

# Introduction to Evaporation



# Introduction to Solvent Evaporation

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# Introduction to Solvent Evaporation

## Introduction

Solvent removal is an essential process for sample preparation across a range of applications in many industries. Many sample formats and solvents are used with no single technique providing a universal solution, but despite the variety of specifics evaporation is well-understood and relatively uncomplicated.

But while evaporation is an intrinsic step in so many applications it's rare to find an evaporation expert in a laboratory, and many facilities use systems that are slow and cumbersome simply because they have always been used. With the technologies available today there is no reason why evaporation should be either complex or time-intensive, and changing practices can result in benefits in throughput and quality of results.

This guide has been written to provide advice on how solvent evaporation and concentration can be made simple, safe, efficient and effective.

## 1. The basics

### Solvent removal

Evaporation is the process of removing a solvent by vaporising it to a gas from the liquid state. Some solvents evaporate rapidly on their own, while others require the application of heat to speed up the process.

True evaporation occurs only at the liquid surface, while boiling occurs simultaneously throughout the body of liquid. A wide range of types of systems are referred to generically as "evaporators" but in many cases they are actually causing boiling.

Sublimation is the shift from a solid to a gas without passing through the liquid state. Sublimation is the solvent removal process used in freeze drying.

### Types of system

Evaporation systems use heat, vacuum and vapour pressure differential in various combinations to speed up and control the evaporation of solvents.

#### **Nitrogen Blow-Down Evaporation**

In these systems, an inert gas such as nitrogen is blown down through needles onto samples in tubes, vials or microplates to create a flow over the liquid surface. Heat is normally applied to the samples via pre-warming the inert gas and by heating the sample holder to hasten evaporation.

A common use of blow-down is for concentrating large volumes to just a few millilitres for subsequent processing by other techniques. Specialised teat-ended tubes are available for this procedure and some commercial systems have basic automatic stop mechanisms based on liquid level detection.

**Benefits:** The technique enables open access equipment use, and is comparatively inexpensive ranging from self-assembled apparatus to simple commercial systems. Blow down evaporation is relatively fast for volatile solvents.

**Drawbacks:** Nitrogen blow-down can be rather slow for solvents with high boiling points or those that are difficult to evaporate such as water, or solvent mixtures which contain water.

Temperature level and uniformity is difficult to control and samples can be prone to overheating during the process, and consequently the technique offers poor recovery of volatile analytes.

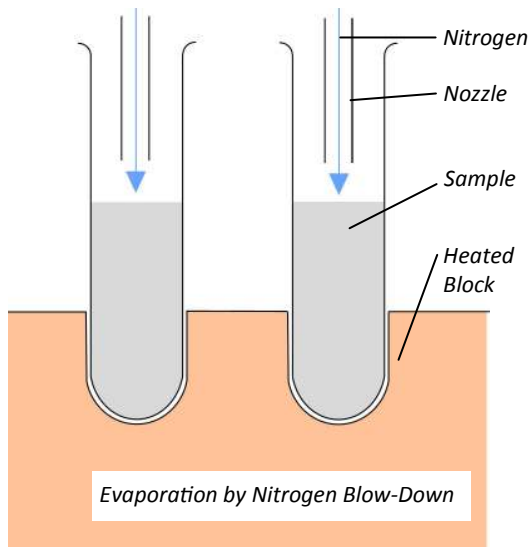
As a manual process blow down evaporation requires continuous monitoring by the user to detect the end point of the drying process. The technique typically achieves poor final dryness and splashing may occur, particularly if the gas flow rate is too high, leading to sample cross-contamination.

