The Fundamentals of Solid Phase Extraction (SPE)

It would be ideal if every sample could be accurately and precisely analyzed without the need for any sample preparation. Unfortunately, that's usually not the case. Often, the matrix that may or may not contain the analytes being studied can interfere with both qualitative and quantitative analyses. And, when faced with a particularly complex matrix and/or analytes present at very low concentrations, dilution is no longer an option, and more active sample preparation steps are needed.

There are a wide variety of possible sample preparation options, but one of the most prominent techniques is "solid phase extraction," or SPE. If you need to separate matrix components from your sample so you can monitor analytes without interference, then SPE is likely going to be a useful technique. SPE can be thought of as liquid chromatography without an instrument or chromatogram as the same principles that affect the separations in an analytical liquid or gas chromatograph are employed.

Similar to how there are different mobile and stationary phases in analytical chromatography, there are many different options for SPE products and processes. That's good news because no one has yet discovered one sample preparation procedure that will work for all applications, and until they do, having options to fit the wide variety of testing scenarios is a good thing. For some analysts, SPE method development may not be necessary because many method-specific SPE products are available. However, for analysts who do need to develop an SPE method, the abundance of choices can be confusing, especially for those new to SPE.

This article provides insight into how to make the best SPE choice for your sample and analytical goals. It covers the basic principles of SPE, its main separation mechanisms, typical objectives and strategies, formats and characteristics, and method development and cross-referencing. Since there is no one set of steps that applies to all situations, this article is intended to introduce you to a family of SPE products that have instruction sheets with detailed steps to guide you.

Solid Phase Extraction – The Silent Chromatography

If you need to determine a new SPE protocol for your sample because no existing example is available or existing solutions are not adequate for your analytical objectives, it is helpful to keep in mind that SPE is essentially another form of chromatography, albeit one without the benefits of the detector found in a modern analytical chromatograph. With no chromatogram, it's easy to forget that chromatography is happening inside an SPE cartridge, which is why we often refer to SPE as "the silent chromatography."

The SPE system has a mobile phase, which are the solvents used to either wash a sample free of contaminants or to elute analytes of interest. There is a stationary phase, too, which is the SPE sorbent. And, parameters that affect chromatographic separation are also at play in SPE protocols. For instance, the ideas of chromatographic retention, selectivity, and efficiency are all integral to achieving the desired *resolution* between the analytes and interfering matrix components.

Finally, flow rate is critical to ensure that the SPE can efficiently perform the separation. There must be enough opportunities for interaction with the sorbent to avoid breakthrough where the analytes go to waste with the unwanted matrix components.

Similar to chromatography, successful SPE methods set up conditions that create differing degrees of interactions between the components of the sample and the mobile and stationary phases of the SPE system. Understanding the makeup of your sample is an important first step in any SPE method development. Without knowing the physical and chemical properties of your sample, it would be very difficult to match the sample with an SPE sorbent/solvent(s) system.

SPE Separation Mechanisms

Recognizing the primary mechanisms of interaction present in most SPE products can help you determine what is important to know about your sample. There are two principal mechanisms for interaction used in most SPE products: polarity and ion exchange. SPE products typically rely on one or both of these mechanisms, and they can span the range of polarities or ion charge and strength depending on the needs of your sample.

Polarity

When using polarity to separate analytes from the matrix, one of the first choices is to decide which mode is best–normal or reversed. A relatively polar SPE sorbent (e.g., bare silica, alumina, or Florisil) and a relatively nonpolar mobile phase (i.e., normal mode) could be paired to retain polar constituents of a sample while eluting nonpolar components. Alternatively, a relatively nonpolar SPE sorbent (e.g., silica with a C18 or C8 bonded phase) coupled with a relatively polar mobile phase would perform the opposite. This setup would be considered "reversed-mode" because it's the opposite of the normal mode, which came first in the development of these kinds of separations. Some sorbents can operate in either normal or reversed modes depending on the solvent choice and the sample (e.g., CarboPrep Plus, Diol).

SPE phases exist in a range of polarities (e.g., C18 sorbents have greater nonpolar retention than C8). Moreover, the choice of mobile phase solvent also offers a wide range of polarities, often very tunable by using blends of solvents, buffers, or other additives. There is a great degree of finesse possible when using polarity differences as the key characteristic to exploit to separate your analytes from matrix interferences (or from each other).

