



Protein gel electrophoresis handbook

Techniques and tools for
publication-quality results

Strategies and solutions to drive your success

Protein gel electrophoresis is a simple way to separate proteins prior to downstream detection or analysis, and is a critical step in most workflows that isolate, identify, and characterize proteins. In this handbook, you will find information on selecting the appropriate separation scheme, choosing the right gel and equipment, and preparing samples for analysis. Also included are troubleshooting guides, how-to videos, selection guides, and buffer recipes to help you achieve optimal results. Our portfolio of high-quality protein electrophoresis products unites gels, stains, molecular weight markers, running buffers, and blotting products to provide you with a range of options designed for your experiments.



See a complete listing of all available products and more at [thermofisher.com/separate](https://www.thermofisher.com/separate)

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Electrophoresis overview

Electrophoresis is defined as the transport of charged molecules through a solvent by an electric field. Electrophoresis is a simple, rapid, and sensitive analytical tool for separating proteins and nucleic acids. Any charged ion or molecule will migrate when placed in an electric field. Most biological molecules carry a net charge at any pH other than at their isoelectric point and will migrate at a rate proportional to their charge density.

The mobility of a biological molecule through an electric field will depend on the following factors:

- Field strength
- Net charge on the molecule
- Size and shape of the molecule
- Ionic strength
- Properties of the matrix through which the molecules migrate (e.g., viscosity, pore size)

Support matrix

Two types of support matrices are commonly used in electrophoresis: polyacrylamide and agarose. The support matrices act as porous media and behave like a molecular sieve. Separation of molecules is dependent upon the gel pore size of the support matrix used. Agarose has a large pore size and is ideal for separating macromolecules such as nucleic acids and protein complexes. Polyacrylamide has a smaller pore size and is ideal for separating most proteins, peptides, and smaller nucleic acids.

Polyacrylamide gel electrophoresis (PAGE)

Polyacrylamide gels are generated by the polymerization of acrylamide monomers. These monomers are crosslinked into long chains by the addition of bifunctional compounds such as N,N'-methylenebisacrylamide (bis), which react with the free functional groups of the chain termini. The concentration of acrylamide and bisacrylamide determines the pore size of the gel. The higher the acrylamide concentration, the smaller the pore size, resulting in resolution of lower molecular weight molecules and vice versa.

PAGE allows one to separate proteins for different applications based on:

- The acrylamide matrix
- Buffer systems
- Electrophoresis conditions



Did you know

Arne Tiselius won the Nobel Prize in Chemistry for electrophoretic analysis of serum proteins in 1948

The acrylamide matrix

Linear vs. gradient gels

Gels that have a single acrylamide percentage are referred to as linear gels, and those with a range are referred to as gradient gels. The advantage of using a gradient gel is that it allows the separation of a broader range of proteins than does a linear gel.

Continuous vs. discontinuous gels

Researchers occasionally refer to gels as continuous or discontinuous. A continuous gel is a gel that has been formed from a single acrylamide solution in the entire gel cassette. A discontinuous gel is formed from two acrylamide solutions: a small, low-percentage stacking gel where the protein wells reside, and a larger portion of gel that separates the proteins. In the traditional Tris-glycine protein gel system, the proteins are stacked in the stacking gel between the highly mobile leading chloride ions (in the gel buffer) and the slower, trailing glycine ions (in the running buffer). The reason for using the stacking gel is to improve the resolution of the bands in the gel. These stacked protein bands undergo sieving once they reach the separating gel.

Mini vs. midi protein gels

Commercial gels are available in two size formats: mini gels and midi gels. Both gels have similar run lengths, but midi gels are wider than mini gels, allowing midi gels to have more wells or larger wells. The additional wells in the midi gels permit more samples or large sample volumes to be loaded onto one gel.

Buffer systems

Electrophoresis is performed using continuous or discontinuous buffer systems. A continuous buffer system utilizes only one buffer in the gel and running buffer. A discontinuous buffer system utilizes a different gel buffer and running buffer [1]. This system may also use two gel layers of different pore sizes and different buffer composition (the stacking and separating gel). Electrophoresis using a discontinuous buffer system results in concentration of the sample in the stacking gel and higher resolution as a result.

Electrophoresis conditions

The separation of proteins is dependent on the electrophoresis conditions used, some of which are described below.

Denaturing conditions (SDS-PAGE)

Electrophoresis is performed under denaturing conditions using an anionic detergent such as sodium dodecyl sulfate (SDS). SDS denatures and unfolds the protein by wrapping around the hydrophobic portions. SDS binds at a ratio of ~1.4 g SDS per gram of protein. The resultant SDS-protein complexes are highly negatively charged and are resolved in the gel based on their size.

Nondenaturing conditions (native PAGE)

Electrophoresis is performed under nondenaturing (native) conditions using buffer systems that maintain the native protein conformation, subunit interaction, and biological activity. During native electrophoresis, proteins are separated based on their charge-to-mass ratios.

Reducing conditions

Electrophoresis is performed under reducing conditions using reducing agents such as dithiothreitol (DTT), β -mercaptoethanol (β -ME), or tris(2-carboxyethyl)phosphine (TCEP). The reducing agents completely unfold the denatured proteins into their subunits by cleaving the disulfide bonds between cysteine residues.

1D vs. 2D PAGE

The most common form of protein gel electrophoresis is comparative analysis of multiple samples by one-dimensional (1D) electrophoresis, in which samples are loaded into wells, a current is applied to separate the proteins, and the resulting migration of the protein bands is visualized by staining or on a western blot.

Multiple components of a single sample can be resolved most completely by two-dimensional electrophoresis (2D-PAGE). The first dimension separates proteins according to their native isoelectric point (pI) using a form of electrophoresis called isoelectric focusing (IEF). The second dimension separates proteins by mass using ordinary SDS-PAGE. 2D PAGE provides the highest resolution for protein analysis and is an important technique in proteomic research, where resolution of thousands of proteins on a single gel is sometimes necessary. The main focus of this handbook is on 1D electrophoresis.

Protein gel chemistries

PAGE utilizes a discontinuous buffer system to concentrate or “stack” samples into a very sharp zone in the stacking gel at the beginning of the run. In a discontinuous buffer system, the primary anion in the gel is different (or discontinuous) from the primary anion in the running buffer. Invitrogen™ Bolt™ Bis-Tris Plus gels, Invitrogen™ NuPAGE™ Bis-Tris and Tris-acetate gels, and the Laemmli system–based Invitrogen™ Novex™ Tris-Glycine gels are examples of discontinuous buffer systems and work in a similar fashion. However, Bis-Tris and Tris-acetate systems operate at a lower pH as a result of the ions that are in the system.

Tris-glycine chemistry

In a Tris-glycine system (Figure 1), three ions are primarily involved:

- Chloride (–), supplied by the gel buffer, serves as the leading ion because it has the highest attraction to the anode relative to other anions in the system.
- Glycine (–), the primary anion provided by the running buffer, serves as the trailing ion, because it is only partially negatively charged and remains behind the more highly charged chloride ions in a charged environment.
- Tris base (+), a common ion present in both the gel and the running buffers. During electrophoresis, the gel and buffer ions in the Tris-glycine system form an operating pH of 9.5 in the separating region of the gel.

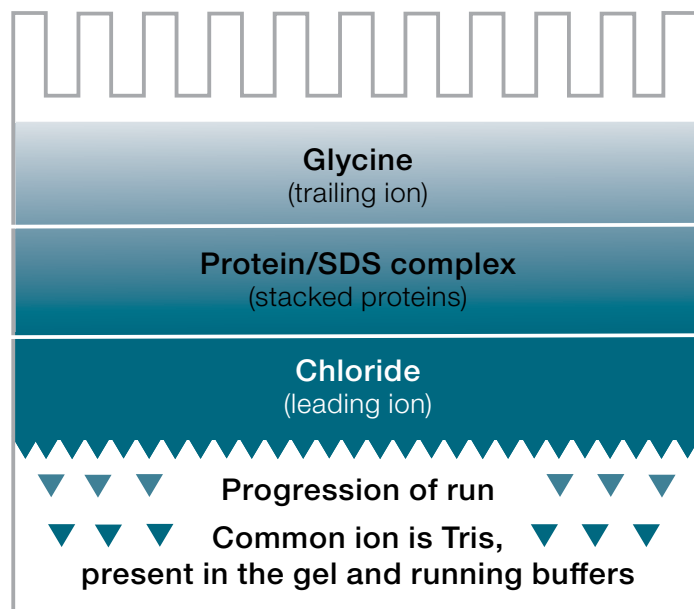


Figure 1. Tris-glycine gel system.

