Analyzing Cleaning and Personal Care Products by Gas and Liquid Chromatography

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Introduction

The cleaning products industry is a multi-billion dollar industry. The average consumer uses a wide range of products to promote both personal and public health. Of the products used in one’s home, there are several basic categories: personal cleansing, laundry, dishwashing, and household cleaning. These products are designed to improve personal hygiene, reduce levels of microorganisms, and improve personal appearance.

As with all consumer products, there is a need to test both final products and raw materials. This helps to ensure consistent product performance, as well as personal and environmental safety. Quantifying individual components also is useful for optimizing the manufacturing process, for determining product shelf life, and for comparing competitive products.

Chromatographic techniques such as gas chromatography (GC) and high pressure liquid chromatography (HPLC) are powerful tools in the analysis of cleaning and personal care products. In this technical guide, we explore how GC and HPLC can be used to quantify components of these important products. For GC assays, general detectors, such as the flame ionization detector (FID), or more information-rich detectors, such as the mass spectrometer (MS), can be used. GC/MS is particularly useful for analyzing complex formulations, such as fragrance blends, and for identifying unknown components or contaminants. HPLC is applicable to a wide range of personal care product ingredients, such as antimicrobial agents, preservatives, and some surfactants. In general, UV-visible or light-scattering detectors can be used.

Product Types

Cleaning and personal care products can be categorized in a number of ways. The Soap and Detergent Association (SDA) groups soaps and detergents into four general categories: personal cleansing, laundry, dishwashing, and household cleansing. Personal cleansing products include liquid and bar soaps, and heavy duty cleaners. Laundry detergents and laundry cleaning aids can be purchased in a variety of forms: powders, gels, liquids, sprays, and sheets. In addition to dirt and stain removal, they are used to bleach, soften, and freshen laundry. Dishwashing products also are marketed in a variety of forms: liquids, gels, and powders. Although they fall within the same category, hand dishwashing detergents and automatic dishwashing detergents generally have different formulations, as conditions for their use are quite different.

Household cleaners include a wide variety of products, as no single product will work well on all surfaces and soils. All-purpose cleaners are intended for general use, and can be used on a variety of surfaces, including various combinations of plastic, paint, metal, porcelain, glass, and wood. Specialty cleaners, for more specific applications, include products for glass, tubs and tile, ovens, toilet bowls, or rugs and upholstery. Abrasive cleaners contain small mineral or metal particles for removing heavy soil loads from small areas. For unclogging kitchen and bathroom drains, drain openers incorporate caustic ingredients that generate heat to melt fatty deposits and chemicals that oxidize soil deposits.

In addition to these cleaning products, a wide range of products promote personal hygiene: deodorants, mouthwashes, oral hygiene products, moisturizing lotions, and more. These products contain ingredients to cleanse, disinfect, deodorize, moisturize, and/or scent the user.

Basic Ingredients in Cleaning and Personal Care Products

Surfactants and Builders

The major components of cleaning products are surfactants and builders. Surfactants (surface active agents) are used to reduce the surface tension of water, enabling the cleaning solution to more efficiently wet the surface to be cleaned. Without the surfactant, water’s high surface tension causes it to bead on a surface, and cleaning is much more difficult. In addition, surfactants emulsify oils and other soils, and hold them in solution so they can be rinsed away.
Surfactant-containing solutions can be applied to a wide variety of surfaces, including tile, ceramic, and cloth - and hair. Builders often are used to increase the effectiveness of a surfactant. Builders reduce water hardness by “tying up” hardness minerals, through chelation with the minerals or by forming an insoluble precipitate. Examples of builders/chelating agents include sodium citrate (the sodium salt of citric acid) and ethylenediamine tetraacetic acid (EDTA). Other builders, such as sodium carbonate, reduce water hardness by forming insoluble precipitates (e.g., calcium carbonate).

Surfactants generally are classified by their ionic properties in water. Anionic surfactants, such as alcohol ethoxylates, alkyl sulfates, and soaps, are negatively charged in solution. Anionic surfactants are used in laundry detergents and some dishwashing detergents, household cleaners, and personal cleaning products.

Cationic surfactants, such as quaternary ammonium compounds, carry a positive charge in solution. They are used in products such as fabric softeners. Amphoteric surfactants, which can be either positively or negatively charged, often are used in personal cleansing products, due to their mildness.

