Principles and chemical compatibility chart

Laboratory filtration

cytiva

Filtration simplified

Basic filtration concepts and terms

Selecting a filter with the appropriate properties can help you achieve accurate results and reach discovery faster. But with so many types of filters to choose from, how can you be sure you're making the right choice? Cytiva, maker of Whatman™ brand filtration products, has assembled this compilation of basic filtration concepts and terms to clarify the various options available to you and speed up your selection process.

Ash content

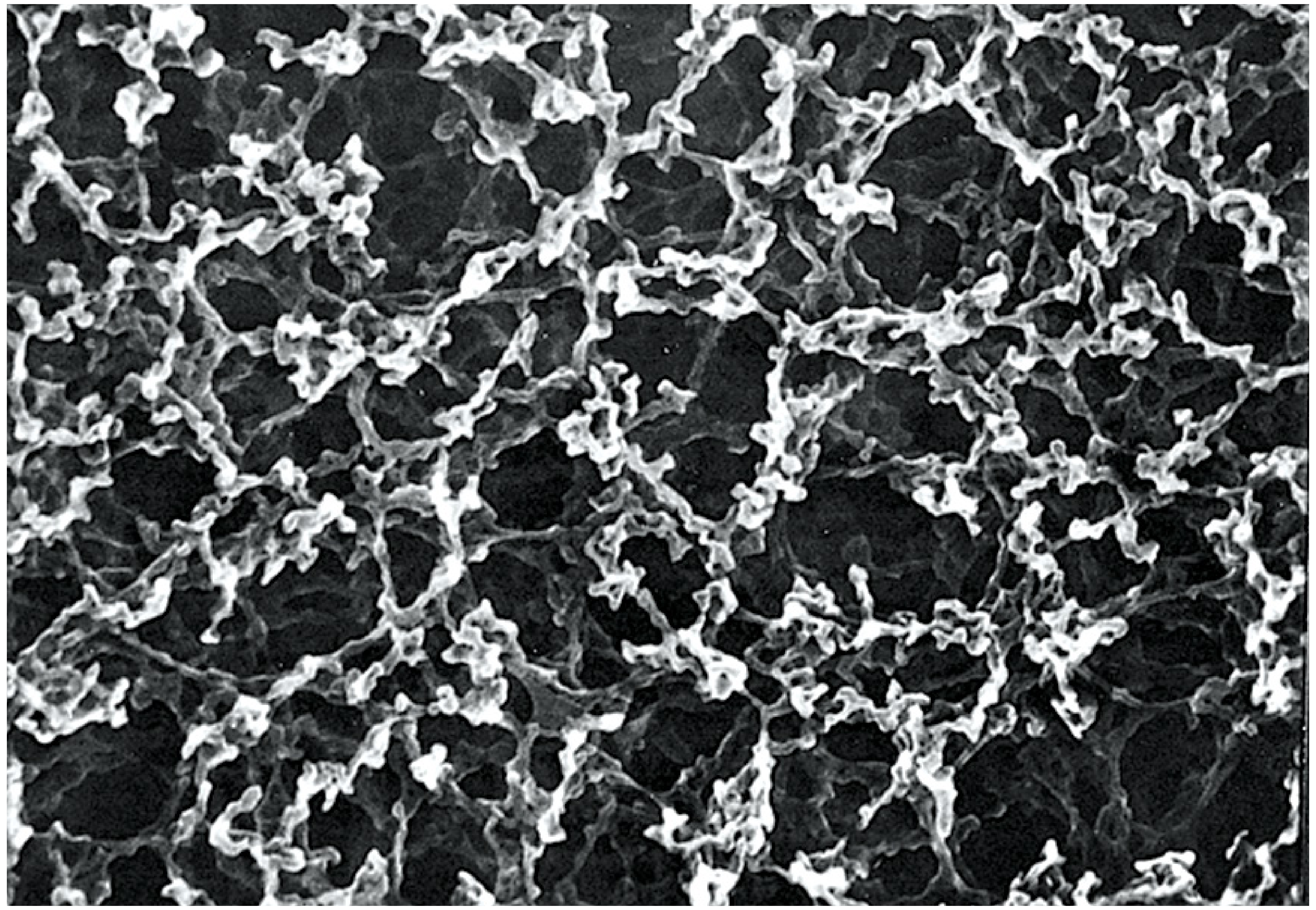
Determined by ignition of the cellulose filter at 900°C in air. Minimizing ash content is essential in gravimetric applications and also a useful measure of the level of general purity.