- Gel buffer ions are Tris and chloride (pH 8.7)
- Running buffer ions are Tris, glycine, and SDS (pH 8.3)
- Gel operating pH is 9.5

Bis-Tris chemistry

In the case of the Bis-Tris system (Figure 2), three ions are primarily involved:

- Chloride (–) supplied by the gel buffer, serves as the fast-moving leading ion.
- MES or MOPS (–) (depending on the running buffer choice) serves as the trailing ion.
 - MES: 2-(N-morpholino) ethane sulfonic acid
 - MOPS: 3-(N-morpholino) propane sulfonic acid
- Bis-Tris (+) acts as the common ion present in the gel while Tris (+) is provided by the running buffer.

The combination of a lower-pH gel buffer (pH 6.4) and running buffer (pH 7.3–7.7) leads to a significantly lower operating pH (pH 7.0) during electrophoresis, resulting in better sample integrity and gel stability.

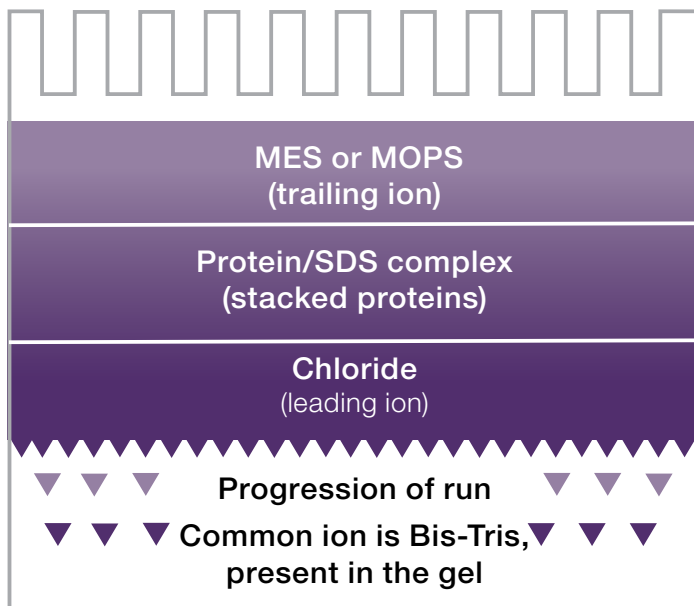


Figure 2. Bis-Tris gel system.

- Gel buffer ions are Bis-Tris and chloride (pH 6.4)
- Running buffer ions are Tris, MES or MOPS, and SDS (pH 7.3)
- Gel operating pH is 7.0

Tris-acetate chemistry

With the Tris-acetate system (Figure 3), three ions are primarily involved:

- Acetate (–), the leading ion from the gel buffer
- Tricine (–), the trailing ion from the running buffer
- Tris (+), the common ion (in both gel and running buffer)

This system also operates at a significantly lower pH than the Tris-glycine system, resulting in fewer gel-induced protein modifications.

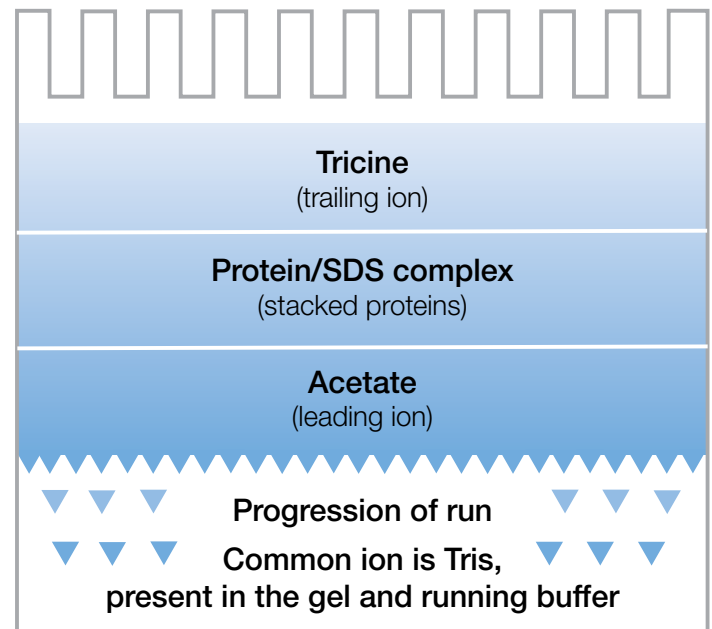


Figure 3. Tris-acetate gel system.

- Gel buffer ions are Tris and acetate (pH 7.0)
- Running buffer ions are Tris, tricine, and SDS (pH 8.3)
- Gel operating pH is 8.1

Tricine chemistry

The tricine system (not pictured) is a modification of the traditional Tris-glycine gel system that uses a discontinuous buffer system specifically designed for the resolution of low molecular weight proteins in the range of 2–20 kDa. As a result of reformulating the Laemmli running buffer and using tricine in place of glycine, SDS-polypeptides form behind the leading ion front rather than running with the SDS front, thus allowing for their separation into discrete bands.

Choosing the right protein gel

Bis-Tris chemistry vs. Tris-glycine chemistry

The most widely used gel system for separating a broad range of proteins by SDS-PAGE is Tris-glycine gels (Laemmli system), comprising a stacking gel component that helps focus the proteins into sharp bands at the beginning of the electrophoretic run and the resolving gel component that separates the proteins based on size. This classic system uses a discontinuous buffer system where the pH and ionic strength of the buffer used for running the gel (Tris, pH 8.3) is different from the buffers used in the stacking gel (Tris, pH 6.8) and resolving gel (Tris, pH 8.8). The highly alkaline operating pH of the Laemmli system may cause band distortion, loss of resolution, or artifact bands (Figure 4).

The major causes of poor band resolution with the Laemmli system are:

- Hydrolysis of polyacrylamide at the high pH of the resolving gel, resulting in a short shelf life of 8 weeks
- Chemical alterations such as deamination and alkylation of proteins due to the high pH of the resolving gel
- Reoxidation of reduced disulfides from cysteine-containing proteins, as the redox state of the gel is not constant
- Cleavage of Asp-Pro bonds of proteins when heated at 100°C in Laemmli sample buffer, pH 5.2

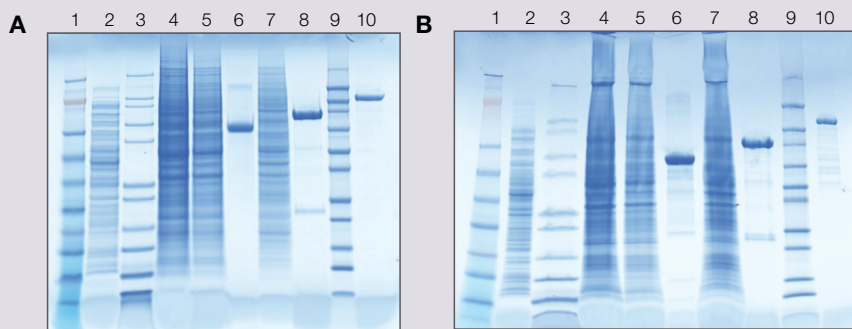


Figure 4. Protein separation using (A) an Invitrogen™ Bolt™ Bis-Tris Plus gel and (B) Bio-Rad's Tris-glycine gel.

Unlike traditional Tris-glycine gels, Invitrogen™ NuPAGE™ and Bolt™ gels are Bis-Tris HCl-buffered (pH 6.4) and have an operating pH of about 7.0. The neutral operating pH of the Bis-Tris system provides the following advantages over the Laemmli system:

- Longer shelf life of 16 months, due to improved gel stability
- Improved protein stability during electrophoresis at neutral pH, enabling sharper band resolution and accurate results [2]
- Complete reduction of disulfides under mild heating conditions (70°C for 10 minutes) and absence of cleavage of Asp-Pro bonds
- Reduced state of the proteins maintained during electrophoresis and blotting of the proteins when using Invitrogen™ NuPAGE™ Antioxidant or Invitrogen™ Bolt™ Antioxidant

Denaturing gel systems

NuPAGE Bis-Tris and Bolt Bis-Tris are well suited for separating a broad range of protein sizes. To separate high-abundance proteins, select our robust Invitrogen™ Novex™ Tris-Glycine gel chemistry. Tris-acetate gel chemistry, offered in Invitrogen™ NuPAGE™ Tris-Acetate gels, is recommended for the separation of high molecular weight proteins up to 500 kDa. Tricine gel chemistry is designed for the separation of low molecular weight proteins and peptides. Invitrogen™ Novex™ tricine gels enable increased resolution of proteins with molecular weights as low as 2.5 kDa.