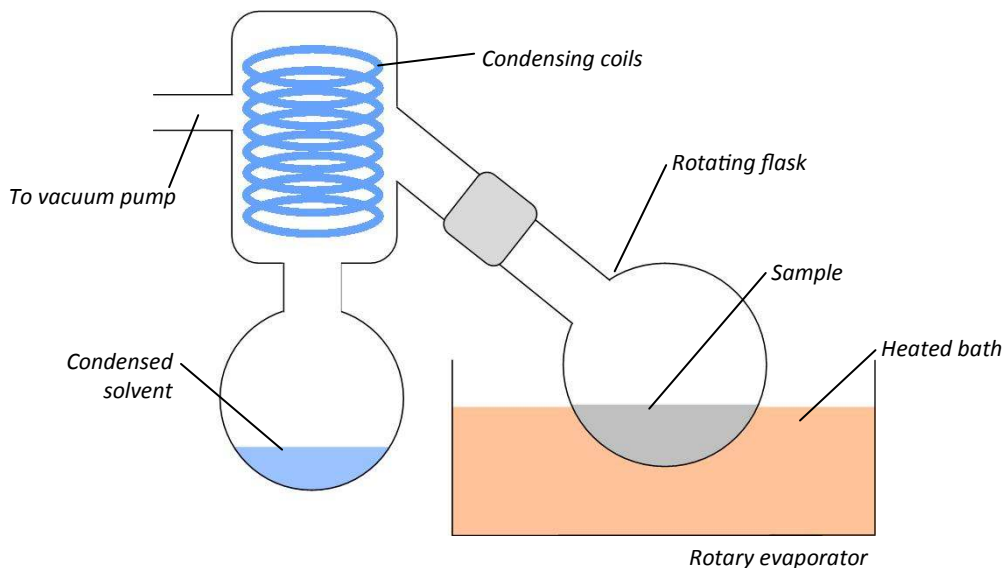
### **Vortex and Rotary Evaporation**

Vortex systems boil batches of samples under vacuum. The lower pressure means a lower temperature is required to boil the solvent, reducing the risk of damaging the analyte. The sample tubes are swirled during the process to create a vortex which creates a large sample surface area for evaporation.

A rotary evaporator is essentially similar, usually only for a single sample contained in a flask.

**Benefits:** The large sample surface area makes evaporation relatively rapid. Some rotary evaporators can be programmed with specific temperature and pressure





parameters to suit different solvents and control bumping. Built-in condensers make solvent recovery easy.

**Drawbacks:** The resultant dried product is spread across the vessel walls, which can make sample recovery more difficult. Moreover the swirling movement generates insufficient g force to prevent solvent bumping and hence vortex evaporators are prone to sample loss and cross contamination. In some vortex systems, evaporation is further accelerated by use of heating lamps directed into the sample vessel, but these systems are prone to overheating all or part of a sample as it becomes dry.

As with nitrogen blow-down, many rotary evaporators require continuous monitoring to manually detect the end of drying and prevent over-drying or heating damage.

### **Vacuum Drying**

By applying a controlled vacuum the boiling point of the solvents can be lowered to the point that the liquid vaporises with only minimal use of additional heat. High performance vacuum pumps ensure the low pressures which are required for faster solvent removal.

Simple vacuum drying is especially suited to products with a high surface area, for example granules. It is commonly used for solid products such as foodstuffs and industrial components where the primary solvent is water.

**Benefits:** The product is safe from heat damage as it remains at a controlled low temperature.

**Drawbacks:** The drop in pressure causes the solvent to boil, which makes this technique unsuitable for liquids. However boiling can be prevented by using a vacuum in combination with other techniques, such as centrifugal force (see centrifugal evaporators) or freezing (see freeze drying).

## **Freeze Drying**

By first freezing the product, freeze drying avoids two of the problems of evaporation: bumping (boiling) and heat damage.

The product is frozen to a point where it is completely solidified – note that this may be significantly lower than the point at which it appears solid. By means of a very low vacuum the solvents are forced to sublime directly to a gas without passing through the liquid phase. Heat is added in a controlled manner to speed up the drying, and the solvents are collected in a condenser.

Freeze drying is used for a wide range of products include pharmaceuticals, foods and for preparing samples for analysis.

**Benefits:** The product is not exposed to excessive temperatures that may cause damage. Both heat and vacuum are precisely controllable, resulting in a safe, specific and repeatable process. The resulting product is a hydrophilic solid.

