

Centrifugal Devices for Ultrafiltration & Microfiltration

Nanosep[®], Microsep[™], Macrosep[®], and Jumbosep[™] Devices

A full range of precise, high-performance products to rapidly process volumes from 50 μ L to 60 mL

- **Speed processing** – quickly concentrate samples from starting volumes of < 50 μ L to 60 mL.
- **Ease visual identification** – devices are color-coded for a wide variety of membranes, ranging from 1 kD to 0.45 μ m.
- **Maximize sample recovery** – obtain high flow rates and low non-specific protein and nucleic acid binding with Omega[™] PES membrane.
- **Minimize binding** – low binding Bio-Inert[®] and GHP membranes allow the greatest recovery of samples requiring microfiltration.
- **Prevent solution bypass** – membrane seals stop solution leakage, eliminating sample loss.



Applications

Centrifugal devices can replace traditional separation techniques such as column chromatography, preparative electrophoresis, alcohol or salt precipitation, dialysis, and gradient centrifugation when performing the following:

- Protein or nucleic acid concentration
- Desalting
- Buffer exchange
- Deproteinization of biological samples
- Fractionation of protein mixtures
- Separation of primers from PCR products
- Separation of labeled nucleic acids or proteins from unincorporated nucleotides
- Virus concentration or removal
- Clarification of cell lysates and tissue homogenates

Color Coding

Pall centrifugal devices are color coded for easy visual identification of the MWCO or pore size as indicated.

MWCO/Pore Size	Color
3K	gray
10K	blue
30K	red
50K	green
100K	clear
300K	orange
1,000K	purple
0.2 μ m	aqua
0.45 μ m	wildberry or clear

Selecting the Right Centrifugal Device

Centrifugal devices are ideal for many small-scale laboratory operations. These products can be used to process samples ranging from 50 µL to 60 mL in volume.

Sample Volume

The first consideration in selecting the correct centrifugal device is the volume of starting material. Devices are available in a range of sizes that accommodate the following sample volumes:

Device	Sample Volume
Nanosep® Device	50 µL to 500 µL
Microsep™ Device	500 µL to 3.5 mL
Macrosep® Device	1 mL to 15 mL
Jumbosep™ Device	15 mL to 60 mL

Table 1
Solute Retention Characteristics

Typical Solute Retention+

Solute+	MWCO ⁺⁺⁺										
		1K	3K	5K	10K	30K	50K	100K	300K	1000K	
Sucrose (0.34K)	●	●	●								
Raffinose (0.5K)	●	●	●								
Vitamin B-12 (1.3K)	▲	■	■								
Bacitracin (1.4K)	◆	▲	▲	■	■	●					
Insulin (5.72K)	x	x	x	x	▲						
Cytochrome C (12.5K)	x	x	◆	▲	■						
Ribonuclease A (13.5K)		◆	◆	▲	■						
α-Lactalbumin (14.2K)		x	x	▲	■	▲					
Lysozyme (14.4K)		◆	◆	▲	▲	▲					
Myoglobin (17.8K)		x	x	x	▲	▲	●				
α-Chymotrypsinogen A (24.5K)				◆	◆	■	●				
β-Lactoglobulin B (36K)			x	x	▲	▲					
Ovalbumin (44K)				x	x	▲	●				
Albumin (67K)				x	x	◆	●				
Alcohol Dehydrogenase (150K)						▲	■	■			
IgG (160K)						x	x	■			
β-Amylase (200K)							◆	■			
Apoferitin (443K)						x	▲	▲			
Urease (90 - 650K)						x	▲	■	●		
Thyroglobulin (669K)							x	x	●		
IgM (960K)							x	x	▲		
Bovine Serum						x	▲	▲	●		
Latex Beads (0.085 µm)							x	x	▲		
Latex Beads (0.137 µm)								x	x	▲	
Latex Beads (0.212 µm)										x	

- 1 - 4% + Data derived using stirred cells
 - 5 - 10% ++ 0.1 - 0.2% buffered solutions at 3.7 bar (55 psi)
 - ▲ 20 - 80% +++ Molecular Weight Cutoff (Daltons)
 - ◆ 85 - 95%
 - x 96 - 99%
- Actual retentions and selectivities may vary with pressure, shape, presence of other solutes, adsorption, and ionic conditions.

Molecular Weight Cutoff

Once the device type or sample volume is determined, the next step is to select the appropriate membrane molecular weight cutoff (MWCO, for ultrafiltration) or pore size (µm, for microfiltration). In general, a MWCO should be selected that is three to six times smaller than the molecular weight of the protein to be retained. Other factors can also impact the selection of the appropriate MWCO. For example, if flow rate (or processing time) is a major consideration, selection of a membrane with a MWCO toward the lower end of this range (3x) will yield higher flow rates. If recovery is the primary concern, selection of a tighter membrane (6x) will yield maximum recovery (with a slower flow rate). Table 1 lists typical solute retention properties of Pall Life Sciences ultrafiltration membranes as a function of MWCO. These values should be used as a general guide, as solute retention and selectivity can vary depending on many factors, such as transmembrane pressure, molecular shape or structure, solute concentration, presence of other solutes, and ionic conditions.