Other gel systems

Native gels

In native polyacrylamide gel electrophoresis, proteins are separated according to the net charge, size, and shape of their native structure. Electrophoretic migration occurs because most proteins carry a net negative charge in alkaline running buffers, with proteins of greater negative charge density migrating faster. At the same time, the sieving effect of the gel matrix regulates the migration of proteins according to their size and three-dimensional shape.

The Invitrogen™ NativePAGE™ Bis-Tris Gel System is based on the blue native polyacrylamide gel electrophoresis (BN PAGE) technique developed by Schagger and von Jagow, which overcomes the limitations of traditional native electrophoresis by providing a near-neutral operating pH and detergent compatibility. In this specific system, the Coomassie G-250 dye binds to proteins and confers a net negative charge while maintaining the proteins in their native state. NativePAGE gels are designed to separate proteins up to 10,000 kDa.

Because no denaturants are used in the NativePAGE system, protein subunits are generally retained and information can be gained about the quaternary structure. In addition, some proteins retain their enzymatic activity following separation using the NativePAGE system. Tris-glycine and Tris-acetate gel systems can also be used for native PAGE when used in the absence of SDS in sample and running buffers.

IEF gels

Isoelectric focusing (IEF) is a technique designed to separate proteins according to their isoelectric point (pI) rather than molecular weight. The pI is the pH at which a protein has no net charge and no longer moves in an electric field. These gels can be used to determine the pI or to detect minor changes in a protein due to deamination, phosphorylation, or glycosylation. They can also resolve different proteins of similar size that cannot be resolved on standard SDS-PAGE gels.

Zymogram gels

Invitrogen™ Zymogram gels are composed of gelatin and are used to characterize proteases that utilize gelatin as a substrate, such as matrix metalloproteases, lipases, and other proteases.

Samples are run under denaturing conditions, but due to the absence of reducing agents, proteins can undergo renaturation under appropriate buffer conditions (e.g., Invitrogen™ Novex™ Zymogram Renaturing Buffer). Proteolytic proteins present in the sample consume the substrate in the presence of added divalent metal cations (e.g., Invitrogen™ Novex™ Zymogram Developing Buffer). The gels are then stained to generate clear bands where the substrate has been digested, against a background stained blue.

High-throughput gel electrophoresis

High-throughput gel electrophoresis expands the number of protein samples that can be analyzed in a given time and is especially useful for screening recombination products and protein profiling.

While midi gels enable higher-throughput electrophoresis and western blotting than mini gels, the Invitrogen™ E-PAGE™ High-Throughput (HTP) Precast Gel System is specially designed for fast, bufferless HTP protein analysis. Invitrogen™ E-PAGE™ gels are self-contained, precast gels that include a gel matrix and electrodes packaged inside a disposable cassette. E-PAGE gels are available in 48-well or 96-well formats. These gels are run using the Invitrogen™ E-Gel™ Power Snap Plus Electrophoresis System, which provides both electrophoresis and real-time gel imaging functions in a single benchtop instrument.

Precast vs. handcast gels

Traditionally, researchers poured their own gels using standard recipes that are widely available in the protein methods literature. Today, more researchers rely on the convenience and consistency of commercially available, ready-to-use precast gels. We offer precast gels in a variety of percentages, including difficult-to-pour gradient gels that provide excellent resolution and separate proteins over the widest possible range of molecular weights. Precast gels are also available with several different buffer formulations (e.g., Tris-glycine, Tris-acetate, Bis-Tris, and tricine), which are designed to optimize shelf life, run time, and protein resolution. More importantly, precast polyacrylamide gels minimize the need to work with acrylamide, which is a known neurotoxin and suspected carcinogen.

However, some scientists need unique gel formulations not available in precast gel formats. In those cases, the gel-pouring process can be made easier by using newer, leak-free handcast systems, such as the Invitrogen™ SureCast™ system, or by using preassembled empty gel cassettes.

Choosing the right gel percentage

In general, the size of the molecule being separated should dictate the acrylamide or agarose percentage you choose. Use a lower percentage gel to resolve larger molecules and a higher percentage gel to resolve smaller ones. The exception to this rule is when performing isoelectric focusing. Refer to the gel migration charts throughout this chapter to find the gel best suited for your application. As a general rule, molecules should migrate through about 70% of the length of the gel for the best resolution. When protein molecular weights are wide ranging or unknown, gradient gels are usually the best choice.

Choosing a well format and gel thickness

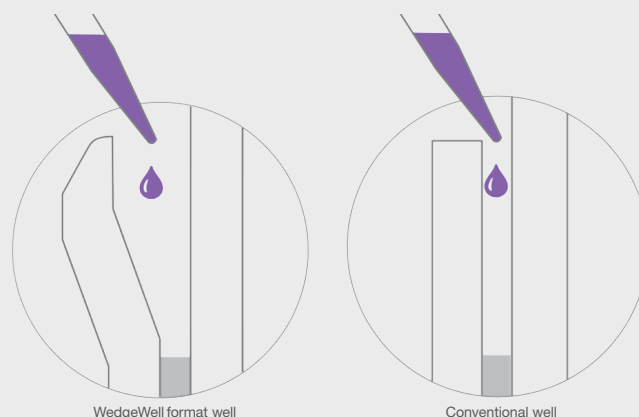
Two thicknesses (1.0 mm and 1.5 mm) are available for popular gel types. If loading large sample volumes (>30 µL), a thicker gel (1.5 mm) may be more appropriate. Another consideration for large sample volumes is choosing a wedge-well format that is found in many of our protein gels. When blotting, remember that proteins will transfer more easily from a 1.0 mm thick gel than from a 1.5 mm thick gel. We offer most of our polyacrylamide gels in twelve different well formats (mini gels: 17-well, 15-well, 12-well, 10-well, 9-well, 1-well, 2D/preparative well, IPG well; midi gels: 12+2-well, 20-well, 26-well).



WedgeWell format wells

Invitrogen™ WedgeWell™ format wells are wedge-shaped wells that double the sample loading capacity compared to traditional wells. WedgeWell format gels are available in mini and midi sizes and in **Bis-Tris**, **Tris-glycine**, and **Tris-acetate** chemistries, offering:

- **Easy sample loading**—larger well openings make loading a breeze even with standard pipette tips, and reduce sample spillover and cross-well contamination
- **Increased sample load**—easier detection of dilute samples and low-abundance proteins
- **Faster run times**—proteins can be separated up to 10 minutes faster than traditional gels



To learn more about WedgeWell format wells, watch the video at thermofisher.com/proteingels