Nonionic surfactants, such as alcohol ethoxylates, are uncharged in solution; they are used in laundry detergents and automatic dishwasher detergents. An example analysis of a nonionic surfactant, Triton® X-100, an octylphenol ethylene oxide with an average of 9.5 ethylene oxide units per molecule, is shown in Figure 1. This surfactant can be analyzed by GC, using a nonpolar phase, such as MXT®-1.

As described above, soaps are anionic surfactants. Basically, soaps are sodium or potassium salts of fatty acids, produced by reacting animal or vegetable fats or oils with a strong alkali. The fat or oil, in its original form, consists primarily of triglycerides—three fatty acids attached to a glycerol backbone. After conversion to the soap — saponification — there is both a hydrophilic (carboxylate group) and a hydrophobic end (alkyl chain) to the molecule. Water, a polar molecule, can now interact with the hydrophilic alkyl chains, while the alkyl chain can interact with relatively non-polar surfaces such as countertops, tile, or skin.

Fatty acids that make up a soap can be analyzed either in the free fatty acid form or after derivatization to the methyl esters (FAMEs). Figure 2 shows an analysis of free fatty acids by GC, using a Stabilwax®-DA capillary column. The acid-deactivated phase in the Stabilwax® DA column gives excellent peak shapes for free fatty acids. Figure 3 is an analysis of fatty acids as methyl esters, separated on an Rtx®-Wax column. FAMEs also can be easily quantified by using a Stabilwax® column.

**Solvents**

Solvents are used primarily to dissolve organic soils. They also clean without leaving residue, making them very useful in products such as glass cleaners. The main criterion for cleaning product solvents is water miscibility, as the solvent must form a solution with the other water-soluble components. Alcohols and...
Alcohols, glycols, and other cleaning solvents can be quantified, using an Rtx®-Wax column.

**Figure 3**
FAMEs analysis on an Rtx®-Wax column.

<table>
<thead>
<tr>
<th>Peak List</th>
<th>Conc. (mg/mL)</th>
</tr>
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<tbody>
<tr>
<td>1. methyl caproate (C6:0)</td>
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</tr>
<tr>
<td>2. methyl caprylate (C8:0)</td>
<td>0.4</td>
</tr>
<tr>
<td>3. methyl nonanoate (C9:0)</td>
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<td>4. methyl caprate (C10:0)</td>
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<tr>
<td>5. methyl laurate (C12:0)</td>
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<tr>
<td>6. methyl myristate (C14:0)</td>
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<td>7. methyl palmitate (C16:0)</td>
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<td>8. methyl palmitoleate (C16:1)</td>
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<td>11. methyl linoleate (C18:2)</td>
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<td>12. methyl linolenate (C18:3)</td>
<td>0.4</td>
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</table>

Rtx®-Wax, 30m, 0.25mm, 0.25µm (cat.# 12423)

- Sample: 1% each solvent in methanol
- Inj.: 1µL split injection (100:1), 4mm inlet liner (cat.# 20814)
- Inj. temp.: 250°C
- Carrier gas: hydrogen, constant flow
- Flow rate: 3.0 mL/min.
- Oven temp.: 35°C (4 min. hold) to 85°C (at 3°C/min., to 200°C @ 15°C/min. (2 min. hold)
- Det.: FID @ 250°C

**Figure 4**
Alcohols, glycols, and other cleaning solvents can be quantified, using an Rtx®-Wax column.

1. methanol
2. iso-propanol
3. ethanol
4. n-propanol
5. iso-butanol
6. n-butanol
7. methyl Cellosolve®
8. limonene
9. Cellosolve®
10. butyl Cellosolve®
11. dipropylene glycol monomethyl ether (DPMGME)
12. diethylene glycol ethyl ether (DEGEE)
13. ethylene glycol
14. tripropylene glycol monomethyl ether (TPMGME)
15. phenyl Cellosolve®

Rtx®-Wax, 30m, 0.32mm ID, 0.25µm (cat.# 12424)

- Sample: 1% each solvent in methanol
- Inj.: 1.0µL split (split ratio 100:1), 4mm inlet liner (cat.# 20814)
- Inj. temp.: 250°C
- Carrier gas: hydrogen, constant flow
- Flow rate: 3.0 mL/min.
- Oven temp.: 35°C (4 min. hold) to 85°C (at 3°C/min., to 200°C @ 15°C/min. (2 min. hold)
- Det.: FID @ 250°C
Figure 5
Excellent, alternative selectivity for cleaning solvents, using an Rtx®-VMS column.

