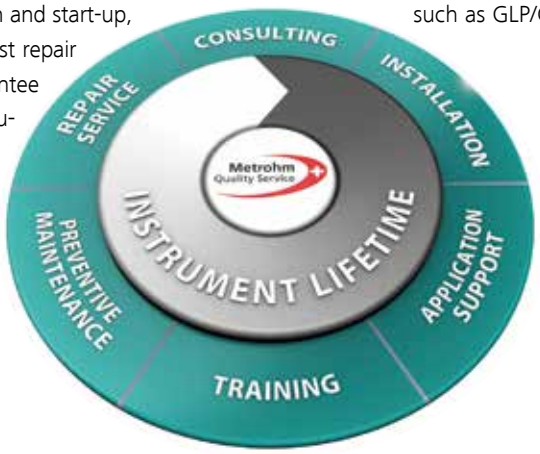
From the production of the crude oil to the refining process and the quality control of the final products, chemical analysis is in constant demand in the oil industry. Those responsible for the accuracy of the results in the laboratory must not make compromises. Be ensured that systems installed and maintained by professionals on a regular basis eliminate threats of instrument failure and profit loss.

With Metrohm Quality Service you are on the safe side from day one. From installation and start-up, to regular maintenance and fast repair – if problems arise – we guarantee that you can rely on your instrument and gain maximum uptime from your instrument.

Metrohm Compliance Service

You can trust Metrohm Compliance Service when it comes to the professional qualification of your analyzers. Installation Qualification/Operational Qualification (IQ/OQ) or Certified Installation (CI) saves you time and money because we configure the system according to your requirements and ensure quick and reliable commissioning.

User instructions lay the foundations for safe, error-free operation. The Metrohm Compliance Service also includes comprehensive documentation and guarantees compliance with the standards of quality management systems such as GLP/GMP and ISO.



Metrohm Quality Service

Metrohm's global Quality Service, and regularly scheduled preventive maintenance in particular, extends your instrument's lifetime and ensures trouble-free operation. Maintenance work is carried out by qualified and certified service engineers. You have the option of selecting different types of service contracts depending on your particular need. With a Total Care Contract, for example, you can rely on the optimum performance of your Metrohm instruments at all times, incurring no additional costs whatsoever and benefit from complete and compliant documentation.

Metrohm Quality Service	Customer benefits
Metrohm Care Contracts	• Minimizes downtime through preventative maintenance • Cost control and savings through free or discounted replacement materials and consumables • Guaranteed reaction times and rapid on-site repair • Documented instrument certification as an ideal preparation for audits
Metrohm Software Care	• High data security and maximum system performance through regular, professional software maintenance
Metrohm Compliance Service	• Customized services and documentation for analytical instrument qualification (AIQ) • Professional start-up (IQ/OQ or Certified Installation) and requalification or recertification by specifically trained employees
Metrohm Remote Support	• Quick resolution of software and application issues directly at the workplace
Metrohm Dosing Test	• Calibration of burettes (e.g., dosing and exchange units) with certification • Accurate measurement results • Verification documentation for compliance with regulations and efficient audits
Metrohm Repair Service	• Rapid availability of repaired instruments thanks to decentralized repair workshops around the world and a central workshop at the manufacturer site • Highly qualified service technicians ensure sustainable repair success • Rapid resolution of problems and minimized downtimes through on-site emergency services and express repairs
Metrohm Spare Parts	• Original spare parts, made in Switzerland and available worldwide • Short delivery times through warehousing from local distributers • Investment security through ten-year spare parts guarantee after discontinuation
Metrohm Application Support	• Access to Metrohm Applications expertise (Application Bulletins, Application Notes, monographs, technical posters and specialized articles) • Rapid and professional resolution of any application issues through personal consultations with our specialists by e-mail, telephone, or remote support • Support for the solution of complex analytical problems, as well as method optimization on-site or at our application laboratory
Metrohm Training Programs	• Basic and advanced training with local representatives, at the Metrohm Academy or directly on-site • Efficient and proper use of all analytical methods, as well as results reliability through competently trained users • Training documentation and certificates for trouble-free audits

Metrohm
Quality Service

Ordering information

Titration

2.848.3010	Oil Titrino plus
2.905.3010	Oil Titrando
2.916.3010	Oil Ti-Touch
2.855.2010	Robotic TAN/TBN Analyzer
2.864.1130	Robotic Balance Sample Processor TAN/TBN
6.0229.010	Solvotrode easyClean, 1 m cable
6.0229.020	Solvotrode easyClean, 2 m cable
6.0430.100S	Ag-Titrode with Ag_2S coating
6.1115.000	Optrode
6.6040.00X	«Oil PAC» application collection