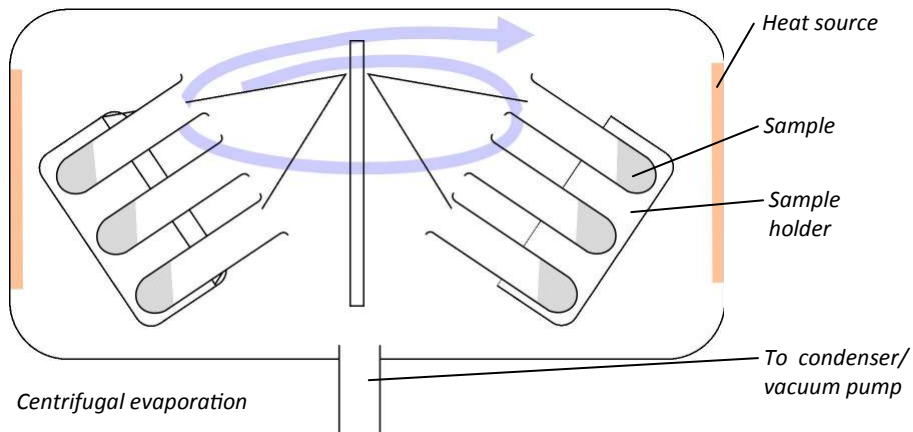
**Drawbacks:** Freeze drying is a comparatively expensive process as it requires the production of very low temperatures. It can also be a long process, with cycles lasting several days being common. Freeze drying is dependent on the solvents being freezable at a reasonable temperature (standard “low temperature” condensers reach as low as  $-85^{\circ}\text{C}$ ) which means many products cannot be effectively freeze dried.

## **Centrifugal Evaporation**

Centrifugal evaporators and concentrators also encourage evaporation by reducing the boiling point of a solvent under vacuum and applying heat. By creating centrifugal g force which confines the evaporation to the very surface of the product, inadvertent boiling and bubbling (“bumping”) can be prevented. Solvent at the liquid surface is at the pressure of the equipment, whereas solvent below this level is at higher pressure due to the extra weight of solvent multiplied by the g force exerted by the centrifuge rotor.

The centrifugal evaporation technique accommodates a wide range of solvents and can concentrate, dry to a film or freeze dry samples.

Benefits: Centrifugation ensures that solvent boils from the sample surface downwards, minimising boiling over and solvent bumping. This prevents sample loss and also means different samples can be evaporated in parallel without cross-contamination. Solvent mixes can be evaporated in a controlled manner by controlling the pressure and heat.



By monitoring product temperature and chamber pressure the end of drying can be automated, preventing over-drying or heat damage.

Samples remain cold but not frozen and so the process can be faster than freeze drying. Cold traps can be used to recover the vapourised solvent.

Drawbacks: Systems with very high rotor speeds generating 500g or more are required to prevent solvent bumping. Care has to be taken with centrifugal evaporation of aqueous samples that are prone to freezing, although these systems can also be used to freeze dry. To ensure good thermal transfer, sample holders must match the container type precisely.

## 2. Avoiding Common Evaporation Problems

When evaporating or concentrating, there are three goals:

- As much product or analyte
- As quickly as possible
- Without causing damaging

# Efficiency

## Analyte recovery

Analyte can be expensive, rare or irreplaceable. Maximising analyte recovery is a matter of losing as little as possible. Product can be lost in a number of ways:

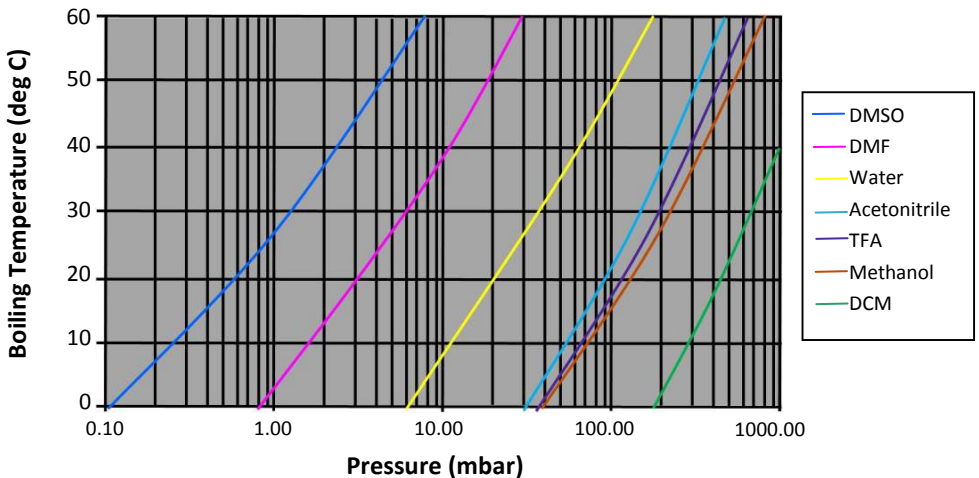
- Product bumping or boiling out of the container while evaporating
- Product being spread around the container after evaporating, making it difficult to access or resolubilise
- Product being left behind transfer between processes or containers, for example transferring to a different container type after evaporation for further processing