1. methanol
2. ethanol
3. iso-propanol
4. tert-butanol
5. n-propanol
6. iso-butanol
7. methyl Cellosolve®
8. n-butanol
9. Cellosolve®
10. ethylene glycol
11. butyl Cellosolve®
12. limonene
13. dipropylene glycol monomethyl ether (DPGME)
14. diethylene glycol ethyl ether (DEGEE)
15. phenyl Cellosolve®
16. tripropylene glycol monomethyl ether (TPGME)

Rtx®-VMS, 60m, 0.25mm ID, 1.4µm (cat.# 19916)
Sample: 1% each solvent in methanol
Inj.: 1µL split injection (100:1), 4mm inlet liner (cat.# 20814)
Inj. temp.: 250°C
Carrier gas: hydrogen, constant flow
Flow rate: 1.5 mL/min.
Oven temp.: 60°C (1 min. hold) to 138°C @ 4°C/min., to 145°C @ 2°C/min., to 210°C @ 15°C/min., to 230°C @ 5°C/min.
Det.: FID @ 250°C

Excellent resolution of short-chain alcohols

Figure 6
Quantify volatile ingredients in an all-purpose cleaner, using an Rtx®-VMS column.

1. butyl Cellosolve®
2. limonene

Rtx®-VMS, 60m, 0.25mm ID, 1.4µm (cat.# 19916)
Sample: Approx. 5% sample in methanol
Inj.: 1µL split injection (100:1), 4mm inlet liner (cat.# 20814)
Inj. temp.: 250°C
Carrier gas: hydrogen, constant flow
Flow rate: 1.5 mL/min.
Oven temp.: 60°C (1 min. hold) to 138°C @ 4°C/min. to 145°C @ 2°C/min. to 210°C @ 15°C/min. to 230°C @ 5°C/min.
Det.: FID @ 250°C

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glycols are popular choices. Cleaning solvents can be resolved using an Rtx®-Wax column (Figure 4) or an Rtx®-VMS column (Figure 5). The latter column gives excellent selectivity and peak shape for a wide range of cleaning solvents. Analysis of an all-purpose cleaner is shown in Figure 6, and a glass cleaner is shown in Figure 7. Analyses of glycols and alcohols are shown in Figures 8–10.

**Acids**

Organic acids, such as acetic and citric acids, are used to reduce the pH of cleaning products, to remove mineral build-up. Inorganic acids, such as hydrochloric, phosphoric, and sulfuric acid also can be included in a formulation. Organic acids can be analyzed either by HPLC or by GC, but HPLC is a better technique for dicarboxylic acids. Figure 11 shows a separation of organic acids on an Ultra Aqueous C18 HPLC column. A GC analysis of short-chain free fatty acids is shown in Figure 12.
Figure 11
Organic acids on an Ultra Aqueous C18 HPLC column.

Peak List: Concentration (µg/mL)
1. malonic acid 500
2. lactic acid 500
3. acetic acid 1000
4. citric acid 2000
5. succinic acid 10
6. fumaric acid 10

Sample: HPLC-grade water
Inj.: 10µL

Column: Ultra Aqueous C18
Catalog #: 9178565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 100Å

Conditions:
Mobile phase: 50mM potassium phosphate, pH 2.5: acetonitrile (99:1)
Flow: 1.5mL/min.
Temp.: 25°C
Det.: UV @ 210nm

Figure 12
Organic Acids on a Stabilwax-DA column.

Stabilwax-DA, 30m, 0.25mm ID, 0.25µm (cat.# 11023)
Inj.: 1.0µL split injection (50:1) of a free acid standard, approximately 10 to 20ng/µL each analyte
Oven temp.: 145°C
Inj. & det. temp.: 250°C
Carrier gas: hydrogen
Linear velocity: 40cm/sec.
FID sensitivity: 2 x 10^-11 AFS

Figure 13
Ethanolamines on a base-deactivated column.