Did you know

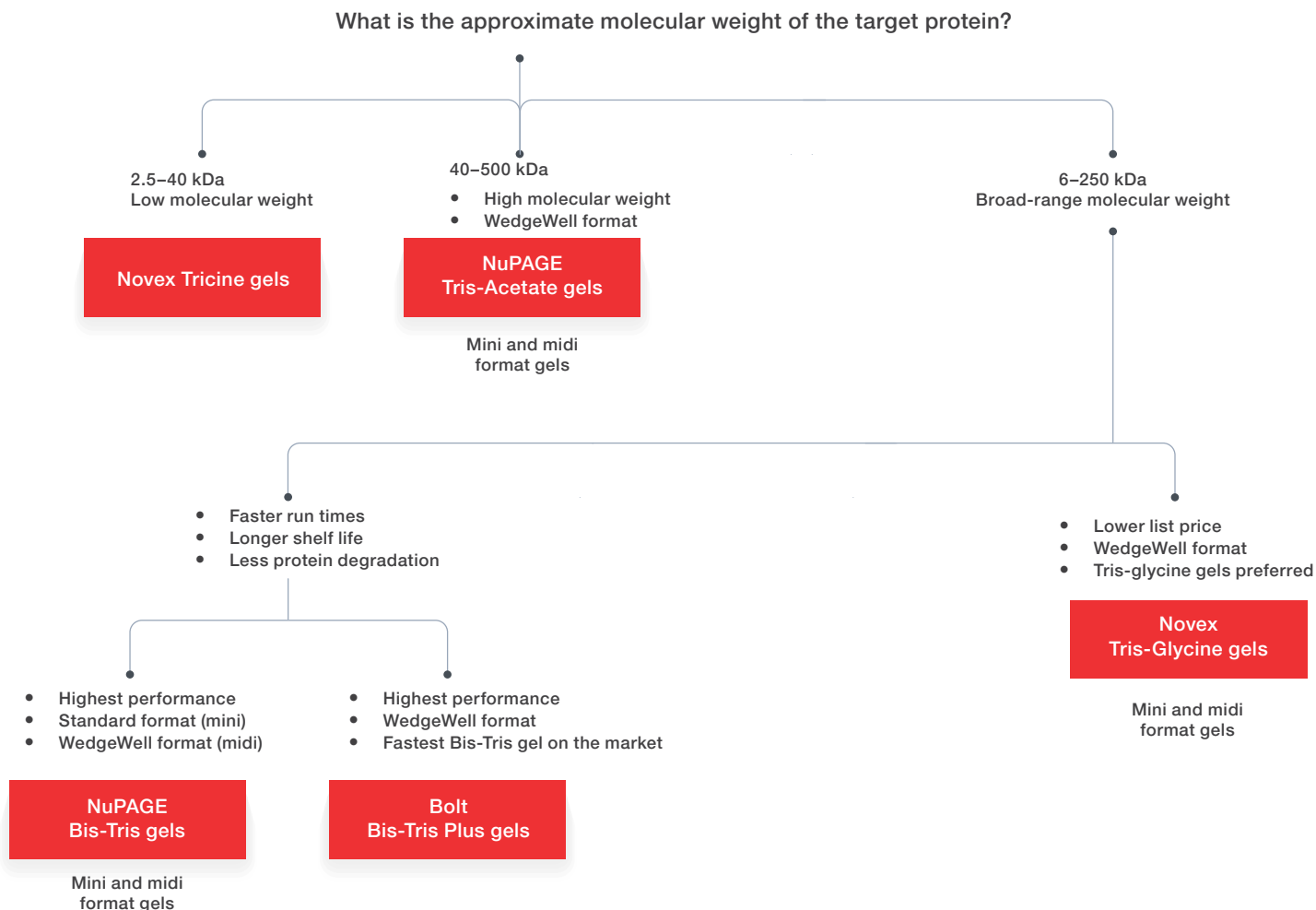
Over 55 years ago, Ulrich K. Laemmli first published on SDS-PAGE as a method for cleavage analysis of structural proteins in bacteriophage T4.

Gel selection guide

Getting started with SDS-PAGE

Use the decision tree below to guide your choice of gel based on the protein molecular weight and the gel format. Still unsure of what gel to choose? Use our interactive product selector at thermofisher.com/proteingelguide. If you would like to replace your current precast gels from another supplier with Invitrogen™ gels, go to thermofisher.com/proteingelconversion.

Gel selection guide



Specialized protein gels

Description	Type of separation	Use for
NativePAGE gels	Net charge, size, and shape of native protein	Analysis of native proteins or protein complexes
Novex IEF gels	Isoelectric point of native protein	Determination of isoelectric point
Zymogram gels	SDS-PAGE	Characterization of proteases that utilize casein or gelatin as a substrate
E-PAGE high-throughput gel system	SDS-PAGE	Fast, high-throughput protein separation

Protein gel performance guarantee

We stand behind the quality of our high-performance protein gels. Purchase Invitrogen protein gels with confidence, knowing that our gels are backed by our protein gel performance guarantee. If an Invitrogen protein gel does not perform in your experiment as described on our website or Certificate of Analysis, we will replace the product at no cost to you, or we will provide you with a credit for future purchase.



Learn about our protein gel performance guarantee at thermofisher.com/proteingelguarantee

Protein gel welcome packs

Protein gel welcome packs are cost-saving product combinations that contain all you need for outstanding protein separation. Protein gel welcome packs include:

- Mini or midi gel tank
- 2 boxes of mini or midi gels
- Running buffer
- Sample buffer
- Reducing agent
- Prestained ladder

Options are available that include mini blot modules and WedgeWell format gels.



Explore available welcome packs at thermofisher.com/proteingelwelcome

Bolt Bis-Tris Plus and NuPAGE Bis-Tris gels

Neutral-pH gel systems for optimal separation

Bolt Bis-Tris Plus and NuPAGE Bis-Tris gels are precast polyacrylamide gels designed for optimal separation of a broad molecular weight range of proteins under denaturing conditions (Figures 5–7). These gels help deliver consistent performance with a neutral-pH environment that minimizes protein degradation, resulting in sharper, well-resolved bands. Additionally, preserving protein integrity becomes particularly important when separating low-abundance proteins. Bolt Bis-Tris Plus and NuPAGE Bis-Tris gels are a good choice when protein integrity is crucial. Bolt Bis-Tris Plus gels are available in the mini gel format and NuPAGE Bis-Tris gels are available in mini and midi gel formats, as well as multiple thicknesses.

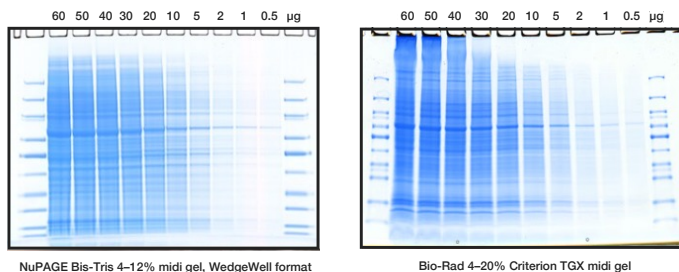


Figure 5. Excellent protein loading capacity of NuPAGE Bis-Tris Midi gels, WedgeWell format. Decreasing loads of HEK293 cell lysate in the NuPAGE Bis-Tris Midi gel show excellent separation, even at high protein loads. Streaking and retention of protein in the wells can be observed in the Bio-Rad gel when protein loads exceed 30 µg.

NuPAGE Bis-Tris gels have been referenced in >90,000 publications.



Bolt Bis-Tris Plus and NuPAGE Bis-Tris gels offer:

- **Excellent protein integrity**—neutral-pH formulation minimizes protein modifications (Figure 6)
- **Fast run times**—separate proteins in 20–35 minutes
- **High sample volume capacity**—WedgeWell format wells double the sample loading capacity and make it easy to load samples
- **More efficient western blot transfer**—neutral pH prevents reoxidation of reduced samples during protein transfer
- **Long shelf life**—up to 16 months at room temperature

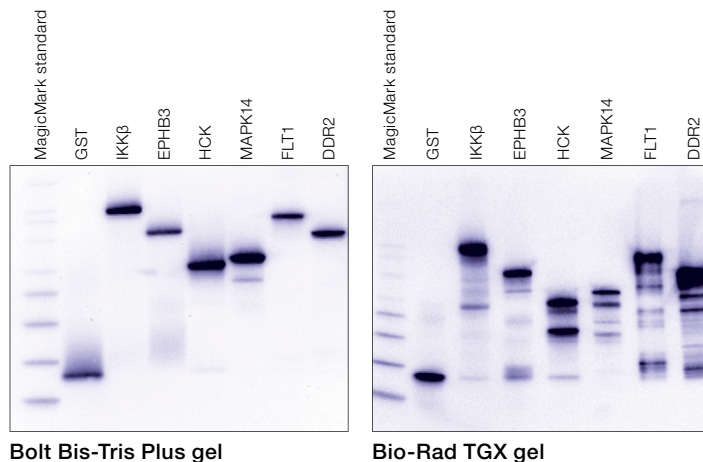


Figure 6. Bolt Bis-Tris Plus mini gels help provide better western blotting results. A western blot of a Bolt gel shows clean, sharp protein bands corresponding to only full-length proteins, whereas a western blot of a Bio-Rad™ TGX™ gel shows multiple low molecular weight degradation products.

View the video to see how easy it is to run an Invitrogen gel [here](#).

Review the quick reference protocol for Bolt gels [here](#).

Review the quick reference protocol for NuPAGE Bis-Tris mini gels [here](#).