The above general rules apply only to globular molecules such as proteins. Nucleic acid molecules in solution behave differently due to their unique biochemical properties. Use Table 2 as a guide to selecting the appropriate MWCO for DNA/RNA applications.

Table 2
MWCO Selection Recommendations

MWCO Selection for Nucleic Acid Applications

MWCO	Base Pairs (DS)	Bases (SS)
1K	5 - 16 Bp	9 - 32 Bs
3K	16 - 32 Bp	32 - 65 Bs
5K	25 - 50 Bp	50 - 95 Bs
10K	50 - 145 Bp	95 - 285 Bs
30K	145 - 285 Bp	285 - 570 Bs
50K	240 - 475 Bp	475 - 950 Bs
100K	475 - 1,450 Bp	950 - 2,900 Bs

MWCO Selection for Protein Applications

MWCO	Membrane Nominal Pore Size*	Biomolecule Size	Biomolecule Molecular Weight
1K			3K - 10K
3K			10K - 20K
5K			15K - 30K
10K			30K - 90K
30K			90K - 180K
50K	5 nm	15 - 30 nm	150K - 300K
100K	10 nm	30 - 90 nm	300K - 900K
300K	35 nm	90 - 200 nm	900K - 1,800K

MWCO Selection for Virus Applications

MWCO	Membrane Nominal Pore Size*	Virus or Particle Diameter
50K	5 nm	15 - 30 nm
100K	10 nm	30 - 90 nm
300K	35 nm	90 - 200 nm
1000K	100 nm	300 - 600 nm

A 100K device should be used to concentrate PCR** products (regardless of size) if primer removal is required or if adapters are to be recovered from restriction digests.

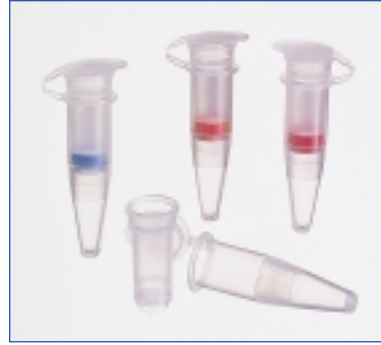
*Nominal pore size as measured by electron microscopy (50K is an estimate).

**PCR technique is a proprietary technology of Roche.

Nanosep® & Nanosep MF Centrifugal Devices

Simple, reliable concentrating and desalting of 50 to 500 µL samples in just 5 to 15 minutes

- Rapid processing of samples.
- Typical recoveries are greater than 90%. Available with low protein-binding Omega™, Bio-Inert® or GHP membranes.
- A wide range of MWCOs, color-coded for easy identification.
- Constructed of low binding polypropylene.
- Ultrasonically welded seals prevent bypass or seal failure.
- Fits standard centrifuge rotors that accept 1.5 mL tubes.



Applications

- Concentrate, purify, and desalt peptides, proteins, oligonucleotides, DNA, and RNA
- Clean up labeling and PCR reactions
- Isolate DNA from agarose gel slices
- Separate proteins, oligonucleotides, and RNA from acrylamide gels
- Sample preparation for HPLC analysis

Specifications

Materials of Construction

Nanosep Devices

Filter Media: Omega membrane (low protein-binding, modified polyethersulfone on polyethylene substrate)

Filtrate Receiver: Polypropylene

Nanosep MF Devices

Filter Media: Bio-Inert (modified nylon) or GH Polypro (GHP, hydrophilic polypropylene) membrane

Filtrate Receiver: Polypropylene

Effective Filtration Area

0.28 cm²

Centrifuge

Fits rotors that accept 1.5 mL tubes

Dimensions

Overall Length (fully assembled with cap): 4.5 cm (1.77 in.)

Capacities

Maximum Sample Volume: 500 µL

Final Concentrate Volume: 15 µL

Filtrate Receiver Volume: 500 µL

Hold-up Volume (membrane/ support): < 5 µL

Operating Temperature Range

0 - 40 °C (32 - 104 °F)

pH Range

Nanosep Devices: 1 - 14

Nanosep MF Devices: 3 - 14

Maximum Centrifugal Force

14,000 x g

Sanitization

Provided non-sterile; may be sanitized by filtering 70% ethanol through the device prior to use.