## Bumping

“Bumping” refers to uncontrolled boiling or bubbling of evaporating products. Bumping can occur throughout a product or intermittently. Many researchers accept a certain amount of bumping as an inevitable fact of evaporation, but there’s no reason it should be tolerated. The behaviour of solvents at different temperatures and pressures is well understood (see below) and therefore controllable. Established technologies are available that automatically balance heat, vacuum and centrifugal force to safely evaporate solvents and solvent mixes.

As well as losing valuable product, bumping risks cross contamination and could pose a hazard to operators and therefore should be avoided at all costs.

**Boiling Temperature v Chamber Pressure for Common Solvents**





## Product loss in container

When the dry or concentrated product is diluted or reconstituted, the solvent naturally runs to the bottom of the container. Any product further up the sides may be missed. Product tends to end up on the sides of a container when it is rotated or vortexed, or when bumping occurs.

Ideally product evaporation should take place in line with the container, with the analyte concentrated in one place at the bottom. This is not achievable with some types of systems, for example rotary evaporators, but the use of swing-arms or angled rotors in some centrifugal evaporators will help collect the drying sample together at the bottom of the container.

After large volumes of weak solution have been dried down, it can be useful to rinse the container with a small amount of solvent and evaporate again.

## Loss when transferring

Every time product is transferred between containers there will inevitably be some loss. Many processes demand the use of specific container types, in which cases some transfer cannot be avoided altogether, but wherever possible it should be minimised. Evaporating a product directly into the relevant container is one way to reduce this type of loss. Fittings are available for some types of evaporator to allow large volumes to be dried or concentrated directly into a small sample vial.

## Solvent recovery

The simpler types of evaporator do not attempt to capture any of the solvents which are eventually caught by air filters in fume hoods or other environmental controls or vented to atmosphere. In these instances the solvent is unrecoverable and is essentially a waste product.

Cold traps, also known as condensers, are relatively inexpensive and can be fitted to many types of evaporator. As well as capturing the escaping solvents very



*Condenser with removable jug, for safe handling of recovered solvents*

effectively, they also increase the efficiency of evaporation by creating a vapour pressure differential between the vaporising product and the dry atmosphere around the condensing surface.

In mixed-solvent solutions, the different solvents can be evaporated off and captured separately by adjusting temperature and pressure.

## **Speed**

Evaporation is driven by two things: energy (heat) and pressure.

In systems that utilise vacuum, the goal is to reduce the pressure to also reduce the amount of heat required for the solvent to boil. Further reducing the pressure likewise reduces the boiling temperature; alternatively, increasing the temperature encourages boiling.

## **Adding Heat**

When applying heat, both the method of heating and the route from the heater to the sample are key. Sample holders should be constructed of conductive material such as solid metals wherever possible as plastics, glass and hollow holders will act as insulators. The sample holders should also fit the sample container as closely as possible to provide a larger contact surface area. This may require different sets of holders for each container type.

Heated air or gas is a common method of introducing heat energy, but it is not very efficient particularly in vacuum systems where there are not many air molecules available. Heating of the sample holder is more effective, either directly, where the sample holder is static, or by means of radiative heating from heat lamps.

The latest evaporation technology uses pressure controlled, low temperature steam. Thermal transfer to the evaporating solvent, from the steam as it condenses on the cold container surface, is extremely efficient. This system has proved particularly effective for high speed evaporation of large volumes.