The adage "like dissolves like" can be helpful when considering polarity as the driver for separation. The more alike a compound is to the polarity of a mobile or stationary phase, the more likely it is to interact more strongly. Stronger interactions with the *stationary* phase lead to longer retentions on the SPE medium. Strong interactions with the *mobile* phase lead to less retention and earlier elution.

Ion Exchange

If the analytes of interest either always exist in a charged state or are able to be put in a charged state by the conditions of the solution they are dissolved in (e.g., pH), then another method of separating them from matrix (or each other) is through the use of SPE media that can attract them with a charge of their own.

In this case, classic electrostatic attraction rules apply. Unlike separations that rely on polarity characteristics and the like-dissolves-like model of interactions, charged state interactions operate on the rule of "opposites attract." For example, you may have an SPE medium that has a positive charge on its surface. To balance that positively charged surface, there is typically a negatively charged species, "an anion," initially bound to it. If your negatively charged analyte is introduced into the system, it has the capability of displacing the initially bound anion and interacting with the positively charged SPE surface. This results in retention of the analyte on the SPE phase. This swapping of anions is called "anion exchange," and it is one example of the broader category of "ion-exchange" SPE products. In this example, positively charged species would have a strong incentive to stay in the mobile phase and not interact with the positively charged SPE surface, so they would not be retained. Additionally, unless the SPE surface had other characteristics in addition to its ion-exchange properties, neutral species would also be minimally retained. However, such blended SPE products *do* exist, allowing you to utilize ion-exchange and reversed-phase retention mechanisms in the same SPE medium (e.g., polymeric ion-exchange SPE sorbents).

An important distinction to keep in mind when employing ion-exchange mechanisms is the nature of the charge state of the analyte. If the analyte is always charged, regardless of the pH of the solution it is in, it is considered a "strong" species. If the analyte is only charged under certain pH conditions, it is considered a "weak" species. Understanding this characteristic about your analyte will determine which type of SPE media to use. Ion-exchange SPE sorbents are also defined in terms of "strength" or "weakness," and thinking about opposites going together will help here, too. It is recommended to pair a weak ion-exchange SPE sorbent with a strong species and a strong ion-exchange sorbent with a weak analyte. Were you to pair a strong analyte with a strong sorbent, it would be likely that the attraction between the two would be too great to easily elute without the use of very strong acidic or basic solutions, which isn't always desirable or practical. Similarly, a weak species paired with a weak ion-exchange sorbent may not exhibit enough retention to adequately hold on to the analyte and prevent breakthrough.

As an example of an ion-exchange mechanism in action, assume your sample contains a weak acid (pK_a 2-8) that you want to retain on the SPE sorbent. Using an ion-exchange retention mechanism will require both the analyte and sorbent to be in their charged states. Since the weak acid analyte will be paired with a strong ion-exchange sorbent, the sorbent will not be a concern as its charge is essentially permanent. However, the sample pH needs to leave the analyte in a charged state (a pH around two units away from the compound's pK_a, and since our example is a weak acid, it would be two units above the pK_a). Generically speaking, acids are species that can be thought of as "giving up positivity," leaving them negatively charged. Since you want to retain the negatively charged analyte (the weak acid's "conjugate base," which is an anion) on the SPE sorbent, an ion-exchange product that will attract anions, or an "anion exchange" sorbent will be needed. Specifically, for this example, a *strong* anion exchange sorbent is recommended, which will adequately retain the charged analyte until the elution solvent conditions change enough to effectively "turn off" the charge state of the analyte—in our case, a pH around two units *lower* than the analytes pK_a. At that point, the neutral analyte will no longer be retained by the ion-exchange sorbent and can be eluted.

In a similar example, the opposite would be true if your sample contained a weak base. This is a species that can be thought of as capable of "giving up negativity," leaving a positive charge behind on the analyte (the weak base's "conjugate acid," which is a "cation"). A strong cation exchange sorbent would be recommended as well as ensuring the sample pretreatment leaves the analyte in its charged state (or around two units *below* the compound's pK_a).

Although it can be confusing, especially to people new to the technique, ion-exchange sorbent can be very effective, especially when coupled with a polarity-based retention mechanism in a mixed-mode format as noted above.

