

$$Ts + Hw = Py^2 + Ry$$

TraceSELECT™

Honeywell

Highest purity

Reliability

**Discover the perfect formula**

## **Inorganic Trace Analysis**

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 atomic emission spectroscopy (ICP-OES), inductively coupled plasma mass spectrometry (ICP-MS), flame atomic absorption spectroscopy (AAS) and graphite furnace 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-AES, 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

<b>HNO<sub>3</sub></b>	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 <sub>2</sub> by HNO <sub>3</sub> 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.	<b>AcOH</b>	Acetic acid is most often used for the extraction of metallic impurities together with sodium acetate.
<b>HCl</b>	Hydrochloric acid is used for many salts of weak acids, e.g., carbonates, phosphates, some oxides, and some sulfides.	<b>HBr</b>	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.
<b>H<sub>2</sub>SO<sub>4</sub></b>	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.	<b>H<sub>3</sub>PO<sub>4</sub></b>	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.
<b>HClO<sub>4</sub></b>	Perchloric acid is a very powerful oxidizing agent at fuming temperatures (boiling point 203 °C). It is usually mixed with HNO <sub>3</sub> to oxidize easily attacked organic matter that might otherwise react violently with HClO <sub>4</sub> . H <sub>2</sub> SO <sub>4</sub> (dehydrating agent) increases oxidizing power. Good solvent for stainless steel and for sulfides.	<b>H<sub>2</sub>O</b>	Water ensures the highest accuracy in trace analysis of ppt range by minimizing blank values.
<b>HF</b>	Hydrofluoric acid is used for digestion of siliceous samples and as an auxiliary reagent to HNO <sub>3</sub> or HClO <sub>4</sub> to eliminate fluoride. With HNO <sub>3</sub> , 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.	<b>TMAH</b>	Tetramethylammonium hydroxide [(CH <sub>3</sub> ) <sub>4</sub> 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.
<b>H<sub>2</sub>O<sub>2</sub></b>	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 <sub>2</sub> O <sub>2</sub> need be used so concentrated sample solutions can be obtained.	<b>NaOH</b>	Sodium hydroxide is frequently used for melting digestions at 500 °C. It attacks platinum and porcelain. Residue is dissolved with 12 M hydrochloric acid.
		<b>KOH</b>	Potassium hydroxide is frequently used for melting digestions at 500 °C. It attacks platinum and porcelain. Residue is dissolved with 12 M hydrochloric acid.
		<b>K<sub>2</sub>CO<sub>3</sub></b>	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.

For more information, visit: [lab-honeywell.com/traceselect](http://lab-honeywell.com/traceselect)



**Honeywell Fluka -  
Ammonium Acetate TraceSELECT**  
73432-100G

### TraceSELECT Ultra Reagents

Product Number	Brand	Product Name	Specification	Packaging
07692	Fluka	Acetic acid	≥99.0% (T)	250 mL, 500 mL, 1 L
96208	Fluka	Hydrochloric acid	≥30-35%	250 mL, 500 mL, 1 L
02650	Fluka	Nitric acid	≥65-71%	250 mL, 500 mL, 1 L, 2 L
12415	Fluka	Perchloric acid	67-72% (T)	250 mL, 500 mL, 1 L
64957	Fluka	Phosphoric acid	≥85% (T)	250 mL, 1 L
77239	Fluka	Sulfuric acid	≥95% (T)	250 mL, 500 mL, 1 L
14213	Fluka	Tetramethylammonium hydroxide solution	25% in water	250 mL