As each solvent has a different thermal profile, settings that are ideal for one type may be completely unsuitable for another. In the event of solvent mixes, the solvents should be evaporated off in order of volatility.

## **Controlling conditions**

There is always a limit to how fast drying can be driven. In processes like rotary evaporation and nitrogen blow-down, increasing the heat or vacuum also increases the ferocity of boiling and more product will be lost. Excessive heat will damage most products (see below).

The evaporation conditions must therefore be optimised for each solvent type or mix. The more advanced evaporation systems can automate the selection of parameters for different solvents and solvent mixes to ensure efficiency with a minimal of operator effort.

Analytes that are particularly volatile will require more cautious drying to avoid losing all the analyte, even if bumping does not occur.



*Defrosting a condenser (cold trap) .*

In systems where bumping is suppressed, multiple samples can be processed simultaneously without risk of cross-contamination.

The use of a cold trap can also increase the speed and efficiency of evaporation (see above).

## **Safety**

There are two risks to the product during evaporation: Damage to the product itself, and contamination from other samples.

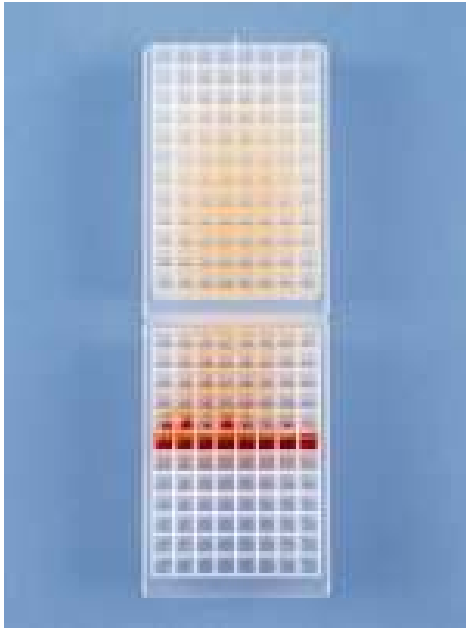
### **Product damage**

Excessive heat affects most types of product, but products that are biological in origin are particularly susceptible to this sort of damage.

Care needs to be taken during drying and especially at the end of drying. While the product is drying evaporation will cool the product and more heat can be tolerated. However when drying has completed this effect will cease and the product temperature will simply increase. This is why over-drying a product can be particularly damaging.

Obviously, any system that relies on operators to manually stop the system is particularly risky. It is not always easy to tell when a sample is dry simply by looking at it and the sample may end up under-dried as well as over-dried.

Some equipment can be programmed to shut off after a set runtime. This system is relatively reliable and easy to use, especially for laboratories handling large numbers of similar samples. Whenever using new products, old products in different volumes or new solvents the new parameters should be calculated and



*An example of cross contamination caused by product bumping out of its original container*

tested carefully before becoming standard procedure. Equipment that can store a number of different programs will make simplify this and prevent programming errors.

The most user-friendly and product-safety-conscious systems are those that automatically sense the endpoint, by monitoring the evaporation rate or detecting the rise in product temperature as evaporative cooling ends.

### **Cross contamination**

The most common cause of cross contamination is from bumping, where product splashes from one container to an adjacent container holding a different sample. Of course the most effective way to prevent this is to prevent bumping altogether (see above). However if this is not

possible, different products should be kept apart from one another and evaporated in separate batches.

Another cause of cross contamination is from condensate. This is particularly relevant to nitrogen blow-down systems, where the escaping vapour can condense on the gas injection needles and drip back into the sample. If several samples are being processed in parallel, the condensate from any or all the samples can condense and contaminate any of the samples. Again the only real solution is to ensure evaporation is conducted in single-product batches.

## **3. Technologies for specific applications**

Evaporation is used in a wide range of applications each with different requirements. Consequently there are many technological innovations that have been developed to accommodate these demands.

### **Heat Sensitive Samples**

Most samples are heat sensitive to some degree. Monitoring the temperature of the heat source is only partly helpful, as evaporation will cause the product to

cool. The end of evaporation is therefore particularly critical, as this cooling effect ceases and the temperature will simply increase.