Performance

Figure 1

Nanosep® Centrifugal Devices Provide the Fastest Spin Times Available for 500 μ L Devices

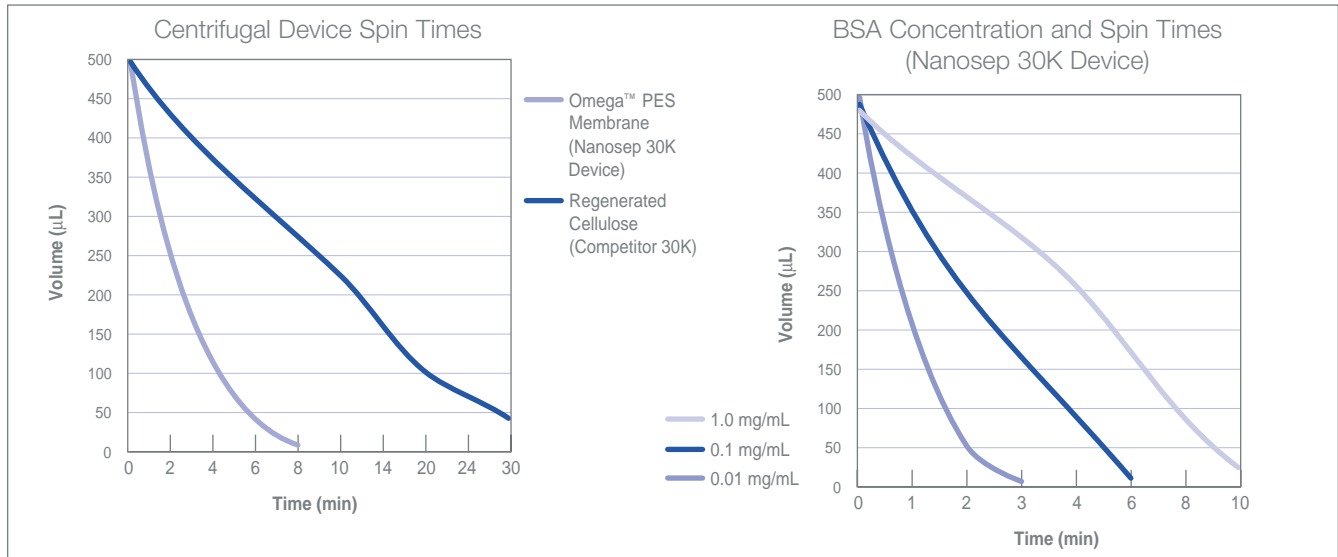


Figure 2

Nanosep Centrifugal Devices are Low Protein Binding and Provide High Protein Recoveries