HOT tip
The Ultra Aqueous C18 column is an excellent choice when using highly aqueous mobile phases. Embedded polar groups prevent collapse of the alkyl chains—even in 100% aqueous environments. See page 12 for more information.

Alkalis
Products with higher pH are useful for dissolving fatty or oily soils. Alkalis, or bases, are used to neutralize acidic ingredients, or to raise the pH. Suitable alcalis include ethanolamines, ammonium hydroxide, and sodium silicate. The more basic compounds, such as ethanolamines, can be analyzed by GC, but a base-deactivated column should be used. Ethanolamines analysis on an Rtx-5 Amine capillary GC column is shown in Figure 13.

Antimicrobial Agents
Antimicrobial agents are included in soaps, detergents, health and skincare products, and household cleaners. By controlling microbial growth, they control disease and odor. More than 300 active ingredients currently are used to control microorganisms. These agents can be categorized as sterilizers, disinfectants, sanitizers, or antiseptics/germicides. Sterilizers are used to eliminate fungi, viruses, and bacteria; disinfectants, to destroy or control fungi and bacteria, but not necessarily their spores; sanitizers, to reduce microorganisms on surfaces. Antiseptics or germicides are used on living people and animals. In the United States, a product used in or on the body, or in processed food, is regu-
lated by the Food and Drug Administration (FDA). Other products fall under the guidelines of the US Environmental Protection Agency (EPA). Examples of antimicrobial agents are: quaternary ammonium compounds, sodium hypochlorite, organic acids, alcohols, iodine, Triclosan, and 4-chloro-3,5-dimethylphenol (para-chloro-meta-xylanol/PCMX). A PCMX assay by HPLC is shown in Figure 14; Figure 15 demonstrates the separation of benzoic and sorbic acids on an Ultra Phenyl HPLC column.

**Preservatives**

Preservatives are used to extend product shelf life. Examples of preservatives used in cleaning and personal care products are BHT (3,5-di-tert-butyl-4-hydroxytoluene), BHA (2- and 3-tert-butyl-4-hydroxyanisole), EDTA (ethylenediamine tetraacetic acid), and glutaraldehyde. BHT and BHA are phenolic antioxidants that can be very effective, even at low concentrations. These compounds can be analyzed either by GC (Figure 16) or by HPLC (Figure 17).
Figure 16
Preservatives BHA and BHT on an Rtx®-50 intermediate polarity column.

Rtx®-50, 30m, 0.53mm ID, 0.50µm (cat.# 10540)
Sample: 50ppm each analyte in methanol
Inj.: 1.0µL direct, gooseneck splitless inlet liner, 4mm (cat.# 20798)
Inj. temp.: 280°C
Carrier gas: helium, constant pressure
Linear velocity: 60cm/sec. @ 50°C
Oven temp.: 50°C to 240°C @15°C/min. (hold 3 min.)
Det.: FID @280°C

Figure 17
Phenolic preservatives, including BHA and BHT, on a Pinnacle II™ C18 HPLC column.

Peak List: Conc. (ppm)
1. propyl gallate 168
2. TBHQ 182
3. 2-BHA + 3-BHA 197
4. BHT 193

Sample:
Inj.: 10µL
Conc.: see peak list
Solvent: methanol
Column: Pinnacle II™ C18
Catalog #: 9214565
Dimensions: 150 x 4.6mm
Particle size: 5µm
Pore size: 110Å
Conditions:
Mobile phase: A = 1% acetic acid B = methanol
Time B (min.) (%)
0 50
4 50
10 90
25 90
26 50
Flow: 1.0mL/min
Temp.: 30°C
Det.: UV @ 280nm

Questions?
Contact Restek’s Technical Service Team! We have answers to your toughest analytical questions.
Call 800-356-1688 or 814-353-1300, ext. 4, email us at support@restek.com or contact your local Restek representative.

Secure, Reliable Column-to Column Connections

Use a Vu2 Union™ connector when you:
• Connect a guard column to an analytical column.
• Connect a column to a transfer line or restrictor line.
• Connect two columns in a series.
• Repair a broken column.

The Vu2 Union™ connector’s open design allows visual confirmation of the seal; secondary seals ensure a leak-tight connection.