There are a number of temperature monitoring technologies available. Many systems monitor the temperature of the sample holder, but again this measurement on its own should be used with caution. Probes can be used to directly measure the temperature at any point in any sample container, allowing for real-time feedback and accurate temperature control. Temperature setpoints can be determined based on the solvents involved or on the specific requirements of an analyte. This can be used to determine the end of evaporation either manually or automatically.

In automated systems, monitoring the heatflow combined with temperature control can be used to complete the entire evaporation process or to progress to the next step, for example evaporation of a different solvent, or a lyophilisation step.

## Solvent Mixtures

Solvent mixtures are particularly prone to bumping. “Bumping” is simply boiling in an uncontrolled manner and by controlling the pressure (vacuum) combined with high centrifugal forces bumping can be eliminated. For solvent mixtures evaporation usually involves a multi-step process, where pressures are optimised to evaporate off the solvents in order of volatility. The more sophisticated evaporators can automate this process: by monitoring the heatflow each stage of evaporation can be precisely detected and the system will move on to the next stage.

Volatile solvents will boil off first and collect in the condenser but if they remain in the condenser and are present when higher boiling point solvents are evaporated, the condensed volatiles will boil out of the condenser and may well “spoil” the vacuum. Vacuum spoiling affects final dryness of the samples, considerably lengthens run times and in the very worst cases, the ability to evaporate higher boiling point solvents at all. It also reduces the lifetime of the pump. Auto draining condensers can avoid the effect of



*Solvent mixtures must be evaporated off in order of volatility*

vacuum spoiling with the added bonus that volatile solvents can be collected and safely disposed of, reducing VOC emissions.

A key component of the driving force for efficient evaporation is the trapping power of the condenser which is ultimately more important than the ability to achieve low temperatures. The temperature of the condenser must be low enough to capture the vapour quickly and efficiently, but not so low that condensing power is much reduced.

## High Boiling Point Solvents (eg; DMSO, NMP)

For solvents with high boiling points, simply raising the temperature is not an option as it would damage the sample. In order to lower the solvent boiling point, a higher vacuum (lower pressure) is required. For samples with a boiling point of 165°C or more, a pump is required which can achieve a final pressure of 0.5 mbar or less. Oil free scroll pumps are particularly effective for the highest boiling point solvents.

## Low Auto-Ignition Solvents (eg: Di-Ethyl Ether, Pentane)

Some solvents have a low auto-ignition point which can be extremely hazardous when mixed with air combined with the heating aspect of evaporation. In these instances the air in the evaporator must be replaced with an inert gas such as nitrogen or argon before the process starts. A good gas purge system should also fill the sample chamber with inert gas at the end of the process, keeping sensitive samples which may also be prone to air oxidation under a gas blanket until an operator can safely remove them.

## Volatile Compounds

Most samples can become volatile under the right conditions. Generally, the smaller the size of a molecule the easier it is to volatilise, and this is especially true for organic molecules. However, when a sample is of low molecular weight (less than 300) and/or has high volatility – for example, a straight-chain organic molecule with few side groups – then some sample may also be lost through sublimation during the evaporation process. Good pressure control can prevent this sublimation and it is important to stop the evaporation process as soon as the samples are dry.

## Large volumes

Evaporating large volumes of liquid poses a number of challenges, the most obvious being run times, but also rate of evaporation and condenser performance. When it comes to very large volumes, the size of the centrifuge chamber also

becomes a limiting factor as only containers below a certain size may physically fit. Systems which can automatically draw solvent into the vessel from an external source combined with an auto draining condenser can handle much larger volumes by concentrating the product down in stages. In this way, typical volumes of 5-100 litres can be easily evaporated in a continuous process.

The buildup of large amounts of solvent in the condenser can cause it to function increasingly inefficiently and eventually “overload”. This causes the solvent to bypass the condenser, spoiling the vacuum in the vessel and potentially damaging the vacuum pump. It is possible to simply buy ever bigger condensers, but a simpler solution is a system that can automatically defrost and drain. The latest systems can pause the evaporation process to automatically defrost and resume once the condenser has drained. Either process is automated by the evaporator control system to ensure perfect timing.