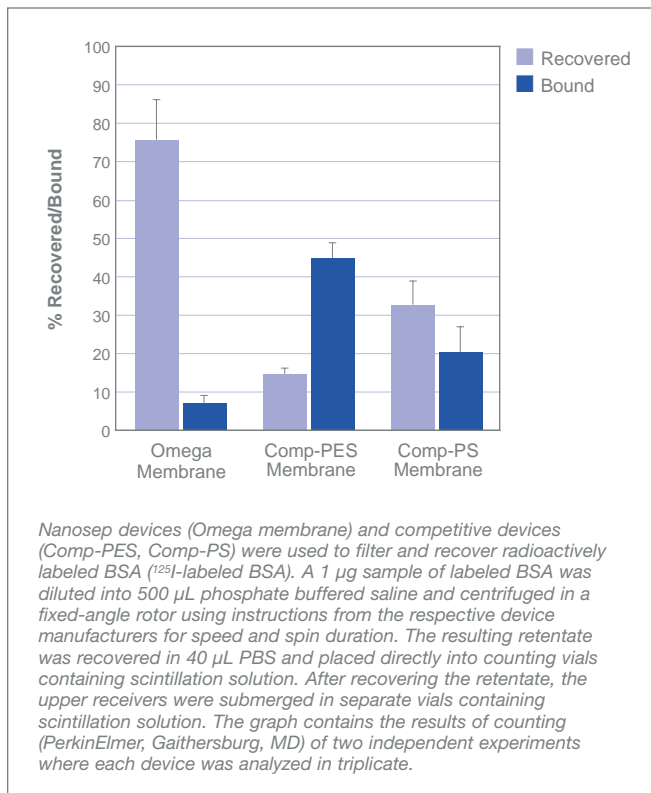


Figure 3

Nanosep Centrifugal Devices are Low DNA Binding and Provide High DNA Recoveries

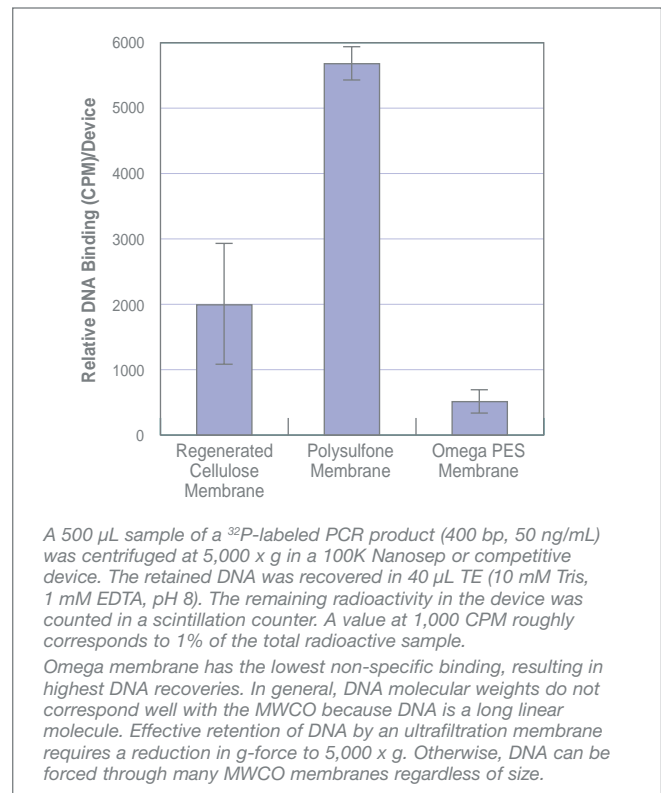


Figure 4
Reduce RCF to Increase Recovery of DNA Fragments

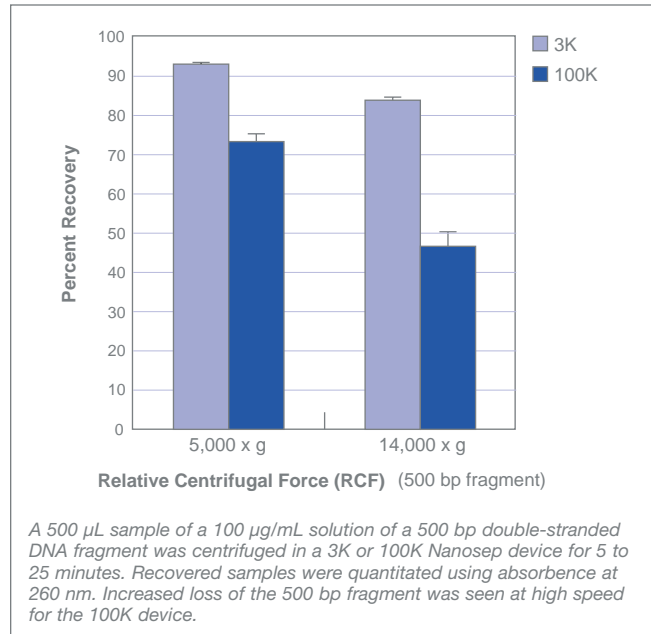
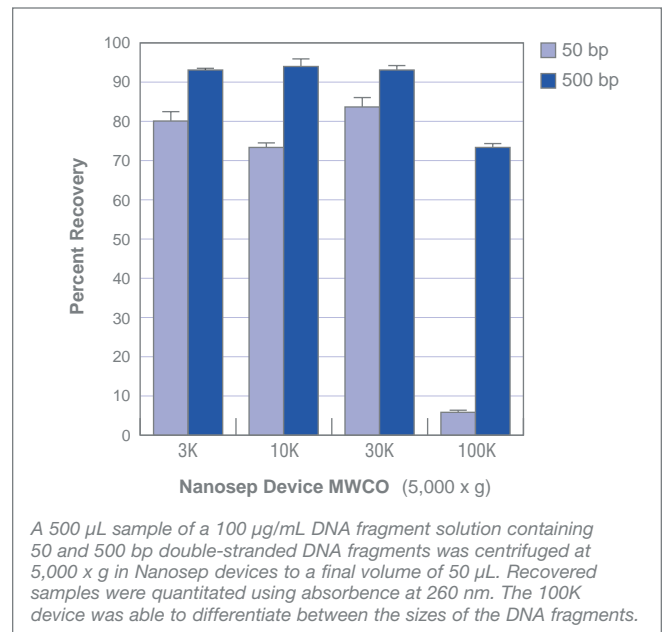


Figure 5
Nanosep® Devices are Available in a Range of MWCOs to Best Meet Your Application Requirements



Ordering Information

Nanosep Centrifugal Devices with Omega™ Membrane

Product No.	Description	Packaging
OD003C33	3K, gray	24/pkg
OD003C34	3K, gray	100/pkg
OD003C35	3K, gray	500/pkg
OD010C33	10K, blue	24/pkg
OD010C34	10K, blue	100/pkg
OD010C35	10K, blue	500/pkg
OD030C33	30K, red	24/pkg
OD030C34	30K, red	100/pkg
OD030C35	30K, red	500/pkg
OD100C33	100K, clear	24/pkg
OD100C34	100K, clear	100/pkg
OD100C35	100K, clear	500/pkg
OD300C33	300K, orange	24/pkg
OD300C34	300K, orange	100/pkg
OD300C35	300K, orange	500/pkg

Nanosep MF Centrifugal Devices with Bio-Inert® Membrane

Product No.	Description	Packaging
ODM02C33	0.2 μm , aqua	24/pkg
ODM02C34	0.2 μm , aqua	100/pkg
ODM02C35	0.2 μm , aqua	500/pkg
ODM45C33	0.45 μm , wildberry	24/pkg
ODM45C34	0.45 μm , wildberry	100/pkg
ODM45C35	0.45 μm , wildberry	500/pkg