### TraceSELECT Reagents

Product Number	Brand	Product Name	Specification	Packaging
45727	Fluka	Acetic acid	≥ 99.0% (T)	100 mL, 500 mL, 1 L, 2.5 L
09857	Fluka	Ammonium hydroxide solution	≥ 25% in water (T)	100 mL, 500 mL
06454	Fluka	Formic acid	≥ 88.0% (T)	250 mL
08256	Fluka	Hydrochloric acid	≥ 30% (T)	100 mL, 500 mL, 1 L, 2.5L
84415	Fluka	Hydrochloric acid	≥ 37% fuming (T)	100 mL, 500 mL
47559	Fluka	Hydrofluoric acid	47-51% (AT)	100 mL, 500 mL
84385	Fluka	Nitric acid	> 69.0% (T)	250 mL, 500 mL, 1 L, 2.5L
77227	Fluka	Perchloric acid	67-72% (T)	100 mL, 500 mL, 1 L
79614	Fluka	Phosphoric acid	~ 85% (T)	100 mL, 500 mL
30955	Fluka	Potassium hydroxide solution	≥ 30% in water (T)	250 mL
13171	Fluka	Sodium hydroxide solution	≥ 30% in water (T)	250 mL
84716	Fluka	Sulfuric acid	≥ 95% (T)	500 mL, 1 L, 2.5 L
68556	Fluka	Tetramethylammonium hydroxide solution	25% in water	250 mL
95305	Fluka	Water		250 mL, 500 mL, 1 L, 2.5 L, 10 L

### TraceSELECT Salts

Product Number	Brand	Product Name	Specification	Packaging
73432	Fluka	Ammonium acetate	≥ 99.9995%	100 g
09725	Fluka	Ammonium chloride	≥ 99.9995%	25 g, 100 g
09726	Fluka	Ammonium phosphate monobasic	≥ 99.9999%	25 g, 100 g
09979	Fluka	Ammonium sulfate	≥ 99.9999%	100 g
90033	Fluka	Cesium chloride	≥ 99.9995%	25 g, 100 g
16722	Fluka	Cesium iodide	≥ 99.9995%	25 g
62462	Fluka	Lithium carbonate	≥ 99.998%	25 g, 100 g
60348	Fluka	Potassium bisulfate	≥ 99.995%	25 g
60111	Fluka	Potassium carbonate sesquihydrate	≥ 99.995%	50g

## TraceSELECT Salts (continued)

Product Number	Brand	Product Name	Specification	Packaging
05257	Fluka	Potassium chloride	≥ 99.9995%	25 g, 100 g
60216	Fluka	Potassium phosphate monobasic	≥ 99.995%	25 g, 100 g
60371	Fluka	Potassium hydroxide hydrate	≥ 99.995%	25 g
30533	Fluka	Potassium iodide	≥ 99.999%	100 g
60347	Fluka	Potassium phosphate dibasic	≥ 99.999%	100 g
60429	Fluka	Potassium nitrate	≥ 99.995%	25 g, 100 g
59929	Fluka	Sodium acetate	≥ 99.999%	25 g, 100 g
71347	Fluka	Sodium carbonate	≥ 99.9999%	25 g, 100 g
38979	Fluka	Sodium chloride	≥ 99.999%	25 g, 100 g
01968	Fluka	Sodium hydroxide monohydrate	≥ 99.9995%	25 g, 100 g
71752	Fluka	Sodium nitrate	≥ 99.999%	25 g, 100 g
71629	Fluka	Sodium phosphate dibasic	≥ 99.999%	100 g
71492	Fluka	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 (10 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. However, palladium nitrate has become one of the most popular. 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

Product Number	Brand	Product Name	Specification	Packaging
95164	Fluka	Cesium chloride/Lanthanum chloride matrix modifier solution	CsCl and LaCl <sub>3</sub>	250 mL, 500 mL, 1 L
428868	Fluka	Calcium matrix modifier solution	2% Ca <sup>2+</sup> in 1% HNO <sub>3</sub>	100 mL
428884	Fluka	Lanthanum matrix modifier solution	5% La <sup>3+</sup> in 1% HCl	100 mL
428892	Fluka	Magnesium matrix modifier solution	2% Mg <sup>2+</sup> in <5% HNO <sub>3</sub>	100 mL

## Spectroscopic Buffers for Flame AAS

In flame AAS, spectroscopic buffers are often used to suppress physical, ionization, and chemical interferences. The Schuhknecht and Schinkel buffer solution, as used in the determination of alkali elements, has become particularly important.