Chemical compatibility

It is very important to ensure that the structure of the filter media will not be impaired by exposure to certain chemicals. In addition, exposure to these chemicals should not cause the filter to shed fibers or particles, or add extractables. Length of exposure time, temperature, concentration and applied pressure can all affect compatibility. Cytiva has provided chemical compatibility charts to aid your filter selection.

Depth filters

Depth filters are usually characterized as filters that retain particles on the surface and within the filter matrix. All conventional fibrous filters (whether manufactured from cellulose, borosilicate glass microfiber or other fibrous material) are depth filters and are normally characterized by good loading capacity.



Membrane filters allow the efficient retention of submicron particulates and organisms.

Hydrophilic

Because hydrophilic filters possess an affinity for water and can be wetted with virtually any liquid, they are typically used for aqueous solutions and compatible organic solvents.

Hydrophobic

These types of filters repel water, and are thus best suited for filtering organic solvents as well as for venting and gas filtration applications.

Liquid flow rate (including Herzberg method)

Under practical filtration conditions, the liquid flow rate will depend on a number of factors, many of which will be specific to the solid/liquid being filtered. In order to compare filter performances, a standardized set of conditions is required which will characterize liquid flow rate for a given filter without the complicating secondary effects derived from the presence of particulates.

Liquid flow rate can be quantified by a variety of methods. For example, the Herzberg flow rate test where prefiltered, deaerated water is applied to the test filter (effective area 10 cm^2) at a constant hydrostatic head (10 cm). The rate of the flow is measured in seconds per 100 mL.

Flow rate can also be measured by the modified ASTM method which uses a quadrant folded filter held in a wire loop.

Glass microfiber filters are manufactured from 100% borosilicate glass.