Nanosep MF Centrifugal Devices with GHP Membrane

Product No.	Description	Packaging
ODGHPC34	0.45 μm , clear	100/pkg
ODGHPC35	0.45 μm , clear	500/pkg

Microsep™ & Microsep MF Centrifugal Devices

Precise, quick recovery of microliter volumes of concentrate from starting volumes of up to 3.5 mL

- Fast recovery. Achieve 100x concentration and greater than 90% recovery in just minutes.
- Available with low protein-binding Omega™ or Bio-Inert® membrane.
- Microsep device has deadstop to prevent samples from spinning to dryness.
- Ultrasonically welded seals prevent solution bypass.
- Versatile. Omega membrane available in a variety of MWCOs color coded for easy identification.



Applications

- Concentrate dilute protein samples prior to electrophoresis
- Buffer exchange and salt removal
- Remove proteins and particulate from samples for HPLC analysis of drugs, amino acids, and antibodies
- Recover biomolecules from cell culture supernatants or lysates
- Isolate low molecular weight compounds from fermentation broths for natural product screening

Specifications

Materials of Construction

Microsep Devices

Filter Media: Omega membrane (low protein-binding, modified polyethersulfone on polyethylene substrate)

Sample Reservoir and Membrane Support Base: Styrene acrylonitrile (SAN)

Filtrate Receiver and Concentrate Cup: Polypropylene

Cap: Polyethylene

Microsep MF Devices

Filter Media: Bio-Inert membrane (modified nylon)

Sample Reservoir, Membrane Support Base, Filtrate Receiver, and Concentrate Cup: Polypropylene

Cap: Polyethylene

Effective Filtration Area

Microsep Devices: 0.46 cm²

Microsep MF Devices: 0.50 cm²

Dimensions

Outside Diameter: 1.7 cm (0.7 in.)

Overall Length (fully assembled with cap): 9.9 cm (3.9 in.)

Minimum Tube Diameter Adapters

1.7 cm

Capacities

Microsep Devices

Maximum Sample Volume: 3.5 mL

Final Concentrate Volume:

30 - 40 µL (45° angle rotor)

40 - 50 µL (34° angle rotor)

Filtrate Receiver Volume: 3.5 mL

Concentrate Cup Volume: 0.5 mL

Hold-up Volume (membrane/support): 20 µL

Microsep MF Devices

Maximum Sample Volume: 2.0 mL

Filtrate Receiver Volume: 2.0 mL

Hold-up Volume (membrane/support): < 10 µL

Operating Temperature Range

0 - 40 °C (32 - 104 °F)

pH Range

Microsep Devices: 1 - 14

Microsep MF Devices: 3 - 14

Maximum Centrifugal Force

7,500 x g

Centrifuge

A fixed-angle rotor that accepts 17 x 100 mm tubes and is capable of 3,000 to 7,500 x g

Sanitization

Provided non-sterile; may be sanitized by filtering 70% ethanol through the device prior to use.

Ordering Information

Microsep™ Centrifugal Devices with Omega™ Membrane

Product No.	Description	Packaging
OD001C41	1K, yellow	24/pkg
OD001C46	1K, yellow	100/pkg
OD003C41	3K, gray	24/pkg
OD003C46	3K, gray	100/pkg
OD010C41	10K, blue	24/pkg
OD010C46	10K, blue	100/pkg
OD030C41	30K, red	24/pkg
OD030C46	30K, red	100/pkg
OD050C41	50K, green	24/pkg
OD050C46	50K, green	100/pkg
OD100C41	100K, clear	24/pkg
OD100C46	100K, clear	100/pkg
OD300C41	300K, orange	24/pkg
OD300C46	300K, orange	100/pkg
OD990C41	1000K, purple	24/pkg
OD990C46	1000K, purple	100/pkg

Microsep MF Centrifugal Devices with Bio-Inert® Membrane

Product No.	Description	Packaging
ODM02C67	0.2 µm, aqua	24/pkg
ODM02C68	0.2 µm, aqua	100/pkg
ODM45C67	0.45 µm, wildberry	24/pkg
ODM45C68	0.45 µm, wildberry	100/pkg

Macrosep® Centrifugal Devices

Quickly concentrate up to 15 mL of biological sample without valuable sample loss

- Concentrate 15 mL sample volumes to 0.5 mL in 30 to 60 minutes.
- High recoveries, typically greater than 90%.
- Low protein-binding Omega™ membrane and polypropylene housing minimize losses due to non-specific binding.
- Versatile. Omega membrane available in a variety of MWCOs color coded for easy identification.
- Built-in deadstop prevents spinning to dryness.
- Heat-sealed membrane design prevents retentate leakage into the filtrate receiver.