Vu2 Union™ Connector Kits
Kits include: Vu2 Union™ body, 2 knurled nuts, 2 Press-Tight® unions, and 4 ferrules

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**Fragrances & Colorants**

Fragrances and colorants give a unique look or scent to a product. Blue dyes or pigments—bluing agents—absorb in the yellow region of the spectrum, masking age- and use-associated yellowing of clothing and bedding, and making these articles look brighter. Colorants also make a product “seen” in use, as in toilet bowl cleaners and floor sanitizers. Fragrances disguise odors from soils, or from the product itself, as well as provide the desired scent. In general, GC is effective for monitoring or identifying fragrance components. Examples of fragrance assays by GC are shown in Figures 18–20.

**Figure 18**

Personal care product fragrance compounds on an Rtx®-1 column.

- Rtx®-1, 60m, 0.25mm ID, 0.25µm (cat.# 10126)
- Sample: 130ppm eucalyptus oil
- 250ppm camphor
- 260ppm menthol in methanol
- Inj. temp.: 275°C
- Inj.: 1.0µL split injection (20:1), 4mm inlet liner (cat.# 20814)
- Carrier gas: helium, constant flow
- Flow rate: 0.6 mL/min.
- Oven temp.: 80°C to 180°C @ 5°C/min.
- Det.: FID @ 300°C

**Figure 19**

A complex fragrance, lemon oil, resolved on an Rtx®-5 column.

- Rtx®-5, 30m, 0.32mm ID, 0.25µm (cat.# 10224)
- Inj.: wet needle split injection (100:1) of neat lemon oil
- Oven temp.: 75°C (hold 8 min.) to 250°C @ 4°C/min.
- Inj. & det. temp.: 250°C
- Carrier gas: hydrogen
- Linear velocity: 40cm/sec. (flow rate: 3.2 cc/min.)
- FID sensitivity: 2 x 10⁻⁷ AFS

1. heptanol
2. α-thujene
3. α-pinene
4. camphene
5. sabinene
6. camphene
7. 6-methyl-5-hepton-2-one
8. myrcene
9. octanol
10. α-phellandrene
11. 3-carene
12. α-terpinene
13. p-cymene
14. limonene
15. β-terpinene
16. octanol
17. terpinolene
18. limool
19. nonanal
20. citronellal
21. terpinene-4-ol
22. α-terpineol
23. decanol
24. octyl acetate
25. nerol
26. nerol
27. carvone
28. geraniol
29. geranium
30. nonyl acetate
31. citronellyl acetate
32. neryl acetate
33. geranyl acetate
34. dodecanol
35. β-caryophyllene
36. trans-α-bergamotene
37. α-humulene
38. β-bisabolene
**Miscellaneous Ingredients**

Other ingredients used in cleaning, sanitizing, and personal care products include abrasives, such as quartz or sand; anti-redeposition agents, such as carboxymethylcellulose, that prevent soils from resettling on cleaned surfaces; bleach (e.g., sodium hypochlorite), for whitening and stain removal; enzymes, for removing specific soils, such as proteins; and fabric softeners, such as quaternary ammonium compounds.

**Summary**

A wide and disparate list of ingredients is used in cleaning and personal care products to solubilize soils, wet surfaces, mask odors, or perform a variety of other functions. Gas chromatography and liquid chromatography are used to monitor specific components, to ensure product quality. Restek chromatographic columns and supplies ensure peak performance of these chromatographic assays. For assistance with your specific applications, please call Restek’s Technical Service Team at 800-356-1688 or 814-353-1300, ext. 4, or email us at support@restekcorp.com. We will be happy to work with you.

**References**

2. The Soap and Detergent Association. www.sdahq.org
Ultra Phenyl 5µm Columns (USP L11)

Physical Characteristics:
- particle: 5µm spherical
- fully end-capped
- pore size: 100Å
- pH range: 2.5 to 7.5
- carbon load: 10%
- temperature limit: 80°C

Chromatographic Properties:
- High-purity, highly retentive, base-deactivated phase with alternative selectivity to hydrocarbon phases, especially for aromatic analytes.

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Ultra Aqueous C18 5µm Columns (USP L1)

Physical Characteristics:
- particle: 5µm spherical
- not end-capped
- pore size: 100Å
- pH range: 2.5 to 7.5
- temperature limit: 80°C

Chromatographic Properties:
- Highly retentive and selective for reversed phase separations of polar analytes. Highly base deactivated. Compatible with highly aqueous (up to 100%) mobile phases.