A multi-element standard for lithium, sodium, and potassium is also available for this method. The Schinkel buffer solution enables the method to be expanded to include up to 14 mono- and divalent elements, with simple calibration being all that is required for the analysis.

### Spectroscopic Buffers for Flame AAS

Product Number	Brand	Product Name	Specification	Packaging
20980	Fluka	Aluminum nitrate-Cesium chloride buffer	Buffer solution according to Schuhknecht and Schinkel	500 mL
20982	Fluka	Cesium chloride-Lanthanum chloride buffer	Buffer solution according to Schinkel	500 mL
95164	Fluka	Cesium chloride-Lanthanum chloride buffer	CsCl 100 g/L, LaCl <sub>3</sub> 100 g/L (in water)	250 mL

1. Schuhknecht, W.; Schinkel, H. Fresenius J. Anal. Chem. 1963, 161, 194.
2. Schinkel, H. Fresenius J. Anal. Chem. 1984, 10, 317.

## 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

Product Number	Brand	Product Name	Specification	Packaging
71321	Fluka	Sodium borohydride	≥ 99%	25 g, 100 g
30533	Fluka	Potassium iodide	≥ 99.999%	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.

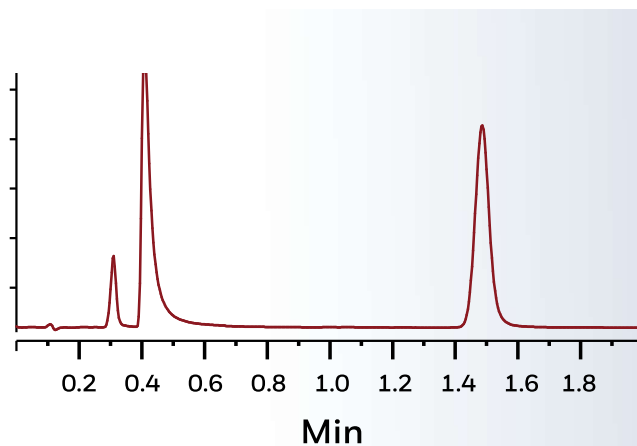
The toxicity of trace metals in food, clinical chemistry, biology, and environmental sciences is an area of increasing interest. In the environment, many diverse species of an element can be present. In addition, different species of the same element can possess very different degrees of toxicity.

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**

Hg<sup>2+</sup>, MeHg<sup>+</sup>, EtHg<sup>+</sup> 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.



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

## 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.

### TraceSELECT Solvents Ideal for Speciation Analysis

Product Number	Brand	Product Name	Specification	Packaging
01324	Riedel-de Haën	Acetonitrile	≥99.9%	1 L
04516	Riedel-de Haën	2-Propanol	≥99.9%	1 L
42105	Riedel-de Haën	Methanol	≥99.9%	1 L
92328	Riedel-de Haën	Ethylene glycol butyl ether	≥ 99.5%	1 L
69508	Riedel-de Haën	Acetone	≥ 99.9%	1 L
72781	Riedel-de Haën	N,N-Dimethylformamide	≥ 99.99995%	1 L

1. Michalke, B. The coupling of LC to ICP-MS in element speciation; Part II: Recent trends in application. Trends in Analytical Chemistry, 2002, 21(3), 154–165.
2. IUPAC, Pure and Applied Chemistry, 2000, 72, 1453–1470.

# 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



### Multi-mode Electrode (MME)

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of Metrohm AG, Switzerland

## High Purity Reagents for Voltammetry

Product Number	Brand	Product Name	Specification	Packaging
94068	Fluka	Citric acid monohydrate	≥99.9998%	100 g
05878	Fluka	L-Ascorbic acid	≥99.9998%	100 g
12819	Fluka	DL-Tartaric acid	≥99.9995%	25 g
39692	Fluka	Ethylenediaminetetraacetic acid	≥99.995%	25 g
93722	Fluka	Oxalic acid dihydrate	≥99.9999%	100 g

To learn more about Honeywell's Research Chemicals Portfolio, visit [lab-honeywell.com](http://lab-honeywell.com) or email us at [rcc@honeywell.com](mailto:rcc@honeywell.com)

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