Water determination according to Karl Fischer

Coulometric KF titration

2.831.0010	831 KF coulometer including generator electrode with diaphragm and 728 Stirrer
2.831.0110*	831 KF coulometer including generator electrode without diaphragm
2.756.0010	756 KF coulometer with built-in printer including generator electrode with diaphragm and 728 Stirrer
2.756.0110*	756 KF coulometer with built-in printer including generator electrode without diaphragm
2.851.0010	851 Titrando including generator electrode with diaphragm and 801 Stirrer
2.851.0110*	851 Titrando including generator electrode without diaphragm
2.852.0050	852 Titrando including generator electrode with diaphragm and 801 Stirrer
2.852.0150*	852 Titrando including generator electrode without diaphragm
2.899.0010	899 Coulometer with built-in stirrer including generator electrode with diaphragm
2.899.0110	899 Coulometer with built-in stirrer including generator electrode without diaphragm
2.875.9020	875 KF Gas Analyzer with TFT monitor (incl. ***tiamo***™)
2.875.9050	875 KF Gas Analyzer without TFT monitor (incl. ***tiamo***™; monitor and keyboard are required)

* The magnetic stirrer has to be ordered separately.

Volumetric KF titration

2.870.1010	870 Titrino plus complete
2.890.0110	890 Titrando with Touch Control
2.901.0010	901 Titrando including titration cell and indicator electrode
2.915.0110	915 Ti-Touch with built-in stirrer

Sample preparation

2.136.0100	Polytron PT 1300 D
2.860.0010	860 KF Thermoprep
2.874.0010	874 Oven Sample Processor
2.885.0010	885 Compact Oven Sample Changer
2.136.0200	KF Evaporator

Voltammetry

2.797.0010	797 VA Computrace for manual operation
MVA-2	VA Computrace System with automatic standard addition. Consisting of 797 VA Computrace with two 800 Dosinos.
MVA-3	Fully automated VA Computrace system consisting of 797 VA Computrace with 863 Compact VA Autosampler and two 800 Dosinos for the automatic addition of auxiliary solutions. Allows the automatic processing of up to 18 samples. This system is the optimum solution for automated analysis of small sample series.

Oxidation stability

2.893.0010	893 Professional Biodiesel Rancimat (230 V) including software and accessories

Ion chromatography

Anions and cations in «produced water»

2.930.2560	930 Compact IC Flex SeS/PP/Deg
2.930.2160	930 Compact IC Flex Deg
2.850.9010	2 × 850 Conductivity IC Detector
2.919.0020	919 IC Autosampler plus
6.1006.430	Metrosep A Supp 4 - 250/4.0
6.1050.420	Metrosep C 4 - 150/4.0
6.6059.302	MagIC Net 3.0 Professional

Options

6.5330.100	IC equipment: Inline Dialysis
2.858.0030	858 Professional Sample Processor – Pump – Injector
2.800.0010	800 Dosino
6.5330.190	IC equipment: Dosino Regeneration
6.5330.130	IC equipment: Liquid Handling Station
6.2041.440	Sample Rack 148 × 11 mL

Anions in gasoline-ethanol blends

2.940.1500	940 Professional IC Vario ONE/SeS/PP
2.850.9010	IC Conductivity Detector
2.858.0030	858 Professional Sample Processor – Pump – Injector
6.2041.390	Sample Rack 16 × 120 mL
6.1006.630	Metrosep A Supp 7 - 250/4.0
6.1006.310	Metrosep A PCC 1 HC/4.0
6.6059.302	MagIC Net 3.0 Professional

Options

2.800.0010	800 Dosino
6.3032.210	Dosing unit 10 mL
6.5330.130	IC equipment: Liquid Handling Station

Combustion IC

2.930.9010	Metrohm Combustion IC
6.1006.520	Metrosep A Supp 5 - 150/4.0

Near-infrared spectroscopy – laboratory, atline

2.921.1410	NIRS XDS RapidLiquid Analyzer
2.921.1520	NIRS XDS Interactance Optiprobe Analyzer
2.921.1520	NIRS XDS Transmission Optiprobe Analyzer

Near-infrared spectroscopy – Process

2.928.0110	NIRS XDS Process Analyzer – Microbundle SinglePoint
2.928.1120	NIRS Analyzer PRO – FiberSystem

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