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TraceSELECT™ High Purity Reagents
for Sample Preparation and Analysis.



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Analysis you can trust

With Honeywell's analytical reagents, superior quality and safety standards are a prime focus. We use a comprehensive Quality Assurance System in line with EN 29001 (ISO 9001) and each of our products is manufactured to clear, guaranteed specifications. We employ a large variety of modern analytical methods, such as inductively coupled plasma optical emission spectroscopy (ICP-OES), inductively coupled plasma mass spectrometry (ICP-MS), flame atomic absorption spectroscopy (AAS) and graphite furnace AAS (GF-AAS). This allows for specifically tailored control and analysis procedures for each product.



Atomic Emission Spectroscopy Analysis

Reagents for Inorganic Trace Analysis

Sensitive trace analysis applications require extremely pure sample preparation reagents. These digestive reagents cannot contain metal ions or other impurities. In addition, complete decomposition of the sample is required to achieve reproducible and accurate elemental results by instrumental analytical methods.

Sample wet digestion/dissolution is a method that breaks down the components of a matrix into simple chemical forms. This digestion can occur in three ways:

- With the introduction of energy such as heat
- By using a chemical reagent such as an acid
- By a combination of these two methods

Most analytical measurements using highly sensitive methods (AAS, ICP-AOES, ICP-MS, stripping voltammetry, ion chromatography, etc.) are performed

on samples in solution. One of the most effective and economical sample preparation methods is microwave digestion.

In most cases, achieving homogeneity and mineralization of the sample is sufficient. UV photolysis using hydrogen peroxide and either potassium persulfate or nitric acid is very often the method of choice for the decomposition of organic impurities in aqueous solutions.

The most commonly used reagents for wet decomposition are mineral and oxidizing acids. Wet decomposition has the advantage of being effective on both inorganic and organic materials. It often destroys or removes the sample matrix, thus helping to reduce or eliminate some types of interference.

Table 1 provides an annotated overview of the acids and bases used for wet digestion.

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Digestion/Dissolution Acids and Bases

Table 1

HNO₃	Nitric acid is the most frequently utilized sample dissolution medium. It oxidizes metals not dissolved by HCl and other non-oxidizing acids. Au, Pt metals (except Pd), Nb, Ta, and Zr are not dissolved. Al and Cr are passivated. Sn, Sb, and W give insoluble hydrous oxides. Dissolves most sulfides (except HgS). Unfortunately, the carbon contained in organic materials is only partly converted to CO ₂ by HNO ₃ at temperatures up to 200 °C. Nitric acid should never be used for the digestion of highly aromatic compounds because of the potential for the formation of highly explosive compounds. In the case of alcohols, the samples should be pretreated with sulfuric acid.	AcOH	Acetic acid is most often used for the extraction of metallic impurities together with sodium acetate.
HCl	Hydrochloric acid is used for many salts of weak acids, e.g., carbonates, phosphates, some oxides, and some sulfides.	HBr	Hydrobromic acid is a non-oxidizing acid. It is used in some special applications because it yields better reductive selectivity in the determination of Se(VI) by Hydride Generation-Laser Induced Fluorescence (HG-LIF) than HCl.
H₂SO₄	Sulfuric acid is used when its high boiling point (300 °C) is an advantage, as in expelling a volatile product or increasing the reaction rate. It provides dehydrating and oxidizing properties at high temperatures.	H₃PO₄	Phosphoric acid is commonly used in the semiconductor industry to both clean and etch metal surfaces. The concentration of the phosphoric acid is critical to optimizing these processes.
HClO₄	Perchloric acid is a very powerful oxidizing agent at fuming temperatures (boiling point 203 °C). It is usually mixed with HNO ₃ to oxidize easily attacked organic matter that might otherwise react violently with HClO ₄ . H ₂ SO ₄ (dehydrating agent) increases oxidizing power. Good solvent for stainless steel and for sulfides.	H₂O	Water ensures the highest accuracy in trace analysis of ppt range by minimizing blank values.
HF	Hydrofluoric acid is used for digestion of siliceous samples and as an auxiliary reagent to HNO ₃ or HClO ₄ to eliminate fluoride. With HNO ₃ , HF dissolves Ti, W, Nb, and Zr (and their carbides, nitrides, and borides) as a result of formation of complex fluorides. Certain refractory silicates and other minerals are not decomposed; these must be dissolved by fusion.	TMAH	Tetramethylammonium hydroxide [(CH ₃) ₄ NOH] is an efficient strong alkali used for solubilizing soft tissues and food stuffs. Compared to conventional alkaline sample digestion procedures using NaOH or KOH, using TMAH enables more accurate analysis due to its lower matrix effect. A diluted 0.3 M TMAH solution is also used during the lithographic process in the semiconductor industry.
H₂O₂	Hydrogen peroxide is a very popular oxidizing reagent as it is converted to water and oxygen during the oxidation of biological material. Additional advantages are that there is no acid corrosion of the digestion vessel PTFE walls, no formation of insoluble salts with an acid anion, and no change of the sample matrix by an acid. Because of its strong oxidation power, only small amounts of H ₂ O ₂ need be used so concentrated sample solutions can be obtained.	NaOH	Sodium hydroxide is frequently used for melting digestions at 500 °C. It attacks platinum and porcelain. Residue is dissolved with 12 M hydrochloric acid.
		KOH	Potassium hydroxide is frequently used for melting digestions at 500 °C. It attacks platinum and porcelain. Residue is dissolved with 12 M hydrochloric acid.
		K₂CO₃	Potassium carbonate is the classic reagent for melting digestions at 800 °C. Residue is dissolved with hydrochloric acid.