Applications

- Concentrate and desalt proteins, DNA, and RNA
- Buffer exchange or salt removal of chromatography eluates and gradient fractions
- Recover proteins or other molecules from cell culture supernatants
- Clarify tissue homogenates
- Concentrate viruses
- Wash and concentrate latex bead suspensions

Specifications

Materials of Construction

Filter Media: Omega membrane (low protein-binding, modified polyethersulfone on polyethylene substrate)

Sample Reservoir, Filtrate Receiver, and Concentrate Cup: Polypropylene

Paddle without Membrane and Cap: Polyethylene

Effective Filtration Area

10 cm²

Dimensions*

Outside Diameter: 2.9 cm (1.2 in.)

Overall Length (fully assembled with cap): 10.9 cm (4.3 in.)

**Fits 50 mL tube adapters*

Minimum Tube Diameter Adapters

2.9 cm

Capacities

Maximum Sample Volume: 15 mL

Final Concentrate Volume: 0.5 - 1.5 mL, depending on rotor used

Filtrate Receiver Volume: 15 mL

Concentrate Cup Volume: 1.5 mL

Hold-up Volume (membrane/support): 0.03 mL

Operating Temperature Range

0 - 40 °C (32 - 104 °F)

pH Range

1 - 14

Maximum Centrifugal Force

5,000 x g

Centrifuge

A fixed-angle or swinging bucket rotor is required that accepts 50 mL tubes and is capable of 1,000 to 5,000 x g

Sanitization

Provided non-sterile; may be sanitized by filtering 70% ethanol through the device prior to use.

Performance

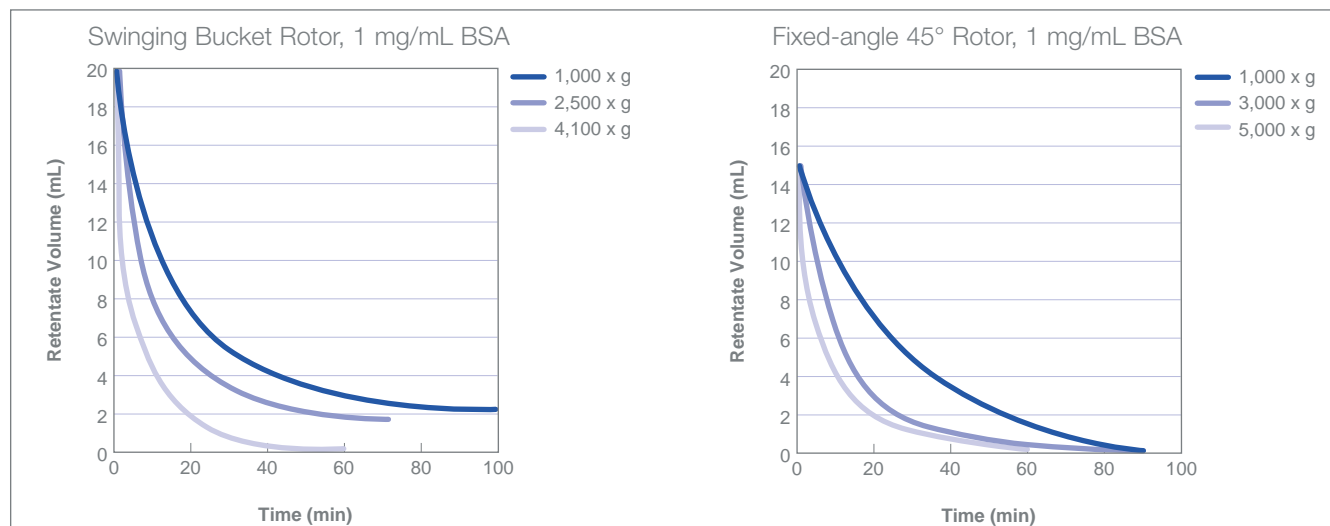
Table 3

Rotor Selection Determines Initial Sample Capacity and Final Concentrate Volume

Rotor Angle	Maximum Sample Volume	Concentrate Volume	Concentration
Swinging Bucket	15 mL	0.5 - 1.0 mL	15 - 30 x, 20 - 40 x
45° Fixed Angle	15 mL	1.0 - 1.5 mL	10 - 15 x
34° Fixed Angle	12.5 mL	1.0 - 1.5 mL	8 - 12.5 x
25° Fixed Angle	9 mL	1.5 - 2.0 mL	4.5 - 6 x

Figure 6

Durable Macrosep® Devices Allow Fast Processing Time



Ordering Information

Macrosep Centrifugal Devices with Omega™ Membrane

Product No.	Description	Packaging	Product No.	Description	Packaging
OD001C36	1K, yellow	6/pkg	OD050C36	50K, green	6/pkg
OD001C37	1K, yellow	24/pkg	OD050C37	50K, green	24/pkg
OD001C38	1K, yellow	100/pkg	OD050C38	50K, green	100/pkg
OD003C36	3K, gray	6/pkg	OD100C36	100K, clear	6/pkg
OD003C37	3K, gray	24/pkg	OD100C37	100K, clear	24/pkg
OD003C38	3K, gray	100/pkg	OD100C38	100K, clear	100/pkg
OD003C39	3K, gray	500/pkg	OD300C36	300K, orange	6/pkg
OD010C36	10K, blue	6/pkg	OD300C37	300K, orange	24/pkg
OD010C37	10K, blue	24/pkg	OD300C38	300K, orange	100/pkg
OD010C38	10K, blue	100/pkg	OD990C36	1000K, purple	6/pkg
OD030C36	30K, red	6/pkg	OD990C37	1000K, purple	24/pkg
OD030C37	30K, red	24/pkg	OD990C38	1000K, purple	100/pkg
OD030C38	30K, red	100/pkg			

For a trial evaluation, a package of 6 devices is provided in a reusable box that also serves as a device holder.