Loading capacity

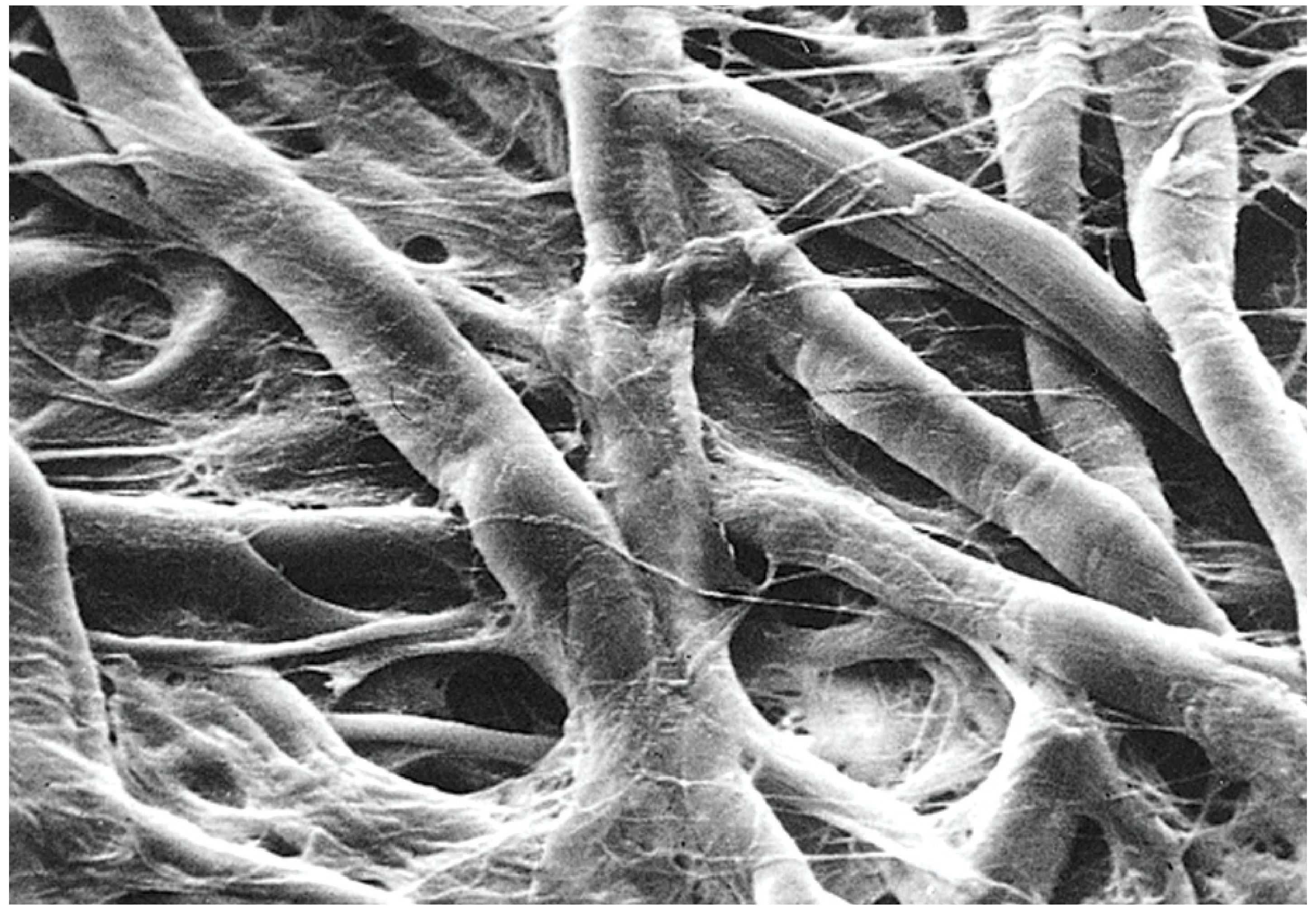
This relates to the ability of a filter to load particulates into the fibrous matrix while maintaining a practical filtration speed and a workable pressure differential across the filter. In general, glass microfiber filters have a high loading capacity when compared with cellulose filters of the same retention rating and thickness. Membranes have inherently low loading capacity.

Particle retention (air/gas)

Retention mechanisms for removing particulates from air or gas enable much higher efficiencies to be realized than those applicable to liquids. Efficiencies for air filtration are normally expressed as percent penetration or retention for a stated airborne particle size. The dioctyl phthalate (DOP) test is commonly used, wherein the filter is tested with an aerosol containing 0.3 µm particles.

Particle retention (liquid)

In a filtration process, the particle retention efficiency of a depth-type filter is often expressed in terms of the particle size (in µm) at which a set level of the total number of particles initially testing the filter is obtained. It is customary to quote the retention levels at 98% efficiency to allow for secondary filtration effects.



Whatman cellulose filter papers exhibit particle retention levels down to 2.5 µm.

Pore size (membranes)