Sample Preparation for Trace Analysis

TraceSELECT™ Ultra and TraceSELECT

Ultra-pure acids, bases, and salts for smelting and wet digestion in environmental, water, and food analysis.

Sample preparation for trace analysis requires reagents of the highest purity. Our TraceSELECT Ultra products for ultra-trace analysis at ppb and even ppt levels are produced by sub-boiling distillation.

Sub-boiling is recognized as the best way to obtain high purity acids with the lowest blank values for ultra-trace analysis. The technique is based on the evaporation of liquid by infrared heating at the surface. It avoids violent boiling and the formation of liquid aerosols that can be transported with the distillate.

To maintain their high purity, TraceSELECT Ultra products are supplied in PTFE PFA (fluoropolymer) bottles. Water and ortho-phosphoric acid are supplied in especially pre-leached HDPE bottles. Recent process improvements have allowed us to reduce our impurity specifications to guarantee the lowest levels of trace impurities in our TraceSELECT Ultra products.

The acids, bases, and salts in the TraceSELECT series have been developed for sample preparation and analysis in the ppb ($\mu\text{g}/\text{kg}$) trace range. Purity and composition are guaranteed with our careful preparation, testing, and verification of the final product for metal content and ionic trace impurities using ICP-OES, ICP-MS and ion chromatography.

To further guarantee purity and stability, TraceSELECT products are packaged in high-quality containers appropriate for each product.

The Honeywell Quality Management System guarantees consistent quality and safety for all TraceSELECT Ultra and TraceSELECT products.

The reagents are produced and bottled under clean-room conditions.



**Honeywell Fluka -
Nitric Acid TraceSELECT**
84385-2.5L

TraceSELECT Ultra Reagents

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
07692-1L	6000037	Acetic acid	≥99.0%	250 mL, 500 mL, 1 L
96208-1L	6002970	Hydrochloric acid	32-35%	250 mL, 500 mL, 1 L
02650-1L	60044472	Nitric acid	67-69%	250 mL, 500 mL, 1 L, 2 L
12415-1L	60044732	Perchloric acid	67-72%	250 mL, 500 mL, 1 L
77239-1L	60047544	Sulfuric acid	≥95%	250 mL, 500 mL, 1 L

TraceSELECT Reagents

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
45727-1L	60046912	Acetic acid	≥ 99.0%	100 mL, 500 mL, 1 L, 2.5 L
09857-500ML	60044623	Ammonium hydroxide solution	≥ 25% in water	500 mL
06454-250ML	60044585	Formic acid	≥ 88.0%	250 mL
08256-1L	60044609	Hydrochloric acid	≥ 30%	100 mL, 500 mL, 1 L, 2.5 L
84415-500ML	6000778	Hydrochloric acid	≥ 37% fuming	500 mL
47559-500ML	6000793	Hydrofluoric acid	47-51%	500 mL
84385-1L	6001107	Nitric acid	> 69.0%	500 mL, 1 L, 2.5 L, 5 L
77227-1L	60047541	Perchloric acid	65-71%	100 mL, 500 mL, 1 L
79614-500ML	6001144	Phosphoric acid	~ 85%	100 mL, 500 mL
84716-1L	60047674	Sulfuric acid	≥ 93%	500 mL, 1 L, 2.5 L
95305-2.5L	60047766	Water		250 mL, 500 mL, 1 L, 2.5 L, 10 L