Learn more at thermofisher.com/nupage

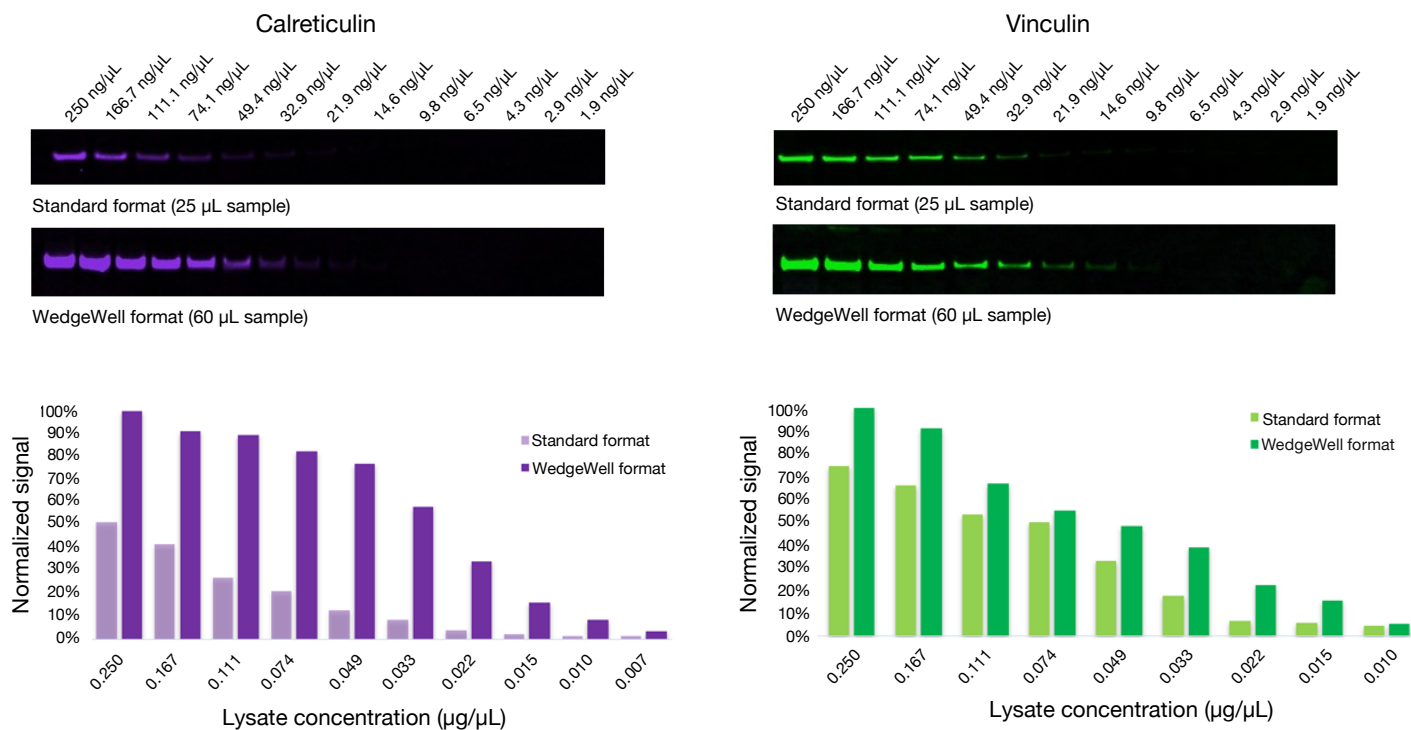


Figure 7. Improved detection of low-abundance proteins. Serial dilutions of a HEK293 cell lysate starting at 250 ng/ μ L were loaded in standard and WedgeWell format NuPAGE Bis-Tris Midi Protein Gels. After transfer and blot processing, fluorescent detection was performed with the Invitrogen™ iBright™ FL1500 Imaging System.

Bolt Bis-Tris Plus mini gel specifications

- Shelf life: 16 months
- Run time: 20–30 minutes on average; 15 minutes with rapid protocols
- Separation range: 0.3–260 kDa
- Polyacrylamide concentrations: fixed 8%, 10%, and 12%; gradient 4–12%
- Gel dimensions: 8 x 8 cm (1 mm thick)
- Maximum sample volume per 10-well gel: ~60 µL, or two-thirds of the sample well volume



The new Bolt™ system is wonderful. I am still amazed that I can run a PAGE gel in 23 minutes. The entire system is incredibly user-friendly, from the Bolt™ precast gels with wedged wells for ease of loading to the Mini Gel Tank system. The bands produced from the westerns were sharp and straight. I would and have highly recommended this system to anyone doing protein work.

—Crystal M., large Canadian university

For one of our projects in the lab, we resolve proteins by electrophoresis to determine the accumulation of ubiquitinated proteins following treatment with a proteasome inhibitor. When we resolved the ubiquitinated proteins using the Tris-glycine gels, we observed a smear. However, when we switched to resolving the ubiquitinated proteins using the Bolt Bis-Tris gels, we were delightfully surprised to observe individual protein bands in place of the smear.

—Susan S., large U.S. university



Bolt Bis-Tris Plus gels

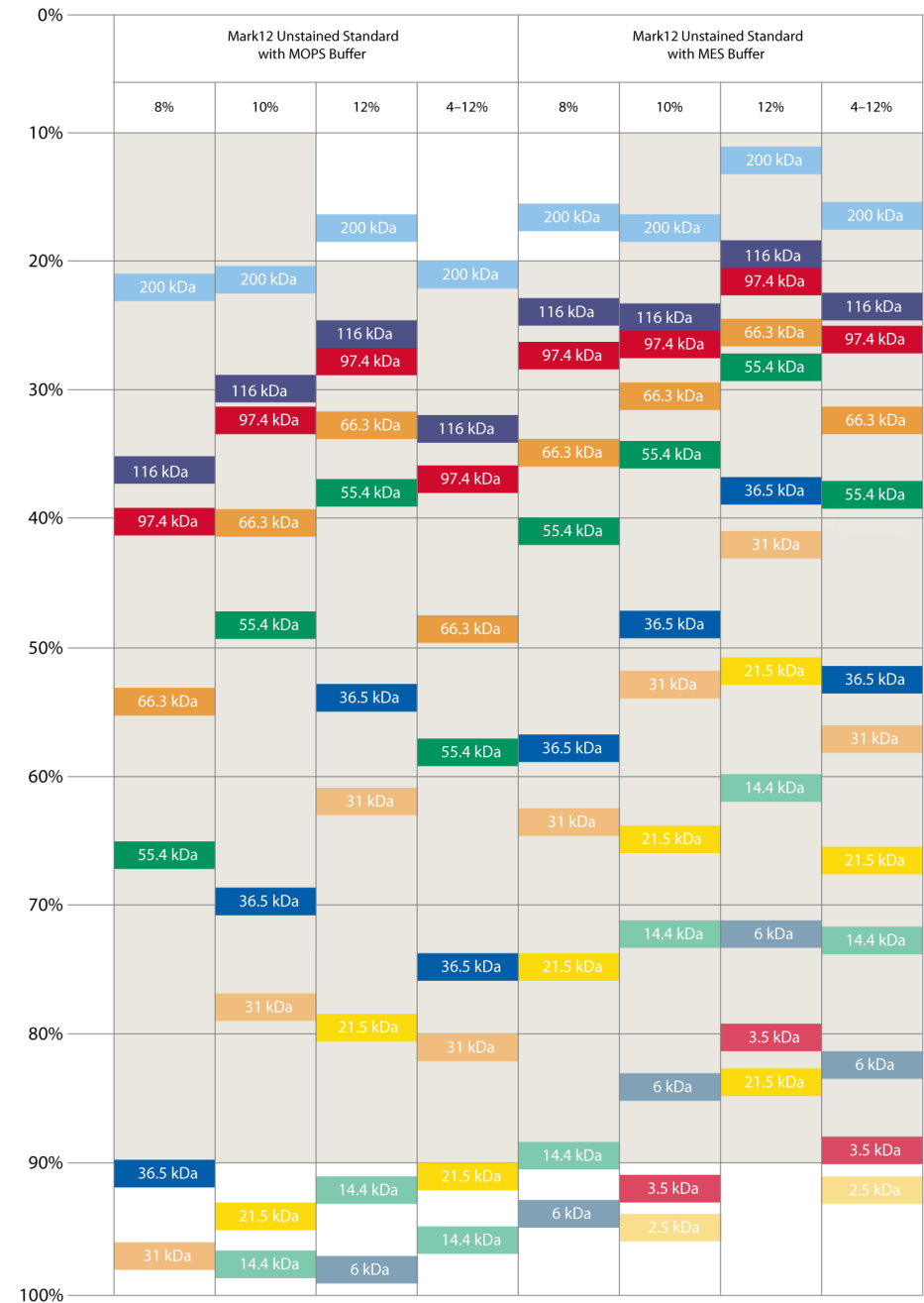


Figure 8. Bolt Bis-Tris Plus gel migration chart. Optimal separation range is shown within the gray areas.