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Pinnacle II™ C18 5µm Columns (USP L1)

Physical Characteristics:
- particle: 5µm spherical
- fully end-capped
- pore size: 110Å
- pH range: 2.5 to 7.5
- carbon load: 13%
- temperature limit: 80°C

Chromatographic Properties:
- Excellent choice as a general purpose C18 column. Intermediate carbon loading and surface area, suitable for a wide range of neutral hydrophobic compounds.

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Pinnacle™ DB C18 5µm Columns (USP L1)

Physical Characteristics:
- particle: 5µm spherical
- endcap: yes
- pore size: 140Å
- pH range: 2.5 - 7.5
- carbon load: 11%
- temperature limit: 80°C

Chromatographic Properties:
- Highly base-deactivated spherical silica manufactured by Restek Corp. Monomeric C18 bonding. Hydrophobic C18 phase suitable for analyses of a wide range of compounds, from acidic through slightly basic. Replaces Hypersil® BDS C18.

<table>
<thead>
<tr>
<th>Length</th>
<th>1.0mm ID</th>
<th>2.1mm ID</th>
<th>3.2mm ID</th>
<th>4.0mm ID</th>
<th>4.6mm ID</th>
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</thead>
<tbody>
<tr>
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<td>9414533</td>
<td>9414535</td>
<td></td>
</tr>
<tr>
<td>50mm</td>
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<td>9414552</td>
<td>9414553</td>
<td>9414555</td>
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<td>100mm</td>
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<td>200mm</td>
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<td>9414522</td>
<td>9414523</td>
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<td></td>
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<td>9414572</td>
<td>9414573</td>
<td>9414575</td>
<td></td>
</tr>
</tbody>
</table>

For a complete listing of our HPLC columns and accessories, request our HPLC catalog (lit. cat.# 59241A), or visit our website.

PEEK® Fitting Extractor
Drill into the broken fitting, then screw the extractor into the fitting and remove it easily.
cat.# 25325, (ea.)

Sonic Debubbler
Just touch the Sonic Debubbler to the inlet line or check valve—ultrasonic vibrations will quickly dislodge or redissolve trapped air bubbles. Reduces downtime or conversion time from one mobile phase to another.
cat.# 20444, (ea.)

www.restek.com
**Restek’s Trident™ Integral System**

- Convenient and economical leak-free guard column system, extremely easy to install.
- Versatile configuration protects against all levels of contamination.
- Integral design eliminates troublesome tubing connections.

The system’s foundation consists of the analytical column configured with our exclusive Trident™ end fitting and XF fitting. This configuration contains the standard internal frit as well as a replaceable cap frit, which can be easily changed without disturbing the packed bed. Changing the external frit can reverse the effects of accumulated particles, such as high backpressure or peak distortion. To obtain this basic configuration, simply order any Restek HPLC column, and add the suffix -700 to the catalog number.

For maximum protection against contaminants and particulate matter, the system can be configured with an integral guard cartridge holder (XG-XF), a guard cartridge, and a replaceable external frit. To obtain this configuration, simply order any Restek HPLC column, add the suffix -700 to the catalog number, and order the appropriate XG-XF male fitting.

**Trident™ Direct**

*Easy-to-Use, Low-Dead Volume—The Ultimate Combination of Convenience and Column Protection*

<table>
<thead>
<tr>
<th>Description</th>
<th>qty.</th>
<th>cat.#</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-pressure filter</td>
<td>ea.</td>
<td>25082</td>
</tr>
<tr>
<td>1cm guard cartridge holder without filter</td>
<td>ea.</td>
<td>25083</td>
</tr>
<tr>
<td>1cm guard cartridge holder with filter</td>
<td>ea.</td>
<td>25084</td>
</tr>
<tr>
<td>2cm guard cartridge holder without filter</td>
<td>ea.</td>
<td>25085</td>
</tr>
<tr>
<td>2cm guard cartridge holder with filter</td>
<td>ea.</td>
<td>25086</td>
</tr>
<tr>
<td>Connection tip for Waters®-style end fittings</td>
<td>ea.</td>
<td>25088</td>
</tr>
<tr>
<td>PEEK® tip standard fittings</td>
<td>ea.</td>
<td>25087</td>
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</table>