TraceSELECT Salts

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
09725-100G	6001868	Ammonium chloride	≥ 99.9995%	25 g, 100 g
09979-100G	6001885	Ammonium sulfate	≥ 99.9999%	100 g
90033-100G	60047737	Cesium chloride	≥ 99.9995%	25 g, 100 g
16722-25G	60044946	Cesium iodide	≥ 99.9995%	25 g
60216-100G	6002763	Potassium phosphate monobasic	≥ 99.995%	25 g, 100 g
60371-25G	60047178	Potassium hydroxide hydrate	≥ 99.995%	25 g
59929-100G	6002756	Sodium acetate	≥ 99.999%	25 g, 100 g
71347-100G	6002829	Sodium carbonate	≥ 99.9999%	25 g, 100 g
01968-100G	6001398	Sodium hydroxide monohydrate	≥ 99.9995%	25 g, 100 g
71629-100G	60047377	Sodium phosphate dibasic	≥ 99.999%	100 g
71492-100G	6002838	Sodium phosphate monobasic	≥ 99.999%	25 g, 100 g

Melting digestion is used for solid samples like ores, rock, metals, alloys, ceramic, and cement, in order to obtain a homogenous residue, which can be dissolved in diluted TraceSELECT acids. Our TraceSELECT salts obtain a very high purity, with metal traces typically below 10 µg/kg (1.0 ppb).

Trace Analysis: High Purity Reagents

Matrix Modifiers

In graphite furnace AAS, element determinations are increasingly being carried out with matrix modifiers. Chemical modification should be considered if an analyte is highly volatile, or if the analyte and matrix volatilize at similar temperatures.

Such modification would allow ashing at higher (or atomization at lower) furnace temperatures, resulting in elimination of the matrix with no loss

of the analyte (or atomization of the analyte, but not the matrix).

Depending on the element to be determined, various substances are used. A primary criterion for such substances is the absence of the element to be analyzed. For this reason, the following recommended reagents have been specially tested for their suitability as matrix modifiers.

Matrix Modifiers

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
95164-250ML	60048401	Cesium chloride/Lanthanum chloride matrix modifier solution	CsCl and LaCl ₃	250 mL
428892-100ML	60048476	Magnesium matrix modifier solution	2% Mg ²⁺ in <5% HNO ₃	100 mL

Spectroscopic Buffers for Flame AAS

In flame AAS, spectroscopic buffers are often used to suppress physical, ionization, and chemical interferences.

Spectroscopic Buffers for Flame AAS

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
95164-250ML	60048401	Cesium chloride-Lanthanum chloride buffer	CsCl 100 g/L, LaCl ₃ 100 g/L (in water)	250 mL

Reducing Agents for Hydride AAS

Hydride AAS is used for the analysis (especially traces) of arsenic, antimony, tin, selenium, bismuth, and mercury. It is used to separate and preconcentrate analytes from sample matrices by a reaction that turns

them into their hydride vapors. Sodium borohydride is the common reagent of choice for the reduction.

Fluka reagents are specifically analyzed to ensure the absence of hydride generating metals.

Reducing Agents for Hydride AAS

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
71321-100G	60047349	Sodium borohydride	≥ 99%	25 g, 100 g

Solvents for Trace Metal Speciation Analysis

TraceSELECT™ solvents for LC-ICP-MS applications

Honeywell has developed high purity TraceSELECT solvents for speciation analysis by LC-ICP-MS.

TraceSELECT solvents undergo rigorous purification procedures. This is followed by UV spectroscopy, IC, and ICP-MS testing to assure high chemical purity and high UV transmittance.

The blank values for metal traces in these solvents are in the ppb range or lower.

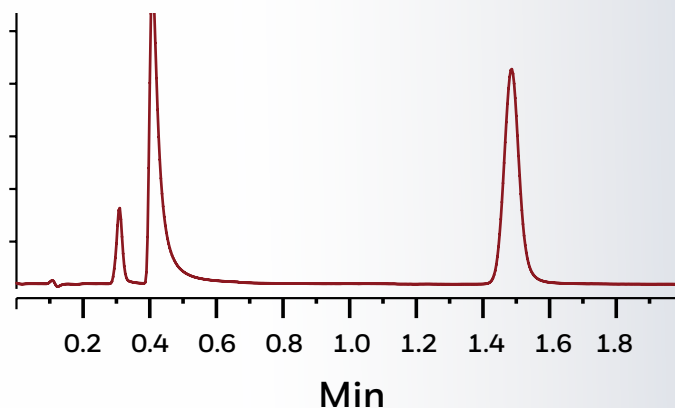
The toxicity of trace metals in food, clinical chemistry, biology, and environmental sciences is an area of increasing interest. In the environment, many diverse species of an element can be present. In addition, different species of the same element can possess very different degrees of toxicity.