NuPAGE Bis-Tris gel specifications

- Shelf life: up to 16 months* at room temperature (4–25°C)
- Average run time: 25 minutes (MES buffer)
- Separation range: 1.5–300 kDa
- Polyacrylamide concentrations: fixed 8%, 10%, and 12%; gradient 4–12%
- Gel dimensions:
 - Mini: 8 x 8 cm (1 or 1.5 mm thick)
 - Midi: 8 x 13 cm (1 mm thick)
 - Midi, WedgeWell format: 8 x 13 cm (1 mm thick)
- Maximum sample volume per 10-well mini gel: 25 µL (1 mm thick); 37 µL (1.5 mm thick; up to 100 µL for WedgeWell format midi gels)

Recommended products

Thermo Scientific™ PageRuler™ Plus and Spectra™ prestained protein ladders are recommended for use with NuPAGE Bis-Tris gels for easy molecular weight determination.

Visualize with Coomassie stain, silver stain, or fluorescent protein stains after electrophoresis (see “Staining gels” on page 60).



Did you know

Timothy Updyke and Sheldon Engelhorn filed a patent for the neutral-pH Bis-Tris gel system in 1996.

Review the quick reference guide for NuPAGE Bis-Tris Mini Gels [here](#).

* Shelf life varies depending on gel format.

NuPAGE Bis-Tris gels (denaturing separation)

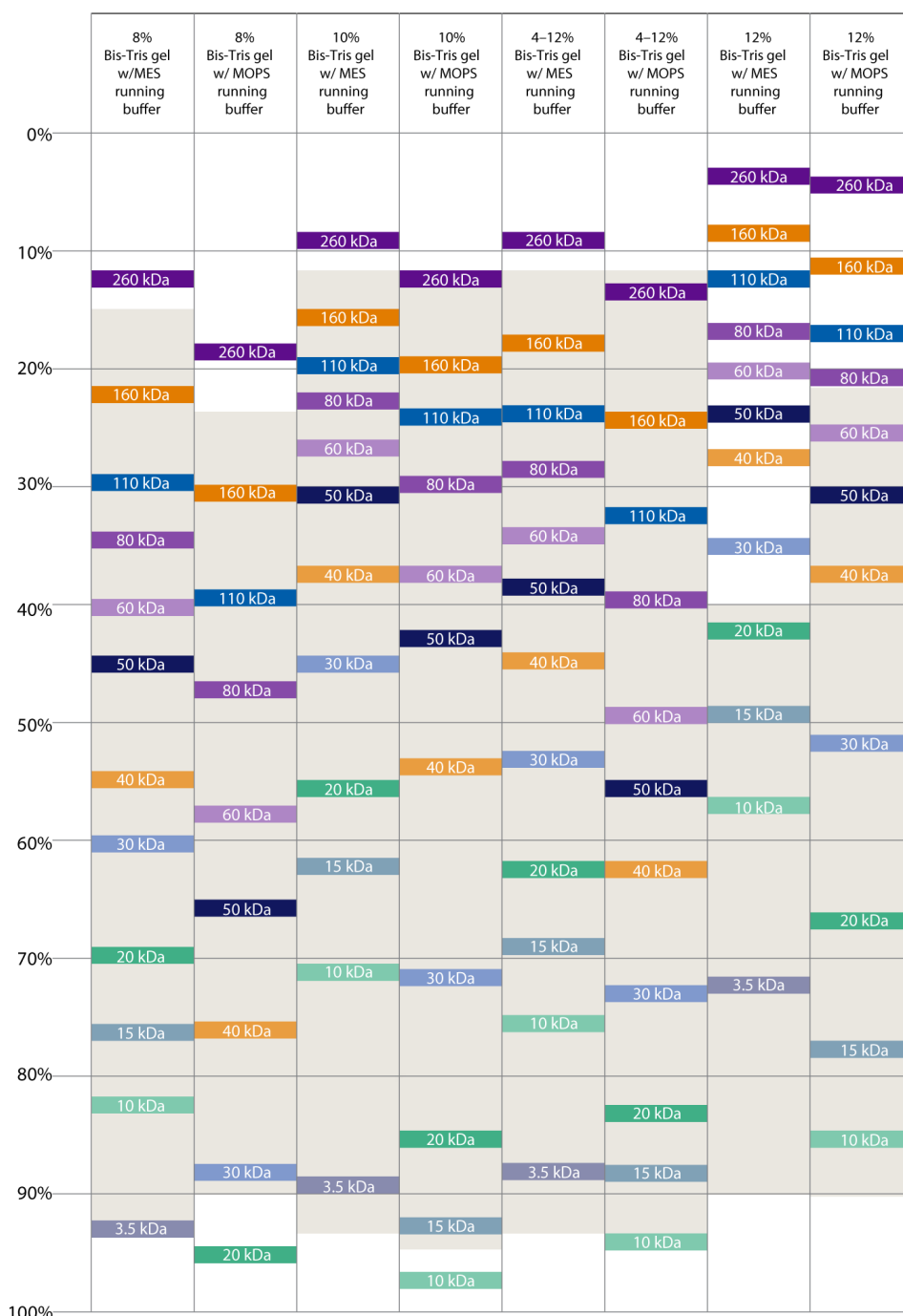


Figure 9. Migration patterns in NuPAGE Bis-Tris gels using Invitrogen™ Novex™ Sharp Prestained Protein Standard or Novex™ Sharp™ Unstained Protein Standard. The optimal separation range is shown within the gray areas.

Novex Tris-Glycine gels

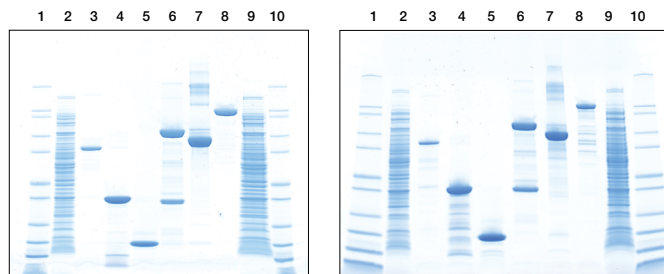
Load up to 100 μ L of sample



The Invitrogen™ Novex™ Tris-Glycine mini gels, WedgeWell™ format, and Invitrogen™ Novex™ Tris-Glycine Plus midi gels are polyacrylamide gels based on traditional Laemmli chemistry that enable the use of Laemmli sample and running buffers. Novex Tris-Glycine gels provide high-quality performance and separation of a wide range of proteins into well-resolved bands (Figures 10 and 11).

Highlights:

- **Wedge-shaped wells**—easily load up to 100 μ L of sample without sacrificing gel width or length (mini gel only)
- **High performance**—excellent protein band resolution and sharpness
- **Improved shelf life**—store gels for up to 12 months at 4°C
- **Fast run conditions**—up to 10 minutes faster than traditional Tris-glycine gels
- **Flexible**—compatible with native and denatured protein samples
- **Cost efficiency**—load more samples in larger-format midi gels and save



Novex 4–20% Tris-Glycine Mini Gel, WedgeWell format

Bio-Rad TGX 4–20% Gel

Figure 10. Better protein resolution and band sharpness with Novex Tris-Glycine Mini Gels, WedgeWell format. Protein ladder, purified proteins, and *E. coli* lysate were loaded on a gradient Novex 4–20% Tris-Glycine Mini Gel, WedgeWell format, and a Bio-Rad TGX 4–20% gradient gel. The Bio-Rad TGX gel displays numerous low molecular weight protein degradation products below major bands in lanes 3, 4, 7, and 8. These are not seen in the Novex Tris-Glycine gel. The Novex gel also displays better protein band sharpness and resolution of lysate than the Bio-Rad gel. **Lanes 1, 10:** 5 μ L Mark12 Unstained Standard; **lane 2:** 10 μ g *E. coli* lysate; **lane 3:** 6 μ g catalase; **lane 4:** 6 μ g carbonic anhydrase; **lane 5:** 6 μ g lysozyme; **lane 6:** 6 μ g hlgM; **lane 7:** 6 μ g BSA; **lane 8:** 6 μ g β -galactosidase; **lane 9:** 20 μ g *E. coli* lysate. The sample volume for lanes 2–9 was 10 μ L.

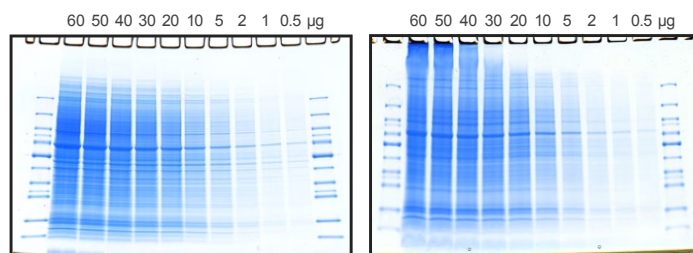


Figure 11. The protein loading capacity of Novex Tris-Glycine Plus midi gels, WedgeWell format, exceeds that of Bio-Rad™ Criterion™ TGX™ gels. The Bio-Rad gel shows streaking, smearing, and retention of protein in the well for protein loads above 20 μ g of lysate.