Uncharacterized Surface Interactions

It's important to be aware of the potential for additional, uncharacterized surface interactions that may affect the overall retentive nature of the sorbent in question. An example of this interaction can be found when considering the different types of silica that may be used for SPE sorbents, especially when employed with a bonded phase (e.g., a C18 ligand) in the reversed-phase mode. In the case of a C18 silica, if the

surface of the silica has many silanol (i.e., Si-OH) groups available for interaction with the sample, the overall retention characteristics of the sorbent may encompass more than just the expected nonpolar retention of the C18 ligand. For this reason, it is common to see the note that a silica sorbent has or has not been "end-capped." The end-capping process is intended to react with exposed silanol groups and replace the hydroxy group (-OH) with a methyl group (-CH_3), largely mitigating the potential for strong interactions with the silanol group. In addition to exposed silanol groups, the presence of metals incorporated into a silica particle may also cause uncharacterized interactions, which would make predicting retention performance more difficult.

Most SPE vendors strive to provide consistent, well-characterized products, but differences between vendors may exist, even among nominally identical products. Therefore, it is recommended to verify performance when switching between vendors, and in some cases, when switching between lots of a given vendor's materials.

SPE Objectives & Strategies

After becoming familiar with the basic mechanisms at play in most SPE products, the next step is to determine what to retain and what to elute. To some extent, that decision will be bound by the goals of an SPE method. SPE is typically used for one or more of the following reasons.

Purification/Cleanup

Sample purification or "cleanup" is the principal goal of most SPE methods. These methods prioritize selective separation of analytes from other matrix components that could interfere with the analysis. Selectively separating the target analytes from interfering and/or contaminating matrix components before performing the analytical separation can make a substantial difference. Most people developing new SPE methods aim for the following benefits.

Preventing Coelutions with Matrix Interferences:

While coelutions are never ideal, circumstances can affect how serious they are. In the case of GC-FID or LC-UV analyses, for example, coelution may make it impossible to quantify the analyte of interest. Worse still, it may lead to a false identification because the instrument cannot tell the interfering peak from the target analyte.

Even MS and MS/MS users can be negatively impacted. Although an MS may be able to resolve a compound's spectrum from coeluting interferences, these coeluting matrix components can still suppress or enhance the ionization of target analytes, resulting in signals that are biased low or high. This kind of effect can be particularly troublesome because it may never be directly observed. Only through comparing results of carefully prepared matrix-matched calibration standards made in a representative and truly blank matrix (i.e., a matrix that doesn't already contain any of the analytes) with standards made in pure solvent can it be directly measured. In large part, matrix-matched calibrations standards are necessary to correct for this effect, but it would also be helpful if these interfering matrix components could be removed from the sample prior to analysis.

Coeluting matrix components can also cause problems for baselines. This effect can emerge even when matrix interference does not obscure the peak of interest. Coeluting matrix components can make baselines unstable enough to render efficient automated integration difficult. Unstable baselines may make it necessary to manually set integration parameters, peak by peak. This can lead to additional time and workload costs.

At best, coeluting matrix components are a nuisance. At worst, they can lead to undetected inaccuracies in reported results. However, there are some ways to address them if they appear in your analysis.

If the sample has relatively few target analytes in a relatively clean matrix, optimizing the analytical separations may be enough. However, if the matrix is too complex and/or the list of target analytes is too long, optimization will not be sufficient. When the chromatogram gets too crowded, a way to selectively thin the herd *before* the analytical separation is needed. SPE may provide the answer.

Preventing Unwanted Interactions with Matrix Interferences:

While some matrix may elute with the target analytes, causing problems during detection, others may never elute at all and remain in the sample flow path (e.g., GC inlets, GC, or LC columns, etc.). In these cases, matrix components from a previous sample may introduce a new, unwanted opportunity for interaction with the target analytes. This can cause a retention shift for target compounds, which can slow their movement through the chromatographic system and can cause distorted peak shapes (i.e., peak tailing). In some cases, these unwanted components can even react with target compounds, causing chemical reactions that create whole new compounds that were never in the sample to begin with. When this breakdown occurs prior to the analytical column, it can give rise to new peaks. When the breakdown occurs within the analytical column, it can lead to peak distortion. Such matrix-related system contamination threatens data quality, so it is ideal to avoid introducing it in the first place. It may be possible to mitigate these effects by diluting the sample but that will also dilute the target analytes, too. If dilution is no longer the solution, SPE may be the next step.

Avoiding Instrument Downtime Caused by Matrix Buildup:

The accumulation of matrix contamination in a GC or LC instrument can lead to problems over time. In the short term, unwanted interactions between target analytes and matrix contamination may be avoided, but in the long term, problems will likely develop that will require instrument downtime and maintenance.