Jumbosep™ Centrifugal Devices

Convenient and reliable concentration, purification, and diafiltration of 15 to 60 mL biological samples

- Concentrate 60 mL sample volumes to 4 mL in 30 minutes.
- High recoveries, typically greater than 90%.
- Low protein-binding Omega™ membrane and polypropylene housing minimize losses due to non-specific binding.
- Versatile. Available in a variety of MWCOs, color coded for easy identification.
- Built-in deadstop prevents spinning to dryness.
- Unique sealing mechanism prevents retentate leakage and filtrate contamination.
- Economical. Sample reservoir and filtrate receiver can be sanitized or autoclaved, and reused.



Applications

Replaces dialysis, chemical precipitation, and lyophilization in the following applications:

- Concentrate and desalt proteins and nucleic acids
- Buffer exchange or salt removal of chromatography eluates and gradient fractions
- Separate biomolecules from cell culture supernatants
- Concentrate or remove viruses
- Crude fractionation of dilute protein mixtures
- Remove debris and particulates from cell lysates

Specifications

Materials of Construction

Filter Media: Omega membrane (low protein-binding, modified polyethersulfone)

Sample Reservoir and Filtrate Receiver: Polysulfone

Sample Reservoir Cap: Polyethylene

Insert Without Membrane: High density polyethylene

Filtrate Receiver Cap and Insert Release: Polypropylene

Effective Filtration Area

15.2 cm²

Dimensions

Outside Diameter (maximum): 6 cm (2.4 in.)

Overall Height (fully assembled with cap): 11.3 cm (4.5 in.)

Capacities

Maximum Sample Volume: 60 mL

Final Concentrate Volume: 3.5 - 4 mL

Maximum Filtrate Receiver Volume: 60 mL

Hold-up Volume (membrane/support): 0.2 mL

Operating Temperature Range

0 - 40 °C (32 - 104 °F)

pH Range

1 - 14

Maximum Centrifugal Force

3,000 x g

Centrifuge

Swinging bucket rotor is required that accepts flat-bottomed 250 mL bottles and is capable of spinning at up to 3,000 x g

Sanitization

Provided non-sterile; may be sanitized by filtering 70% ethanol through the device prior to use.

Performance

Figure 7

Reduce Set-up and Concentration Times with Jumbosep™ Devices

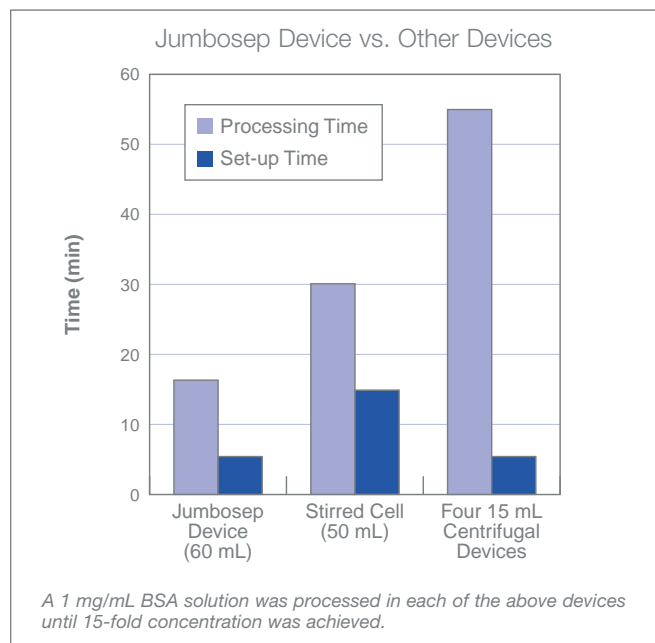
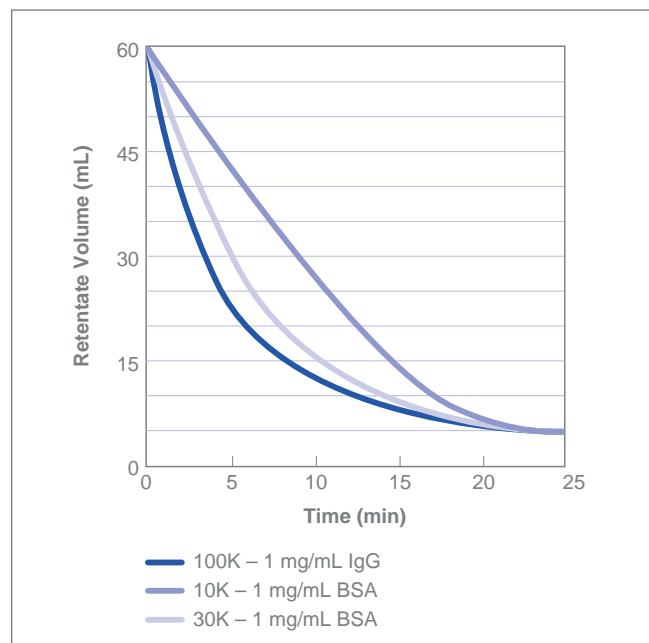