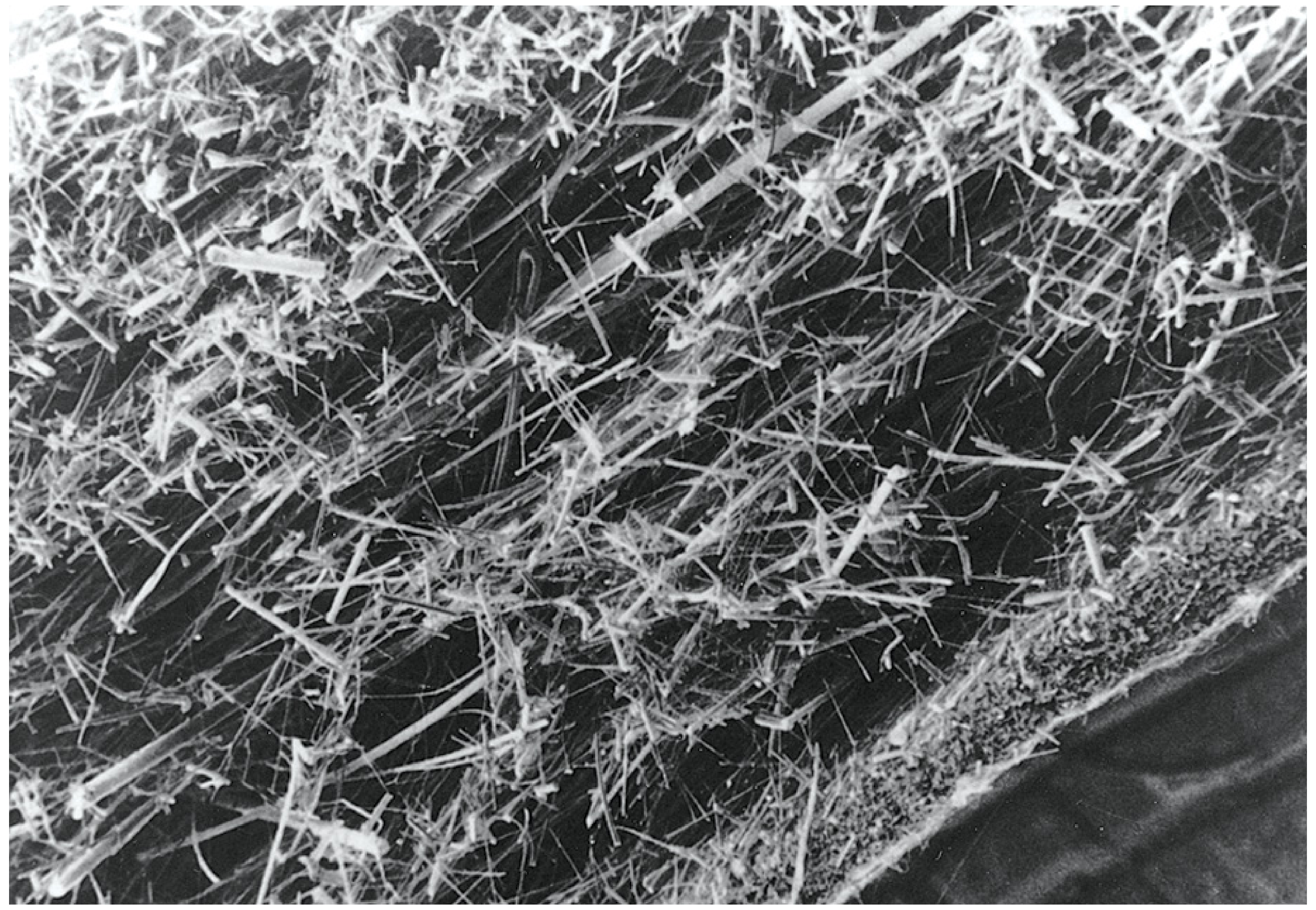
The pore size, usually stated in micrometers (µm), of Whatman membranes is based upon bubble point. Pore size ratings are nominal for all membranes apart from those for Track-Etch and Anopore™. For Track-Etch and Anopore membranes the pore sizes are absolute, as these membranes have true pores (i.e., a top to bottom hole through the membrane).

Prefilters

The life of a membrane filter can be extended many times by placing a prefilter upstream of the membrane. The total particulate load challenging the membrane is considerably reduced thus allowing the membrane to operate efficiently.

Screen or surface filters

Membrane filters are generally described as screen filters because particles are almost entirely trapped on the filter surface. The narrow effective pore size distribution of Whatman membrane filters is one of their major features.



Multigrade GMF 150 combines two filters in one for fast, effective, multilayered filtration.