In the best-case scenario, instrument consumables and hardware perform well between routine preventative maintenance events. But it's

not uncommon for a batch of samples to fail in between scheduled maintenance. In these cases, maintenance and recalibration must be performed, taking down an instrument that has work to do.

Fractionation

The previous section dealt with the need to separate the target analytes from potentially interfering or contaminating matrix components. In other cases, however, it can be helpful to separate the analytes from each other before performing the quantitative analysis.

What if a sample contains two different compound classes (e.g., aliphatic and aromatic compounds in extractable petroleum hydrocarbon (EPH) applications)? Each class might need its own analytical method. In this case, using solid phase extraction can help make gross separations. Using SPE to fractionate a sample prepares it for the fine-tuned separations of the analytical chromatograph.

Concentration

Chromatographers are frequently faced with the challenge of trying to monitor extremely small concentrations of target compounds. Sometimes those concentrations are well below the reliable quantitation limits of available instrumentation. In these cases, a way to concentrate the sample prior to analysis will be needed. Assuming there is enough sample to work with, tailoring an SPE method that will strongly retain the analytes but allow most of the matrix to be eluted may be a good solution. A detectable mass of the target analytes can be collected and then transferred to a vial for analysis via the elution solvent.

SPE Strategies

SPE strategies can be thought of by asking, "what is happening to the analytes? And, how does that fit with the objectives?" In the end, something is getting retained by the SPE sorbent, and something else is getting eluted separately. Between the two, it's recommended to focus on the analytes.

If the primary goal is to separate analytes from interfering matrix compounds, the most straightforward arrangement would be an SPE sorbent that strongly retains the matrix but not the analytes, and a strong elution solvent for the analytes. This "analyte pass-through" approach allows an extract to be eluted through the SPE sorbent and collected, making it then potentially ready for analysis.

However, it's not uncommon that the nature of the sample is such that the best separation of analytes from matrix interferences is achieved by "analyte capture." By using an SPE sorbent that strongly retains the analytes (but not too strongly), the matrix can be washed away, and the analytes can be eluted by switching to a strong analyte elution solvent. This analyte capture approach is likely necessary for sample fractionation if the SPE goal is to perform an initial analyte separation, and it is critical to concentrate the analytes prior to analysis.

SPE Formats and Characteristics

It's advisable to approach SPE method development from the position of understanding the sample's characteristics, defining the sample preparation goals, and then picking SPE sorbents and solvents that will allow the separation of the target analytes from interferences. However, there are some very practical decisions to make regarding the format for the SPE method. It's common to see several different sorbent specifications provided in product descriptions, so it's important to know how these different characteristics might affect the performance of a given product.

When it comes to format, there are a few options to choose from, with some more frequently used than others.

- **Cartridges:** A very common format for SPE products is the cartridge, which is used either in manual or automated systems. It largely consists of a cartridge body containing a bed or beds of the sorbent(s) packed between frits that hold the bed in place, and a reservoir above the sorbent bed for the sample and conditioning or elution solvents to be added. Cartridges come in many different sizes, so it's important to consider the size of the cartridge's reservoir compared to the volume of sample to be extracted. The size of the reservoir in relation to the mass of the SPE sorbent is also important to note since that will affect the retention capacity of the cartridge. Will the reservoir size hold the volume of sample that needs to be analyzed? Will the size of the sorbent bed allow for adequate retention without unwanted breakthrough occurring?
- **96-Well Plates:** Commonly used for higher-throughput labs that are routinely preparing large quantities of samples, the overall format design of the 96-well plate. The overall format design is similar to the cartridge in that a bed of sorbent is housed between frits with a reservoir above to hold the sample and wash/elution solvents. The difference is each of the 96 wells acts like an individual cartridge, so handling large quantities of samples becomes much easier. The use of a 96-well plate format also typically means vials and caps are not needed, which can be a convenience since the 96-well plate SPE product will fit over another 96-well collection plate. The choice of a 96-well plate is likely going to be predetermined as this format typically comes with a variety of other specialized equipment—from pipettors to autosamplers.
- **Dispersive SPE (dSPE):** Developed as a relatively quick and easy way to clean up extracts collected using QuEChERS methodologies, dispersive SPE is a concept that involves adding the SPE sorbent directly to the sample extract and simply shaking and then centrifuging the extract prior to analysis. dSPE products are typically developed to couple with QuEChERS extractions and are therefore focused on the food safety market that QuEChERS was originally developed to support.
- **In-line Sample Prep (ILSP):** For LC-MS and LC-MS/MS applications, it's possible to incorporate a sample prep cleanup step "in line" with the actual analysis through the addition of a cartridge containing a sorbent that is compatible with the analytical LC conditions. In this arrangement, the sample is injected into the instrument and initially passes through the ILSP cartridge. Separation of the analytes from the matrix occurs in the ILSP cartridge. Then, once the analytes have eluted from the ILSP