**Trident™ HPLC Guard Column Cartridges**

<table>
<thead>
<tr>
<th>Guard Column Cartridges</th>
<th>3-pk. (10 x 2.1mm)</th>
<th>3-pk. (10 x 4.0mm)</th>
<th>2-pk. (20 x 2.1mm)</th>
<th>2-pk. (20 x 4.0mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pinnacle II™ C18</td>
<td>921450212</td>
<td>921450210</td>
<td>921450222</td>
<td>921450220</td>
</tr>
<tr>
<td>Pinnacle® DB C18</td>
<td>941450212</td>
<td>941450210</td>
<td>941450222</td>
<td>941450220</td>
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<tr>
<td>Ultra Aqueous C18</td>
<td>917850212</td>
<td>917850210</td>
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<tr>
<td>Ultra Phenyl</td>
<td>910550212</td>
<td>910550210</td>
<td>910550222</td>
<td>910550220</td>
</tr>
</tbody>
</table>

**Trident™ HPLC In-Line Guard Cartridge Holders**

A Trident™ in-line guard cartridge holder can be used with almost any HPLC column by connecting it with a short piece of 1/16” tubing, appropriate nuts and ferrules, or finger-tight fittings. The system can be used with Restek columns or columns from other manufacturers. Holders are available for either 1 or 2cm guard cartridges. Either size can be purchased with or without a prefilter, which provides added protection against the particles that can shorten the lifetime of the guard cartridge.

<table>
<thead>
<tr>
<th>Description</th>
<th>qty.</th>
<th>cat.#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Holder for 1cm guard cartridge</td>
<td>ea.</td>
<td>25021</td>
</tr>
<tr>
<td>Holder with filter for 1cm guard cartridge</td>
<td>ea.</td>
<td>25040</td>
</tr>
<tr>
<td>Holder for 2cm guard cartridge</td>
<td>ea.</td>
<td>25081</td>
</tr>
<tr>
<td>Holder with filter for 2cm guard cartridge</td>
<td>ea.</td>
<td>25080</td>
</tr>
<tr>
<td>Replacement cap frits: 4mm, 2.0µm</td>
<td>5-pk.</td>
<td>25022</td>
</tr>
<tr>
<td>Replacement cap frits: 4mm, 0.5µm</td>
<td>5-pk.</td>
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<tr>
<td>Replacement cap frits: 2mm, 2.0µm</td>
<td>5-pk.</td>
<td>25057</td>
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</tbody>
</table>

*The standard PEEK® tip in Trident™ Direct systems is compatible with Parker®, Upchurch®, Valco®, and other CPI-style fittings. To use Trident™ Direct systems with Waters®-style end fittings, the tip must be replaced with cat.# 25088.*
### GC Columns

**Rtx®-1 Columns**
(Crossbond® 100% dimethyl polysiloxane)
- temp. limits: -60 to 330/350°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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</thead>
<tbody>
<tr>
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<td>0.25</td>
<td>0.25</td>
<td>10123</td>
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<tr>
<td>30</td>
<td>0.32</td>
<td>0.25</td>
<td>10124</td>
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<tr>
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<tr>
<td>60</td>
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<td>10127</td>
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</tbody>
</table>

**Rtx®-5 Columns**
(Crossbond® 5% diphenyl/95% dimethyl polysiloxane)
- temp. limits: -60 to 320/340°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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<td>10239</td>
</tr>
</tbody>
</table>

**XTI®-5 Columns**
(Crossbond® 5% phenyl - extended temp. and inertness)
- temp. limits: -60 to 330/350°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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<td>12238</td>
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<tr>
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<tr>
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<td>12235*</td>
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</tbody>
</table>

**Rtx®-VMS Columns**
(Crossbond® polyethylene glycol)
- temp. limits: -60 to 240/260°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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<td>30</td>
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<td>1.0</td>
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**Stabilwax®-DA Columns**
(Crossbond® Carbowax® for acidic samples)
- temp. limits: 40 to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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**Stabilwax® Columns**
(Crossbond® Carbowax® - provides oxidation resistance)
- temp. limits: 40 to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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<tr>
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<td>12424</td>
</tr>
</tbody>
</table>

**Rtx®-50 Columns**
(Crossbond® 50% methyl/50% phenyl polysiloxane)
- temp. limits: 0 to 300/320°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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</thead>
<tbody>
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<td>0.53</td>
<td>0.50</td>
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**MXT®-1 Columns**
(Silcosteel®-treated metal column)
- temp. limits: -60 to 360°C