Review the quick reference protocol for the Novex Tris-Glycine mini gels, WedgeWell format, [here](#).

Learn more at thermofisher.com/novexwedge

Novex Tris-Glycine gel specifications

- Shelf life: up to 12 months at 4°C
- Average run time: 45 minutes
- Separation range: 8 kDa to 260 kDa
- Polyacrylamide concentrations: fixed 6%, 8%, 10%, 12%, 14%, 16%; gradient 4–12%, 4–20%, 8–16%, 10–20%
- Gel dimensions:
 - Mini, WedgeWell format: 8 x 8 cm (1 mm thick)
 - Midi, WedgeWell format: 8 x 13 cm (1 mm thick)
- Maximum sample volume:
 - In 10-well mini gel, WedgeWell format: 60 µL
 - In 20-well midi gel with standard well format: 25 µL

Recommended products

For sample clean-up prior to electrophoresis, we recommend using the

[Thermo Scientific™ Pierce™ SDS-PAGE Sample Prep Kit](#).

Buffers for denatured proteins: [Invitrogen™ Novex™ Tris-Glycine SDS Sample Buffer](#) and [Tris-Glycine SDS Running Buffer](#), or [Rapid Tris-Glycine SDS Running Buffer \(Powder\)](#).

Buffers for native proteins: [Invitrogen™ Novex™ Tris-Glycine Native Sample Buffer](#) and [Tris-Glycine Native Running Buffer](#).

[PageRuler Plus and Spectra protein ladders](#) are recommended for molecular weight determination with [Novex Tris-Glycine gels](#).

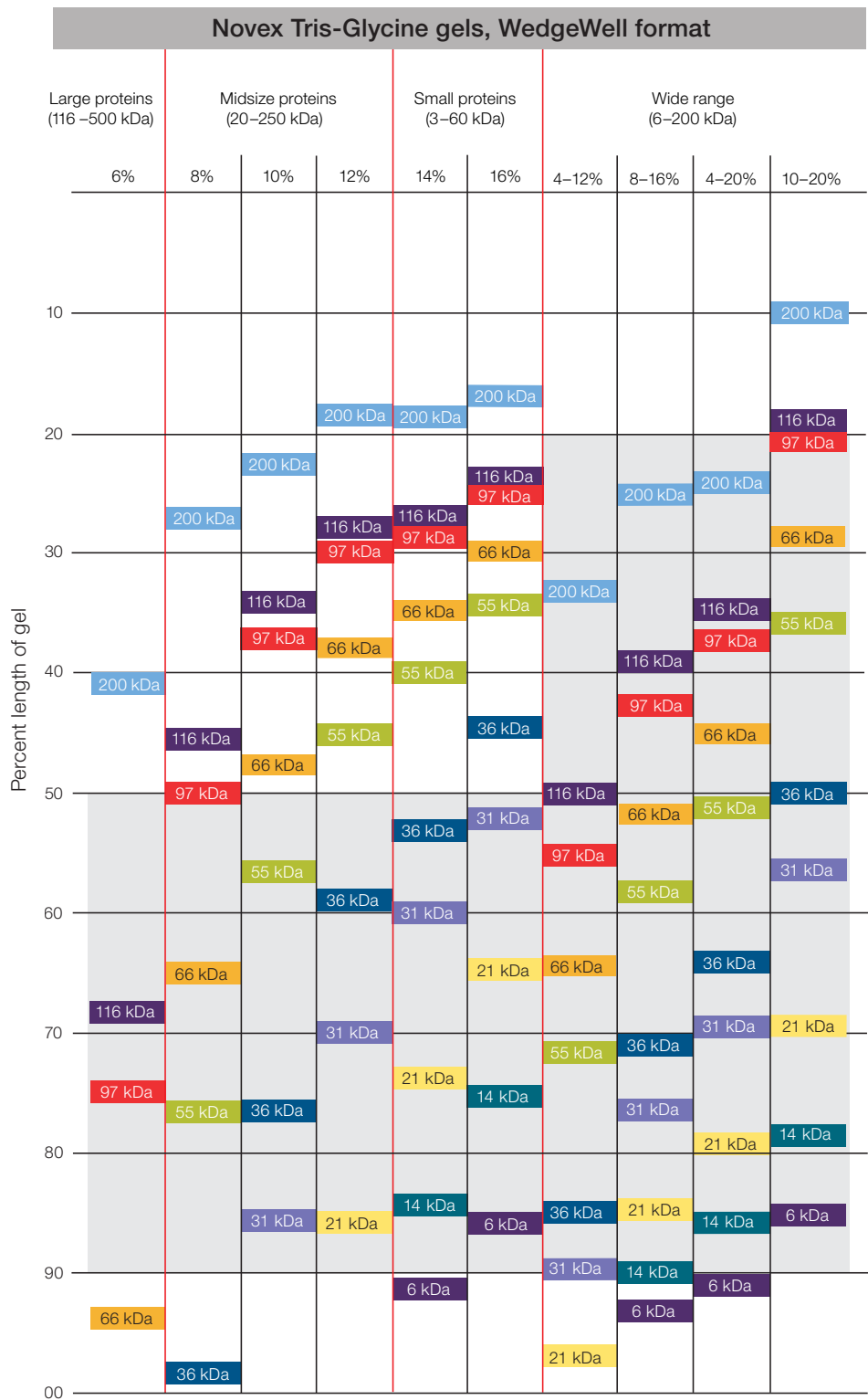


Figure 12. Migration patterns of a protein standard on Novex Tris-Glycine gels, WedgeWell format. Use this chart to select the proper gel for separating proteins based on size. Optimal resolution is achieved when protein bands migrate within the shaded regions. The standard represented here is the Mark12 Unstained Standard under denaturing conditions.



NuPAGE Tris-Acetate gels

High molecular weight protein separation

Tris-acetate gel chemistry enables the optimal separation of high molecular weight proteins. NuPAGE Tris-Acetate gels offer a pH 8.1 environment that minimizes protein modifications and results in sharper bands. NuPAGE Tris-Acetate gels can also be run with Novex Tris-Glycine Native Running Buffer to resolve native proteins more effectively than a Tris-glycine gel system.

NuPAGE Tris-Acetate gels and buffers are designed to allow:

- Optimal separation of high molecular weight proteins (Figures 13 and 15)
- Preservation of protein sample integrity using optimized sample preparation processes
- More efficient western blot transfer—neutral pH prevents reoxidation of reduced samples during protein transfer (Figure 14)
- Double the sample loading capacity with WedgeWell format wells

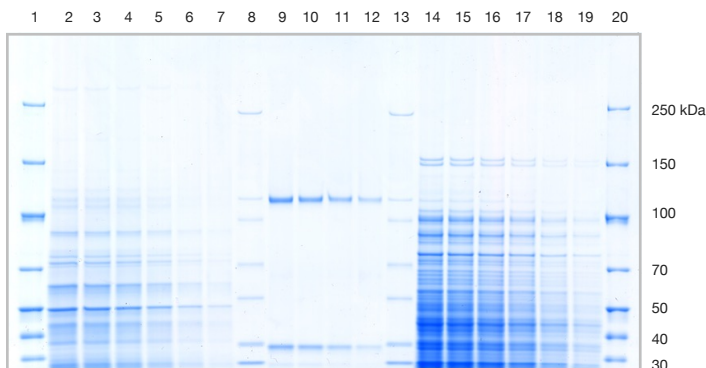


Figure 13. NuPAGE Tris-Acetate gel electrophoresis. An Invitrogen™ NuPAGE™ Tris-Acetate 3–8% gel, WedgeWell format, was loaded as follows: **lanes 1, 20:** 5 µL Thermo Scientific™ PageRuler™ Unstained Broad Range Protein Ladder (Cat. No. 26630); **lanes 2–7:** 10 µg, 8 µg, 6 µg, 4 µg, 2 µg, and 1 µg HeLa cell lysate; **lanes 8, 13:** 5 µL Invitrogen™ Mark12™ Unstained Standard (Cat. No. LC5677); **lanes 9–12:** 240 ng, 180 ng, 120 ng, and 60 ng of protein mix containing β-galactosidase, lactate dehydrogenase, and lysozyme; **lanes 14–19:** 10 µg, 8 µg, 6 µg, 4 µg, 2 µg, and 1 µg *E. coli* lysate. Gel was stained with Invitrogen™ SimplyBlue™ SafeStain.