Filter types and filter holders

Filter papers

The Whatman brand qualitative and quantitative filter papers are, with few exceptions, manufactured from high-quality cotton linters that have been treated to achieve a minimum alpha cellulose content of 98%. These cellulose filter papers are used for general filtration and exhibit particle retention levels down to 2.5 µm. There is a wide choice of retention/flow rate combinations to meet the needs of numerous laboratory applications. The different groups of filter paper types offer increasing degrees of purity, hardness and chemical resistance. Whatman quantitative filter papers have extremely high purity to allow for analytical and gravimetric work.

Glass microfiber filters (GMF)

The properties of borosilicate glass microfibers enable Cytiva to manufacture filters with retention levels extended into the submicron range. These depth filters combine fast flow rate with high loading capacity and retention of very fine particulates. Due to the high void volume exhibited by glass microfiber filters, the loading capacity is considerably higher than for a cellulose filter of similar retention. Glass microfiber filters must be used flat and should not be folded. Whatman glass microfiber filters are manufactured from 100% borosilicate glass and most are completely binder-free. Binder-free glass microfiber filters will withstand temperatures up to 550°C and can therefore be used in gravimetric analysis where ignition is involved.

Membrane filters

Unlike cellulose and glass microfiber depth filters, membrane filters are conventionally classified as surface filters because the filter matrix acts as a screen and retains particulates almost entirely on the smooth membrane surface. The retention levels for these filters extend down to 0.02 µm and allow the efficient retention of sub-micron particulates and organisms. Water microbiology and air pollution monitoring are major applications for membranes.

Standard circle funnel volumes

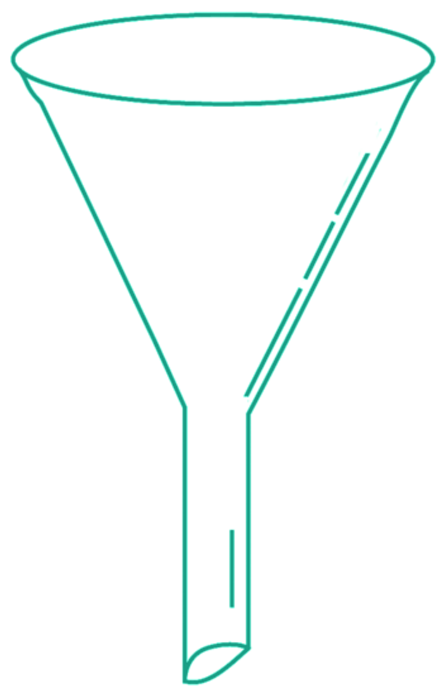
The maximum practical volume of the most popular circle sizes (quadrant folded) is given in the following chart. Membrane and glass microfiber filters are used flat.

Diameter (cm)	Volume (mL)
9	15
11	20
12.5	35
15	75
18.5	135
24	300

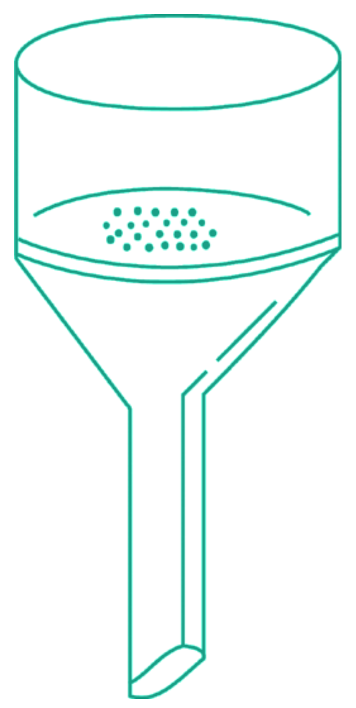
Types of filter holders

A filter matrix requires a suitable support structure to enable it to be used for the filtration of liquids or gases. One of the simplest forms of holder is the conical glass filter funnel into which a quadrant folded or fluted filter paper is placed (A). Some applications require additional motivating force for the solid particulate/liquid separation to occur (i.e., vacuum assisted filtration). This type of filtration can be carried out in a one-piece Büchner style funnel (B) where the filter is used flat on a perforated base sealed into the funnel. Due to the difficulties encountered in cleaning this type of funnel, the demountable 3-piece funnel was developed (C). The Whatman 3-Piece Filter Funnel can be fully disassembled and enables the filter paper to be securely clamped between the support plate and filter reservoir flange. Membrane holders (D) incorporate either sealed-in sintered glass or removable stainless steel mesh supports for the membrane. Syringe and in-line filters are also available. Large diameter membranes are typically used in pressure holders.