The method of heating also becomes critical as it is much harder to uniformly heat larger volumes. Heat lamps are a common heat source, and in large-volume systems high power infrared lamps are common, but these are relatively inefficient and therefore result in slower evaporation rates and usually have little or no temperature control. However the most advanced systems use steam, water is boiled at a low pressure and therefore a safe low temperature. The evaporation of the solvent causes the sample to cool sufficiently so that the steam condenses on the outer surface of the container. This condensation releases maximum energy into the sample far more efficiently than a radiating heat source, ensuring much faster evaporation.

## Sample Concentration

In sample concentration, the starting volume may often be relatively large. The size of the container is therefore important: a small container will not accommodate the large starting volume required, but a large container is not always suitable for very small final amounts. Final analyte quantities may also be extremely small and avoiding losses incurred while manually transferring between containers is particularly important in avoiding poor recoveries.

Specialized concentration accessories are available to meet this requirement. They can hold much larger volumes of solvent than normal, typically up to 500mls, but allow concentration directly into a vial of choice, thus improving recoveries and avoiding manual transfer.

## Corrosive solvents (eg; TFA, HCl, HNO<sub>3</sub>)

Many solvents are corrosive to equipment components, especially anything in rubber, plastic or stainless steel. Evaporating these types of solvent in any non

acid resistant system will cause it to eventually fail, usually irreparably. To prevent damage, susceptible parts must be made in toughened or inert alternatives.

Resistance to TFA (trifluoroacetic acid) is quite common, but systems are available that can also handle even harsher acids such as hydrochloric acid (HCl) and HNO<sub>3</sub> (nitric acid). As the equipment needs to be specially manufactured this capability is usually specified from the beginning as it cannot be retrofitted later.

Many systems that claim to be HCl resistant offer only a slight improvement over standard systems. If you are sourcing an evaporator for work with HCl, ask suppliers for a trial first to establish whether the system will really stand up to the demands.

If external vacuum pumps or cold traps are in use, their tolerance to the solvents should also be established.



*Systems are available that are designed to withstand solvents such as HCl and TFA*

## Lyophilisation

Centrifugal evaporation to dryness traditionally results in a thin film. In some instances this is not always the best result. When working with preparative HPLC solvents, a fully dried compound can sometimes be hard to achieve due to interactions within the sample, occasionally resulting in the formation of a gum or oil which is difficult to reconstitute or remove from the container. A hybrid lyophilisation process can provide a solution to this problem by producing a diffuse dry powder which is easier to redissolve or weigh out. In order to lyophilise in an evaporator, a low temperature condenser and a pump which can achieve full vacuum is required. Generally the volatile component of an organic solvent/water mixture is first removed and the remaining sample is then frozen by carefully controlling the pressure and the condenser emptied before the lyophilisation stage begins.



*A hybrid evaporation / lyophilisation process can produce a dry powder*



The temperature and pressure settings will be different for true freeze drying to those used in hybrid lyophilisation as the sample needs to remain frozen and sublimation requires a higher vacuum than evaporation. Systems are available that can fully automate this process by selecting the correct process settings for the solvents involved.

## Crystallography

Evaporative crystallisation studies for polymorph screening can take a long time, and may be difficult to conduct. Specialised toolkits are now available to enable evaporative crystallisation studies to be carried out in a controlled, repeatable manner. These toolkits enable a wide range of solvents to be evaporated at the same time and at the same slow rate: therefore DCM and Toluene (for example) can be placed in the same system and evaporated such that both solvents dry at the same rate. The evaporation time for each solvent can be precisely controlled to deliver polymorphs of a compound in a controlled and reproducible way.

## Summary

Today a wide range of evaporation and concentration systems are available to accommodate the diversity of applications and samples requiring solvent removal. The correct choice of vacuum pump and cold trap is critical to ensuring optimum evaporation and concentration performance. Pumps with appropriate vacuum level and having high flow rates are recommended, but it is how the vacuum pressure is controlled and optimised for different solvents or solvent mixtures which marks out the boundaries for evaporation. Technology currently exists to



*Different crystal polymorphs can be created in a controlled, repeatable manner*

ensure that sample integrity is maintained at all times so that samples are not lost, overheated or cross contaminated giving confidence to the operator.