<table>
<thead>
<tr>
<th>Length (m)</th>
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<td>0.25</td>
<td>70124</td>
</tr>
</tbody>
</table>

**MXT®-WAX Columns**
(Silcosteel®-treated metal column)
- temp. limits: 20 to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
</tr>
</thead>
<tbody>
<tr>
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<td>70639</td>
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<tr>
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<td>1.0</td>
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**MXT®-200 Columns**
(Crossbond® trifluoropropylmethyl polysiloxane)
- temp. limits: -20 to 290/310°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
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</thead>
<tbody>
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</tr>
<tr>
<td>30</td>
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<tr>
<td>30</td>
<td>0.53</td>
<td>1.0</td>
<td>15055*</td>
</tr>
</tbody>
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**Stabilwax®-WAX Columns**
(Crossbond® polyethylene glycol)
- temp. limits: 20 to 250°C

<table>
<thead>
<tr>
<th>Length (m)</th>
<th>ID (mm)</th>
<th>df (µm)</th>
<th>Cat.#</th>
</tr>
</thead>
<tbody>
<tr>
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<td>12423</td>
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<tr>
<td>30</td>
<td>0.32</td>
<td>0.25</td>
<td>12424</td>
</tr>
</tbody>
</table>

*temp. limits: 40 to 240°C
Fragrance Materials Association Test Mix

Use this mix in essential oils analysis, to aid in the detection of inlet problems, stationary phase degradation, loss of resolution, changes in sensitivity, and the presence of reactive sites in the sample pathway. The required 5% test solution can be conveniently made by diluting the entire 0.5mL of neat mixture to 10mL with acetone.

- benzyl salicylate 362 parts
- cinnamic aldehyde 5 parts
- cinnamic alcohol 3 parts
- cinnamyl acetate 3 parts
- ethyl butyrate 362 parts
- eucalyptol 5 parts
- geraniol 6 parts
- hydrocycitronellal 50 parts
- d-limonene 200 parts
- thymol crystal 3 parts
- vanillin 1 part
- benzoic acid 1% of mix

Neat, 0.5mL in an amber ampul

Each 5-pk. 10-pk.
31807 31807-510 —

ASTM D6042-96 Calibration Mix

This mixture contains the common antioxidants and slips listed in American Society for Testing and Materials (ASTM International) Method D6042-96.

- BHT Irganox® 3114
- erucamide slip Irganox® 1010
- vitamin E Irganox® 1076

50µg/mL each in isopropanol, 1mL/ampul

Each 5-pk. 10-pk.
31628 31628-510 31728

ASTM D6042-96 Internal Standard Mix

- Tinuvin® P

51.8µg/mL in isopropanol, 1mL/ampul

Each 5-pk. 10-pk.
31629 31629-510 31729

USP 467 Calibration Mixture #4


- benzene 2µg/mL
- chloroform 60
- 1,4-dioxane 380
- methylene chloride 600
- trichloroethene 80

Prepared in methanol, 1mL/ampul

Each 10-pk.
36006 36106

Analytical Reference Materials

Fruit Juice Organic Acid Standard

In water, 1mL/ampul

Each 5-pk. 10-pk.
35080 35080-510 —
w/data pack
35080-500 35080-520 35180

In water, 5mL/ampul

Each 5-pk. 10-pk.
35081 35081-510 —
w/data pack
35081-500 35081-520 35181

Ethylene Oxide Standard

ethylene oxide

500µg/mL in dimethylsulfoxide, 1mL/ampul

Each 10-pk.
36006 36106

Restek will create the right solution for you!

“The Company Chromatographers Trust”

☑ Quotations supplied quickly.
☑ Mixtures made to your EXACT specifications.
☑ Most reference materials shipped within 5-7 days after receipt of your order.*

Restek should be your first choice for custom-made reference materials. Our inventory of over 3,000 pure, characterized, neat compounds ensures you of maximum convenience, maximum value, and minimum time spent blending mixtures in your lab. For our online custom reference material request form, visit www.restek.com/Reference-Standards

*Availability of raw materials and final product testing required may affect delivery of some mixtures. International orders require additional shipping time.