cartridge onto the analytical column—but before the matrix components do—separate pumping and valving setup switches the flow through the ILSP cartridge. The analytes proceed through the analytical column to detection, but a wash solvent backflushes the ILSP cartridge to waste, preparing it for the next injection.

- **Disks:** For some specific applications (e.g., the concentration of drinking water samples when monitoring for chlorinated, benzidine-containing, or nitrogen-containing pesticides), sorbent material is embedded into a glass or PTFE disk format. This format is likely specified in methods (e.g., U.S. EPA Methods 515.2 and 553). Disk formats can also be helpful when cleaning up samples that might otherwise clog the cartridge format. Additionally, since the recommended flow rate through a disk format is typically much higher than a cartridge, large volume samples (e.g., 1 L) might be cleaned up in less time using an SPE disk.
- **Bulk:** Some SPE sorbents are sold in bulk for customers who prefer to create their own sample prep apparatuses. Unless a customer has specific reason to buy bulk sorbent, this is not a common format for typical SPE method development.

In addition to the format configuration, the materials of construction are also important when it comes to compatibility with the sample and the potential to produce unwanted interference from the SPE product itself. Even the highest quality plastic cartridges may not be resistant enough to some samples, so an inert glass may be required. Additionally, while frit materials made from compounds like PTFE are typically extremely inert, if the analysis includes low-level monitoring of poly- or perfluoroalkyl substances (PFAS), another option may be required to avoid background contamination.

SPE Characteristics of Note

After identifying a potential separation mechanism to employ (polarity, ion exchange, or both) and a sorbent to try, there are several additional SPE characteristics that may be encountered on a product's description. These characteristics can have an impact on the performance of a method, so it's helpful to understand why they are important enough to be presented on a product's description.

Below is a list of commonly encountered specifications and how they might affect the performance of an SPE method.

Sorbent Characteristics

- **Particle Characteristics:** It's usually uncommon to encounter different particle sizes or pore size/volumes within a given vendor's products; however, a difference may be observed when comparing one vendor to another. If the pore size of the particles in question is large enough for the target analytes to enter, then, in most cases, the particle and pore size/volume are most relevant when considering the following two characteristics: surface area and carbon load.
- Note: Particle size can be found in either a direct measurement of size, such as a 60 µm particle, or as a "mesh size." Mesh size is a measure of the number of openings in a linear inch of the mesh: a higher mesh size means there are more openings of a smaller size. Higher mesh sizes equate to smaller particles.
- **Surface Area (typically given in m^2/g) :** Defined by the particle's size and the size and volume of the particle's pores, the surface area will be a representation of how much surface is available for interactions with the sample as it passes through the sorbent. The higher the surface area, the higher the retention. Sorbents that report smaller particle sizes and smaller pore sizes will have greater surfaces areas, gram for gram, than sorbents with larger particles and pore size.
- **Carbon Load (typically given as % of total sorbent mass):** Similar to and related to surface area is the concept of carbon load. Some SPE sorbents have a chemical bonded to the surface of the particle. A classic example is a C18 ligand bonded to the surface of a silica particle, which makes the otherwise normal phase silica particle a reversed-phase SPE sorbent because of the C18's ability to retain nonpolar compounds. In these cases, the carbon load value is an indication of the surface coverage of the bonded ligand and is an indicator of how much retention that sorbent will have. This number is best used as a point of reference where sorbents that report higher carbon loads will, mass for mass, have a higher retention potential than sorbents with a lower carbon load.
- **Ion-Exchange Capacity (typically given in mEq/g):** A sorbent's ion-exchange capacity is a measure of how many sites are available to exchange loosely bound counterions by capturing other ions in the sample. While a detailed exploration of the commonly used unit, milliequivalents/gram, is beyond the scope of this article, in general terms, the greater the value, the greater the capacity of the sorbent to retain charged species in the sample.