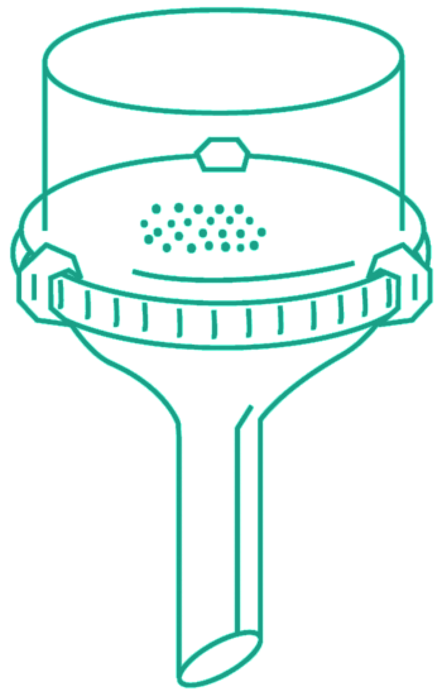
(A)



(B)



(C)



(D)

Selecting the right filter

The selection of a laboratory filter depends on the conditions and objectives of the experiment or analytical procedure.

The three most important characteristics of any laboratory filter are:

- Particle retention efficiency
- Fluid flow rate through the filter
- Loading capacity

In addition, according to the particular application, other important characteristics may require examination. For instance, wet strength, chemical resistance, purity and ash level may assume equal importance under certain circumstances.

The vacuum level placed across a filter will influence the flow rate, however it is not a linear relationship. For example, for depth filters, it has been found that when the vacuum increases over about 5 cm Hg, no significant increase in flow rate occurs. Generally, the optimum vacuum level is between 2-5 cm Hg. The type of support under the filter can also play a significant role in the level of vacuum that can be applied to a fibrous material.

Possible formats

Much of Cytiva's filtration media are available in flat format or encapsulated.

Standard 58° or 60° funnels

Glass/Polyethylene funnel diameter (mm)	Filter paper size (cm)
35	5.5
45	7.0
55	9.0
65	11.0
75	12.5
90	15.0
100	18.5
160	24.0
180	32.0
220	40.0
260	50.0

Büchner funnel filter selection

Diameter (mm)	Perforated area (mm)	Filter paper size (mm)
43	32	42.5
63	42	55
83	60	75
100	77	90
114	95	110
126	105	125
151	135	150
186	160	185
253	213	240

Typical particle sizes

		µm
Gelatinous precipitates	Metal hydroxides	25–40
	Precipitated silica	25–40
Crystalline precipitates	Ammonium phosphomolybdate	20
	Calcium oxatate	15
	Lead sulfate	10
	Barium sulfate (hot ppt.)	8
	Barium sulfate (cold ppt.)	3
Blood cells	Platelets	2–3
	Erythrocytes (average)	7
	Polymorphs	8–12
	Small lymphocytes	7–10
	Large lymphocytes	12–15
	Monocytes	16–22

		µm
Bacteria*	Cocci	0.5
	Bacilli	1.0 × (2.0–6.0)
	Serratia marcescens	0.5 × (0.5–1.0)
	Pneumococcus	1.0
	Bacillus tuberculosis	0.3 × (2.5–3.5)
	Amoeba	12–30
	Escherichia Coli	0.5 × (1.0–3.0)
	Smallest bacteria	0.22
Other microorganisms, etc.	Yeast cells	2.0–8.0
	Tobacco smoke	0.5
	Colloids	0.06–0.30
	Rye grass pollen	34
	Ragweed pollen	20
	Puffball spores	3.3

* Where bacteria are rod-shaped, range of lengths is given in brackets

Membrane information

Polytetrafluoroethylene (PTFE)

Hydrophobic membrane. Resistant to organic solvents as well as strong acids and bases. Low protein binding. Low in extractables. Main applications are the filtration of non-aqueous samples. Prior to filtering of aqueous samples the membrane must be pre-wetted with a water-miscible organic solvent.