Highly efficient cold traps are now available that not only speed concentration and drying rates, but by automatically defrosting and draining recover solvents in liquid form thereby reducing environmental impact and eliminating time lost to defrosting procedures.

## More Information

Do you have more questions? Genevac have been dedicated to the science of evaporation since 1990. For more information visit: [www.genevac.com](http://www.genevac.com)



## **Genevac Products**

### **EZ-2 Personal Centrifugal Evaporators**

The EZ-2 is a compact sample concentrator which combines great performance, ease of use and compatibility with all commonly used solvents and acids. In addition to accommodating many more samples, it can operate entirely unattended. For extra peace of mind with thermally sensitive samples, the EZ-2 temperature control and Auto Stop systems protect your samples during operation. There is no need for special training – just load, set and walk away.



### **HT Series High Throughput Evaporators**

HT series evaporators are ideal for parallel evaporation bottlenecks in high throughput and production laboratories, having high performance and high sample capacities. The multi-layer rotor ensures efficient use of valuable laboratory bench space as well as high performance and high throughput evaporation. Evaporation times do not vary across the HT range, the same overall evaporation time is required to dry a full load of samples in an HT-4X as is required in an HT-8 or HT-12.



### **Rocket Synergy High Speed Centrifugal Evaporators**

Rocket technology enables the rapid evaporation of larger volumes of solvent in parallel and batch processing up to 100 litres—all without supervision. The system controls the whole process, temperature, duration, prevention of bumping and foaming, and stopping the method at the correct point, be that concentrated or fully dry.



### **miVac Sample Concentrators**

miVac is a range of centrifugal vacuum concentrators capable of removing water and organic solvents from a variety of sample formats including tubes, microplates, and vials. Built-in methods optimise the concentration of water and water mixtures, while a range of accessories improve performance and reduce time even further.



## Sample Holders

The correct sample holders should be used for each container. This ensures

- Better heat transfer to the product, which means faster evaporation
- Less container breakage—less product waste
- Smooth operation of evaporator



Genevac manufactures a range of sample holders from high grade aluminium to very precise specifications. Aluminium is an ideal material for high thermal conductivity and low weight. The precision manufacture is important to maximise heat transfer and to minimise container breakages.

Standard aluminium sample holders are hard anodised for protection against all normal organic solvents including TFA, HCl and thionyl chloride.\*

Sample holders are available for a wide range of bottles, tubes, flasks and vials. New holders can also be designed if required.

## Dry Large Volumes Directly into Vials

**SampleGenie®** enables large volumes to be dried or concentrated directly into a small vial, in one simple step.

SampleGenie comprises a large flask to which the vial is joined via an inert seal. Standard flasks, suitable for a range of vials, can be filled up to 250ml, while the GC autosampling version can be filled up to 400ml. The Standard SampleGenie can accept vials up to 70mm in height and 28mm diameter.



## About Genevac

Genevac's high performance centrifugal solvent evaporator systems are designed for use in chemistry, biology and analytical science applications and are in use in laboratories worldwide.

## Why Genevac?

Genevac endeavours to provide the highest quality products, service and support. This is achieved through a unique range of innovative, high performance products and a commitment to customer satisfaction.

Genevac's continuous programme of collaborative research has led to the development of many unique features which are designed to ensure optimum evaporation conditions and sample integrity.

### Sample Protection

SampleGuard and SampleShield temperature control are found on HT High Throughput systems and EZ-2 personal evaporator series. These technologies monitor and control the maximum temperature of the samples to protect them from any possibility of overheating when evaporation is complete. The unique Dri-Pure system prevents solvent bumping and consequent loss of product or cross-contamination.

### High Speed Evaporation

CoolHeat technology dries samples rapidly while the high speed vapour pumping mechanism maintains low sample temperatures during evaporation.

The revolutionary SpeedTrap cold trap provides high performance solvent trapping and is incredibly simple to use.

Patented Rocket Technology, used in the Rocket series evaporators, enables very fast evaporation with the highest levels of safety for both user and sample.

### HCl resistance

Genevac evaporators are robust systems designed to be resistant to the most common solvents and acids used within the chemistry laboratory, including TFA, DCM (methylene chloride), and DMSO.

For more information visit [www.genevac.com](http://www.genevac.com)



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