Cartridge Characteristics

- **Hold-Up Volume:** An SPE product's hold-up volume is the amount of solvent volume necessary to elute an unretained species. This concept may be recognized from terms such as "hold-up volume/time" or "dead volume/time" in reference to analytical chromatographic systems.
- **Loading Capacity:** An SPE sorbent's loading capacity is an estimate of how much material it can retain and is typically given as approximately 10% of the sorbent bed weight. However, this estimate assumes the retention of a compound that is very well-retained by the sorbent using a weak solvent. Many things affect the ultimate loading capacity (e.g., nature of sample, solvent, flow rate, etc.), so the actual loading capacity may be much lower for compounds that do not interact with the sorbent's principal separation mechanism or are eluted with very strong solvents. As noted below, the most reliable way to know this for the sample/SPE method is to determine loading capacity empirically.

Use Included SPE Product Instructions as a Guide

Given the vast variation between different types of samples, analytes, and analyses, no single SPE method will work for everyone. Instead, after developing an understanding of your sample, and pairing that with an appropriate SPE product, that product will have its own set of instructions that can be referenced and refined to meet your particular analytical objectives.

The Value of Experimenting During SPE Method Development

It's recommended to run several experiments during method development to understand where all the analytes of interest are during all steps of the SPE method. These experiments will help refine your analysis in the following ways:

- Validate the choice of sorbent and solvents.
- Ensure the use of the smallest SPE product necessary to meet the method objectives.
- Ensure analytes are not lost during loading or washing steps due to sample breakthrough.
- Ensure analytes are not left behind on the sorbent because they have not been effectively eluted under the chosen conditions.

Typically, two experiments to conduct would be a "mass balance" and a "breakthrough" study, and both only need to be performed during method development to ensure the process is well-suited for the samples in question.

Mass Balance: This study helps gauge the movement of analytes during the entire SPE process, which involves collecting everything that elutes from the SPE product during each step of the process. Performing this study with carefully prepared samples that closely approximate the composition of real samples will confirm if you are retaining what you want to retain and are eluting what you want to elute at each step of the process.

Breakthrough: This study is conducted using a range of sample volumes (same analyte concentrations) that bracket the intended volume for the developed method. In each case, the sample is loaded, and the SPE process is performed. After the different load volumes have been added, the SPE protocol proceeds, and the extract(s) are collected for analysis. The percent recovery is calculated based on the concentration and the total volume used in each case. If there is a problem with retention, the plotted results should show the points at which different compounds, under the load conditions, would breakthrough and be lost during the sample loading step. Care should be taken to make sure each sample volume is loaded at the same rate to make sure the retention efficiency isn't changed because of load rate.

Do you need help developing an SPE method?

There are a lot of choices to make when establishing an SPE method, but the foundations laid out in this article outline the first steps to get started. Solid phase extraction can be thought of as chromatography under a different name. As you delve deeper into developing an SPE method, you may have questions specific to your matrix, target analytes, and analysis. We're here to help because chromatography is what we do.

Contact your local Restek representative today at **www.restek.com/contact-us** with any questions you have about using SPE in your lab.

Resprep CarboPrep Plus SPE Cartridges

- Designed specifically for the cleanup of sample extracts for organochlorine pesticides analysis.
- Excellent alternative to Florisil products, especially for the removal of nonvolatile matrix components that contaminate GC inlets and columns.
- Proprietary treatment renders the carbon consistent and clean, ensuring the same selectivity tube to tube and lot to lot with no interfering background.
- Uses the same hardware, solvents, and solvent volumes as traditional Florisil cleanup, so switching is simple.

Description	Packing	Volume	qty.	cat.#
Resprep CarboPrep Plus SPE Cartridges	CarboPrep Plus	3 mL, 95 mg	30-pk.	25845

25845

Resprep EPH Fractionation SPE Cartridge

- Method-specific performance for extractable petroleum hydrocarbon (EPH) analysis of soil and water samples.
- Complete separation of aliphatic and aromatic compounds into distinct fractions.
- Guaranteed background level under the strict reporting limits of MA and NJ EPH methods.
- Superior lot-to-lot reproducibility and storage stability ensured by rigorous QC testing and moisture-resistant packaging.
- Choose 5 g cartridges for higher loading capacity; use 2 g cartridges for automated systems, time-saving, and solvent reduction.