Figure 8

Concentrate Dilute Protein Samples in Less Than 30 Minutes with 10K, 30K, and 100K Jumbosep Devices



Ordering Information

Jumbosep Device Starter Kits

Product No.	Description	Packaging
FD000K65	Generic starter kit (no membrane or inserts)	4/pkg
FD003K65	3K starter kit, gray	4/pkg
FD010K65	10K starter kit, blue	4/pkg
FD030K65	30K starter kit, red	4/pkg
FD100K65	100K starter kit, clear	4/pkg
FD300K65	300K starter kit, orange	4/pkg

*The Generic Starter Kit includes four holders, cups, and caps. Membrane inserts sold separately. Starter Kits include four holders, cups, caps, and membrane inserts.

Jumbosep Device Membrane Inserts

Product No.	Description	Packaging
OD003C65	3K membrane insert, gray	12/pkg
OD010C65	10K membrane insert, blue	12/pkg
OD030C65	30K membrane insert, red	12/pkg
OD100C65	100K membrane insert, clear	12/pkg
OD300C65	300K membrane insert, orange	12/pkg

Accessory Products

Product No.	Description	Packaging
FD001X65	Filtrate receiver and cap	12/pkg
FD002X65	Sample reservoir and cap	12/pkg
FD003X65	Insert release	24/pkg

Diafiltration

A fast, efficient method for salt removal, buffer exchange, and fractionation—can be substituted in nearly all dialysis applications.

Diafiltration is a technique using ultrafiltration membranes to remove salt or solvent, exchange buffers, or fractionate different size biomolecules in macromolecular solutions. Macromolecules retained by the membrane are concentrated as solvent and low molecular weight species are removed. However, a simple concentration of the macromolecular sample will not completely remove the smaller species. Therefore, the smaller species must be “washed” from the sample using multiple wash volumes (diafiltration).

Diafiltration can perform salt or solvent removal and buffer exchange quickly and conveniently compared to conventional methods such as dialysis and gel filtration. Dialysis procedures can take up to several days compared to only hours with diafiltration. Large volumes of buffer with multiple changes are required for dialysis.

Diafiltration offers the advantage of less total liquid volumes to manipulate, and no beakers or buckets with wet bags to handle. Set up can be done quickly and easily, and does not require attention during the procedure. After the diafiltration process, the sample can be concentrated for further analysis or purification. This is an advantage compared to gel filtration or dialysis when the sample can be diluted during the separation process, requiring an additional concentration step. There is no loss or contamination using diafiltration as could occur with a two-step process.

In addition, diafiltration can be used to fractionate macromolecules which are similar in molecular size. Ultrafiltration membranes typically have a distribution of pore sizes. In practice, molecules which are close to the membrane cutoff will be greater than 90% retained by the membrane. Molecules that are slightly smaller than the MWCO will be partially retained (typically 20 to 80%). Multiple diafiltration steps can remove partially retained molecules while retaining proteins or macromolecules larger than the membrane MWCO.

Complementary Products

- **AcroPrep™ 96- and 384-well Filter Plates** can be used for a variety of molecular biology, combinatorial chemistry, and screening applications.
- **AcroWell™ 96-well Filter Plates with BioTrace and GHP Membranes** can be used for hybridization-based assays such as dot blots, ELISAs and TRF.
- **Vivid™ Gene Array Slides** feature a unique membrane construction that allows high signal-to-noise ratios, requires less template, and provides consistent results.
- **BioTrace™, Biodyne®, and FluoroTrans® Transfer Membranes** offer precise performance and compatibility with nearly every detection system available.
- **Stirred Cell Systems** feature high performance ultrafiltration membranes ultrasonically sealed into 10 mL and 150 mL cells.
- **Ultrafiltration Membrane Discs** are highly porous, providing fast flow rates and high recoveries.



Life Sciences

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Fax: 02 9428-5610

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Fax: 0043-1-49 192-400

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Tel: 905-542-0330
800-263-5910 (in Canada)
Fax: 905-542-0331

Canada – Québec
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800-435-6268 (in Canada)
Fax: 514-332-0996

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Japan – Tokyo
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Fax: 3-3495-5397

Korea – Seoul
Tel: 2-569-9161
Fax: 2-569-9092

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