Polyvinylidene difluoride (PVDF)

Hydrophilic membrane. Resistant to a broad range of organic solvents. Low protein binding.

Polypropylene (PP)

Slightly hydrophobic membrane. Resistant to a wide range of organic solvents.

Polyethersulfone (PES)

Hydrophilic membrane. Broad solvent compatibility. Suitable for filtration of aqueous and compatible organic solvents. Higher liquid flow than either PTFE or PVDF. Low in extractables. Low protein binding.

Nylon/polyamide (NYL)

Hydrophilic membrane. Resistant to a range of organic solvents. Suitable for use with high pH samples. Binds proteins, which makes it unsuitable for protein recovery applications.

Cellulose acetate (CA)

Hydrophilic membrane. Limited solvent resistance. Very low protein binding capacity, which makes it an excellent choice for protein recovery applications.

Cellulose nitrate (CN)

Hydrophilic membrane. Limited resistance to organic solvents. High liquid flow rate. High protein binding capacity, which makes it unsuitable for protein recovery applications.

Regenerated cellulose (RC)

Hydrophilic membrane. Resistant to a very wide range of solvents. Suitable for use with either aqueous solutions or organic solvents. Compatible with HPLC solvents. Very low protein binding capacity, which makes it an excellent choice for protein recovery applications.

Anopore (ANP) (membrane used in Anotop™ filters)

Anopore™ is a hydrophilic membrane with excellent organic solvent compatibility. Suitable for use with both aqueous and organic samples. The membrane has very tight pore-size distribution. Not suitable for use with very acidic or very basic samples.

Glass microfiber/glass fiber (GMF/GF)

Hydrophilic material. Excellent compatibility with organic solvents and strong acids (apart from hydrofluoric acid) and bases. Either used as a prefilter or as a final filter.

Chemical compatibility of membranes and housings

Solvent	ANP	CA	CN	PC	PE	GMF	NYL	PP	DpPP	PES	PTFE**	PVDF	RC
Acetic acid, 5%	R	LR	R	R		R	R	R	R	R	R	R	R
Acetic acid, glacial	R	NR	NR			R	LR	R	R	R	R	R	NR
Acetone	R	NR	NR	NR	R	R	R	R	R	NR	R	NR	R
Acetonitrile	R	NR	NR			R	R	R	R	NR	R	R	R
Ammonia, 6N	NR		NR	NR	LR	LR	R	R	R	R	R	LR	LR
Amyl acetate	LR	NR	NR	NR	R	R	R	R	R	LR	R	LR	R
Amyl alcohol	R	LR	LR			R	R	R	R	NR	R	R	R
Benzene*	R	R	R	NR	R	R	LR	NR	NR	R	R	R	R
Benzyl alcohol*	R	LR	LR	LR	R	R	LR	R	R	NR	R	R	R
Boric acid	R	R	R	R	R	R	LR	R	R		R	R	R
Butyl alcohol	R	R	R	R	R	R	R	R	R	R	R	R	R
Butyl chloride*						R	NR	NR	NR		R	R	
Carbon tetrachloride*	R	NR	R	LR	R	R	LR	NR	NR	NR	R	R	R
Chloroform*	R	NR	R	NR	R	R	NR	LR	LR	NR	R	R	R
Chlorobenzene*	R		LR	NR		R	NR	LR		NR	R	R	R
Citric acid						R	LR	R		R	R	R	R
Cresol*		NR	R			R	NR	NR	NR	NR	R	NR	R
Cyclohexanone	R	NR	NR			R	NR	R	R	NR	R	R	R
Cyclohexane*	R	NR	NR	R	R	R	NR	NR	NR	NR	R	R	R
Diethyl acetamide		NR	NR			R	R	R	R		R	NR	R
Dimethyl formamide	LR	NR	NR			R	R	R	R	NR	R	NR	LR
Dioxane	R	NR	NR	NR	R	R	R	R	R	LR	R	LR	R
DMSO	LR	NR	NR	NR	R	R	R	R	R	NR	R	LR	LR
Ethanol	R	R	NR	R	R	R	R	R	R	R	R	R	R
Ethers*	R	LR	LR	R	R	R	R	NR	NR	R	R	LR	R
Ethyl acetate	R	NR	NR	NR	R	R	R	R	R	NR	R	NR	R
Ethylene glycol	R	LR	LR	R	R	R	R	R	R	R	R	R	R