Description	Method	Packing	Volume	qty.	cat.#
Resprep EPH Fractionation SPE Cartridge	EPH Fractionation: Complete separation of aliphatic and aromatic hydrocarbons into distinct extract fractions. Guaranteed background level under MA and NJ EPH method limits.	Silica packing.	15 mL, 5 g	15-pk.	23240
	EPH Fractionation: Complete separation of aliphatic and aromatic hydrocarbons into distinct extract fractions. Guaranteed background level under MA and NJ EPH method limits.	Silica packing.	6 mL, 2 g	30-pk.	25999

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Certificates of analysis for this product are provided electronically. To view and download your certificate, simply visit www.restek.com/documentation

25999

ordering notes

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- Remove both proteins and phospholipids from biological samples in one easy, high-efficiency procedure.
- Avoid signal suppression by removing interfering phospholipids from the sample matrix.
- No method development—straightforward and effective sample preparation for acids, bases, and neutral compounds.
- Offered in 96-well plate format for high-throughput or automated workflows and in cartridge format for lower throughput applications.
- 3-way versatility for filtration—compatible with all common devices:
  - Vacuum manifolds
  - Positive pressure manifolds
  - Centrifugation

Description	qty.	cat.#
Resprep PLR SPE 96-Well Plate, 25 mg/2 mL each well	ea.	28301

Resprep Polymeric SPE Cartridges and 96-Well Plates

- Silica-free, bonded polymeric material—no unwanted secondary silica interactions, even with basic compounds.
- High surface area—higher loading capacity compared to silica-based sorbents.
- Stable over a wide pH range (0–14)—won't hydrolyze under extreme conditions.
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ordering notes

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Description	Packing	Particle Size	Recommended Analytes	Volume	qty.	cat.#
Resprep Polymeric SPE 96-Well Plate	HLB	30 µm	General-purpose for acids, bases, or neutrals; high capacity for polar compounds.	10 mg	ea.	28453
	HLB	30 µm	General-purpose for acids, bases, or neutrals; high capacity for polar compounds.	30 mg	ea.	28454
Resprep Polymeric SPE Cartridge	HLB	30 µm	General-purpose for acids, bases, or neutrals; high capacity for polar compounds.	1 mL, 30 mg	100-pk.	28449
	HLB	60 µm	General-purpose for acids, bases, or neutrals; high capacity for polar compounds.	3 mL, 60 mg	50-pk.	28450
	HLB	60 µm	General-purpose for acids, bases, or neutrals; high capacity for polar compounds.	6 mL, 200 mg	30-pk.	28264
	HLB	60 µm	General-purpose for acids, bases, or neutrals; high capacity for polar compounds.	6 mL, 500 mg	30-pk.	28265
Resprep Polymeric SPE 96-Well Plate	MAX	30 µm	Acids	10 mg	ea.	28459
	MAX	30 µm	Acids	30 mg	ea.	28460
Resprep Polymeric SPE Cartridge	MAX	30 µm	Acids	1 mL, 30 mg	100-pk.	28455
	MAX	60 µm	Acids	3 mL, 60 mg	50-pk.	28456
	MAX	60 µm	Acids	6 mL, 150 mg	30-pk.	28457
	MAX	60 µm	Acids	6 mL, 500 mg	30-pk.	28458
Resprep Polymeric SPE 96-Well Plate	MCX	30 µm	Bases	10 mg	ea.	28465
	MCX	30 µm	Bases	30 mg	ea.	28466
Resprep Polymeric SPE Cartridge	MCX	30 µm	Bases	1 mL, 30 mg	100-pk.	28461
	MCX	60 µm	Bases	3 mL, 60 mg	50-pk.	28462
	MCX	60 µm	Bases	6 mL, 150 mg	30-pk.	28463
	MCX	60 µm	Bases	6 mL, 500 mg	30-pk.	28464
Resprep Polymeric SPE 96-Well Plate	WAX	30 µm	Strong acids	10 mg	ea.	28471
	WAX	30 µm	Strong acids	30 mg	ea.	28472
Resprep Polymeric SPE Cartridge	WAX	30 µm	Strong acids	1 mL, 30 mg	100-pk.	28467
	WAX	30 µm	Strong acids	3 mL, 60 mg	50-pk.	28468
	WAX	30 µm	Strong acids	6 mL, 150 mg	30-pk.	28469
	WAX	30 µm	Strong acids	6 mL, 200 mg	30-pk.	28292
	WAX	30 µm	Strong acids	6 mL, 500 mg	30-pk.	28268
	WAX	60 µm	Strong acids	6 mL, 500 mg	30-pk.	28470
Resprep Polymeric SPE 96-Well Plate	WCX	30 µm	Strong bases	10 mg	ea.	28477
	WCX	30 µm	Strong bases	30 mg	ea.	28478
Resprep Polymeric SPE Cartridge	WCX	30 µm	Strong bases	1 mL, 30 mg	100-pk.	28473
	WCX	60 µm	Strong bases	3 mL, 60 mg	50-pk.	28474
	WCX	60 µm	Strong bases	6 mL, 200 mg	30-pk.	28475
	WCX	60 µm	Strong bases	6 mL, 500 mg	30-pk.	28476