Monitoring elemental species requires an analytical method that is sensitive and specific enough to resolve and quantify the individual species at ultra-trace levels. An individual toxic species may constitute only a fraction of an element's total concentration in a sample.

The coupling of the two well established analytical techniques, HPLC and inductively coupled plasma-mass spectrometry (ICP-MS), is straightforward. This is primarily because the flow rates commonly used with LC are compatible to conventional liquid sample introduction systems, such as those based on pneumatic nebulization.

Thus, the outlet of the LC column is directly connected to the ICP-MS nebulizer. This technique is especially useful in carrying out automated high-throughput speciation analysis. International trends show speciation of metals as an area of very high research interest. In the future, speciation of biological samples will undoubtedly involve determinations of which organic molecules attract which metals in specific sample types.

ICP-MS is a superior detection technique for trace elements in general, but especially for elements of interest, such as arsenic, selenium, cadmium, iodine, and others in chromatographic eluents.



The chromatogram of three mercury species

Hg²⁺, MeHg⁺, EtHg⁺ obtained by HPLC-ICP-MS

Definition of Speciation Analysis

The International Union of Pure and Applied Chemistry (IUPAC) defines speciation analysis as the “analytical activities of identifying and/or measuring the quantities of one or more individual chemical species in a sample.”

A chemical species is a “specific form of an element defined as to isotopic composition, electronic or oxidation state, and/or complex or molecular structure.”

In speciation analysis, the objective is usually to determine the identity and/or concentration of one or more chemical species in a sample, often of natural origin and therefore potentially containing many different species. Care must be taken to choose and execute the analysis to maximize sensitivity and specificity.

Performing a speciation analysis in a complex mixture involves separation, identification, and characterization of various forms of elements in the sample. The most commonly used strategy for speciation analysis is to perform a separation step before a generic detector.

LC separation coupled with ICP-MS

The hyphenated technique HPLC-ICP-MS is a robust, sensitive element-selective method capable of giving a complete picture of the elemental species in a solution.

The elemental response is usually independent of species, so it is often possible to quantify a species even when its structure is unknown (assuming good HPLC recovery). Identification, however, is based solely on retention time matching. Therefore, a compound in the sample can be identified only by comparison with a standard.



**Honeywell Riedel de Haën -
2-Propanol TraceSELECT**
04516-1L

TraceSELECT Solvents Ideal for Speciation Analysis

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
01324-1L	60044463	Acetonitrile	≥99.9%	1 L
04516-1L	60044560	2- Propanol	≥99.9%	1 L
42105-1L	60046853	Methanol	≥99.9%	1 L
69508-1L	60047336	Acetone	≥ 99.9%	1 L
72781-1L	60047444	<i>N,N</i> -Dimethylformamide	≥ 99.8%	1 L

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Ultra Pure Reagents for Voltammetry

TraceSELECT reagents for ultra-trace analysis and metal speciation

Voltammetry is predominantly used for inorganic trace analysis of anions and cations, but can also be used for the determination of various organic compounds. The most important fields of application of inorganic determinations are in metallurgy, environmental analysis, food analysis, toxicology, and clinical analysis.

This technique is also a preferred method for the determination of certain metal speciations, such as Fe(II)/Fe(III) or Cr(III)/Cr(VI). When mercury is used as an electrode in a voltammetric cell, the technique is called polarography.

The reduction of metals into mercury is more favourable than reduction to the solid-state electrode. Further on there is always a clean new Hg electrode surface available for each measurement.



Honeywell Fluka - Nitric Acid TraceSELECT
84385-2.5L

High Purity Reagents for Voltammetry

Honeywell Prod. No.	Fisher Scientific Cat. No.	Product Name	Specification	Available Packaging
94068-100G	60047756	Citric acid monohydrate	≥99.9998%	100 g
05878-100G	60044575	L-Ascorbic acid	≥99.9998%	100 g
93722-100G	60047753	Oxalic acid dihydrate	≥99.9999%	100 g



Multi-mode Electrode (MME)
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