Continues on next page

Solvent	ANP	CA	CN	PC	PE	GMF	NYL	PP	DpPP	PES	PTFE**	PVDF	RC
Formaldehyde	LR	LR	R	R	R	R	R	LR	LR	R	R	R	LR
Freon TF*	R	R	R	R	R	R	NR	NR	NR	R	R	R	
Formic acid		LR	LR			R	NR	R	R	R	R	R	LR
Hexane	R	R	R	R	R	R	R	R	R	R	R	R	R
Hydrochloric acid, conc*	NR	NR	NR	NR	NR	R	NR	LR	LR	R	R	R	NR
Hydrofluoric acid*		NR	NR			NR	NR	LR	LR		R	R	NR
Isobutyl alcohol	R	LR	LR	R	R	R	R	R	R		R	R	R
Isopropyl alcohol	R	R	LR			R	R	R	R		R	R	R
Methanol	R	R	NR	R	R	R	R	R	R	R	R	R	R
Methyl ethyl ketone	R	LR	NR	NR	R	R	R	R	R	NR	R	NR	R
Methylene chloride*	R	NR	LR			R	NR	LR	LR	NR	R	R	R
Nitric acid, conc*		NR	NR	LR	NR	R	NR	NR	NR	NR	R	R	NR
Nitric acid, 6N*		LR	LR			R	NR	LR	LR	LR	R	R	LR
Nitrobenzene*	LR	NR	NR	NR	R	R	LR	R	R	NR	R	R	R
Pentane*	R	R	R	R	wR	R	R	NR	NR	R	R	R	R
Perchloro ethylene*	R	R	R			R	LR	NR	NR	NR	R	R	R
Phenol 0.5%	LR	LR	R			R	NR	R	R	NR	R	R	R
Pyridine	R	NR	NR	NR	R	R	LR	R	R	NR	R	NR	R
Sodium hydroxide, 6N	NR	NR	NR	NR	NR	NR	LR	R	R	R	R	NR	NR
Sulfuric acid, conc*	NR	NR	NR	NR	NR	R	NR	NR	NR	NR	R	NR	NR
Tetrahydrofuran*	R	NR	NR			R	R	LR	LR	NR	R	R	R
Toluene*	R	LR	R	NR	R	R	LR	LR	LR	NR	R	R	R
Trichloroethane*	R	NR	LR	NR	R	R	LR	LR	LR	NR	R	R	R
Trichloroethylene*	R		R			R	NR	LR	LR	NR	R	R	R
Water	R	R	R	R	R	R	R	R	R	R	R	R	R
Xylene*	R	R	R			R	LR	LR	LR	LR	R	R	R

R = Resistant; LR = Limited Resistance; NR = Not Recommended

* Short-term resistance of housing

The above data is to be used as a guide only. Testing prior to application is recommended.

** Membrane may need pre-wetting with isopropanol/methanol if filtering a polar liquid

Material abbreviations:

ANP — Anopore
CA — Cellulose Acetate
CN — Cellulose Nitrate
DpPP — Polypropylene Depth Filter
GMF — Glass Microfiber
NYL — Nylon
PC — Polycarbonate
PE — Polyester
PES — Polyethersulfone
PP — Polypropylene
PTFE — Polytetrafluoroethylene
PVDF — Polyvinylidene Difluoride
RC — Regenerated Cellulose

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