HLB – Hydrophilic-Lipophilic Balance
MAX – Mixed-Mode, Strong Anion Exchange
MCX – Mixed-Mode, Strong Cation Exchange
WAX – Mixed-Mode, Weak Anion Exchange
WCX – Mixed-Mode, Weak Cation Exchange

Resprep Quick-Replace SPE Vacuum Manifolds (12- or 24-Port)

- Disposable, quick-replace valve liners ensure a clean flow path and eliminate cross-contamination of samples extracted on the same port.
- Individual screw-type valves in each SPE port provide precise flow control.
- Easily modified sample collection rack supports a wide variety of collection vessels.
- Solvent-resistant vacuum gauge and bleed valve offer better sealing and vacuum control.
- Valves are compatible with any standard male luer end SPE cartridge.

Description	Includes	Size	qty.	cat.#
Resprep QR-12 Quick-Replace vacuum manifold	Cover with flow control valves & gasket (cat.# 28316-VM); Collection Rack (cat.# 28318-VM); Plate for 16 mm test tubes (cat.# 28319-VM); 100-pk. Quick Replace liners, PTFE (cat.# 28310-VM); 12-pk. Liner guide (cat.# 28312-VM); 12-pk. Test tubes (cat.# 28315-VM)	12-port	kit	28298-VM
Resprep QR-24 Quick-Replace vacuum manifold	Cover with flow control valves & gasket (cat.# 28323-VM); Collection Rack (cat.# 28325-VM); Plate for 16 mm test tubes (cat.# 28326-VM); 100-pk. Quick Replace liners, PTFE (cat.# 28310-VM); 2, 12-pk. Liner guides (cat.# 28312-VM); 2, 12-pk. Test tubes (cat.# 28315-VM)	24-port	kit	28299-VM

28298-VM

Resprep SLE Cartridges and 96-Well Plates

- Faster and easier than SPE and liquid-liquid extraction: just load, wait 5 minutes, then elute.
- Effective removal of proteins, phospholipids, and salts.
- Quick concentration step increases sensitivity.
- Easy to automate for high-throughput laboratories.
- Suitable for a wide range of sample matrices and analyte pKa values.

Volume guidelines: Selecting an SLE format with sufficient loading capacity (1 mg sorbent to 1µL diluted sample) is very important because the entire sample volume (including 1:1 dilution in buffer) is absorbed into the diatomaceous earth sorbent. For example, a 100 µL sample should be diluted 1:1 with buffer for a total volume of 200 µL, which requires use of a 200 mg SLE product.

Description	qty.	cat.#
Resprep SLE cartridges, 200 mg/3 mL cartridge	50-pk.	28302
Resprep SLE cartridges, 400 mg/3 mL cartridge	50-pk.	28303
Resprep SLE 96-well plates, 200 mg/2 mL each well	1-pk.	28304
Resprep SLE 96-well plates, 400 mg/2 mL each well	1-pk.	28305

28302

ordering notes

Certificates of analysis for this product are provided electronically. To view and download your certificate, simply visit www.restek.com/documentation

25858

Resprep VM-96 Vacuum Manifold for 96-Well Plates

- Heavy-duty, stainless-steel and aluminum body stays in place and does not slide like lighter models.
- Viewing window allows easy observation of plate height and drip rate.
- Durable O-ring and gaskets resist solvent damage and provide leak-free seals time after time.
- Precision-manufactured parts assemble quickly and easily with perfect alignment of well plate and collection plate.
- Customize plate height to your exact requirements: precision height adaptor and five shims in a range of thicknesses allow easy, accurate configuration.
- Works with any manufacturer's well plates and collection plates for solid phase extraction (SPE), supported liquid extraction (SLE), protein precipitation (PPT), and filtration.

Description	qty.	cat.#
Resprep VM-96 vacuum manifold	ea.	25858

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Pure Chromatography

Questions? Contact us or your local Restek representative (www.restek.com/contact-us).

www.restek.com

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