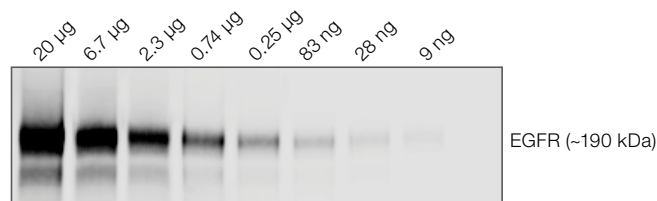
Specifications

- Shelf life: 8 months
- Average run time: 35 minutes
- Separation range: 30–400 kDa
- Polyacrylamide concentrations: fixed 7%; gradient 3–8%
- Gel dimensions:
 - Mini (traditional) and mini (WedgeWell format): 8 x 8 cm (1 or 1.5 mm thick)
 - Midi (traditional) and midi (WedgeWell format): 8 x 13 cm (1 mm thick)
- Maximum sample volume per 10-well mini gel: 25 µL (1 mm thick); 37 µL (1.5 mm thick)

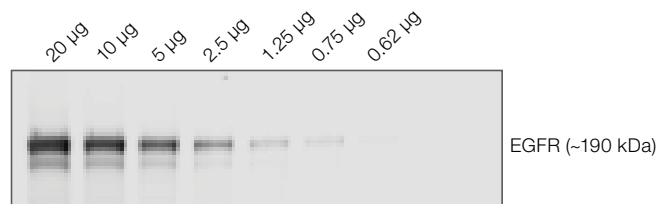
Recommended products

Invitrogen™ HiMark™ Unstained and Prestained Protein

Standards are specifically designed for large protein analysis on NuPAGE Tris-Acetate gels under denaturing conditions. Both standards offer a ready-to-load format and consist of 9 proteins with a size range of 40–500 kDa.



NuPAGE 3–8% Tris-Acetate mini gel



Novex 4–20% Tris-Glycine mini gel, WedgeWell format

Figure 14. Improved transfers of high molecular weight proteins enhance western detection sensitivity. Western blotting analysis of EGFR from A431 lysates transferred from a Novex 4–20% Tris-Glycine mini gel, WedgeWell format, and a NuPAGE 3–8% Tris-Acetate mini gel using the iBlot 2 Gel Transfer Device.

A NuPAGE Tris-Acetate gels
(denaturing separation)

3–8% Tris-acetate gel w/ TA running buffer	7% Tris-acetate gel w/ TA running buffer
	500 kDa
	290 kDa
500 kDa	240 kDa
290 kDa	160 kDa
240 kDa	
	116 kDa
	97 kDa
160 kDa	
116 kDa	66 kDa
97 kDa	
	55 kDa
66 kDa	
55 kDa	40 kDa
40 kDa	

B NuPAGE Tris-Acetate gels
(native separation)

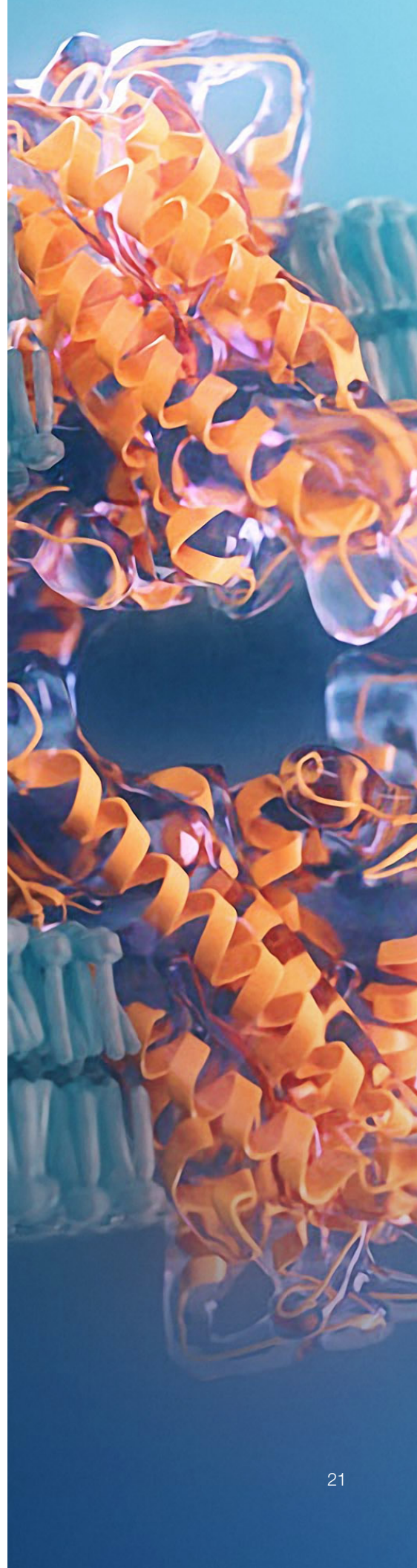
A horizontal bar chart comparing the distribution of protein sizes (kDa) for two groups: 3-8% and 7%. The y-axis represents the percentage of total protein, ranging from 0% to 100% in 10% increments. The x-axis represents the protein size in kDa. The 3-8% group is represented by blue bars, and the 7% group is represented by orange bars. The data is as follows:

Protein Size (kDa)	3-8% Group (%)	7% Group (%)
1,048	15%	10%
720	15%	25%
480	15%	35%
242	10%	15%
146	0%	10%

Figure 15. Migration patterns in NuPAGE Tris-Acetate gels. For optimal results, protein bands should migrate within the gray shaded areas. **(A)** Migration pattern of Invitrogen™ HiMark™ Unstained Protein Standard on a NuPAGE Tris-Acetate gel under denaturing conditions. **(B)** Migration pattern of Invitrogen™ NativeMark™ Unstained Protein Standard on a NuPAGE Tris-Acetate gel under native conditions.

Review the quick reference protocol for NuPAGE Tris-acetate mini gels [here](#).

Learn more about NuPAGE Tris-Acetate gels at thermofisher.com/trisacetate



Novex Tricine gels

High-resolution gels for peptide analysis and low molecular weight proteins

The Invitrogen™ Novex™ tricine gel system is a modification of the Tris-glycine system in which tricine replaces glycine in the running buffer. This system uses a discontinuous buffer system specifically designed for the resolution of low molecular weight proteins (Figure 16).

Advantages of Novex Tricine gels over Tris-glycine gels include:

- Increased resolution of proteins with molecular weights as low as 2 kDa (Figure 17)
- Improved compatibility with direct protein sequencing applications after transferring to PVDF membranes
- Minimized protein modifications, due to the lower pH of the tricine buffering system

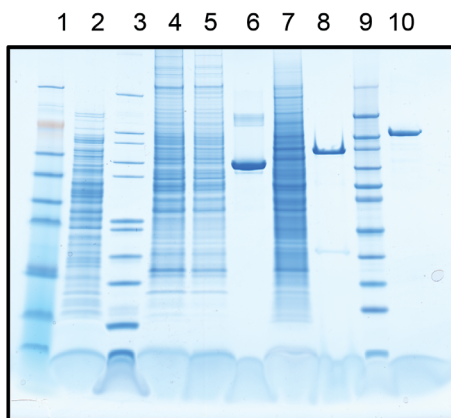


Figure 16. Novex Tricine gel electrophoresis. Protein standards and samples were loaded at 10 µL sample volumes on Invitrogen™ Novex™ 10–20% Tricine Protein Gels. Electrophoresis was performed using the Mini Gel Tank at 200 V (constant). Sharp, straight bands were observed after staining with SimplyBlue SafeStain. Image was acquired using a flatbed scanner. **Lane 1:** SeeBlue Plus2 Prestained Standard; **lane 2:** 10 µg *E. coli* lysate; **lane 3:** Mark12 Unstained Standard (blend of 12 purified proteins); **lane 4:** 40 µg HeLa cell lysate; **lane 5:** 20 µg HeLa cell lysate; **lane 6:** 5 µg BSA; **lane 7:** 40 µg Jurkat cell lysate; **lane 8:** 5 µg GST fusion protein; **lane 9:** Novex Sharp Unstained Protein Standard; **lane 10:** 5 µg β-galactosidase.

Novex Tricine gels

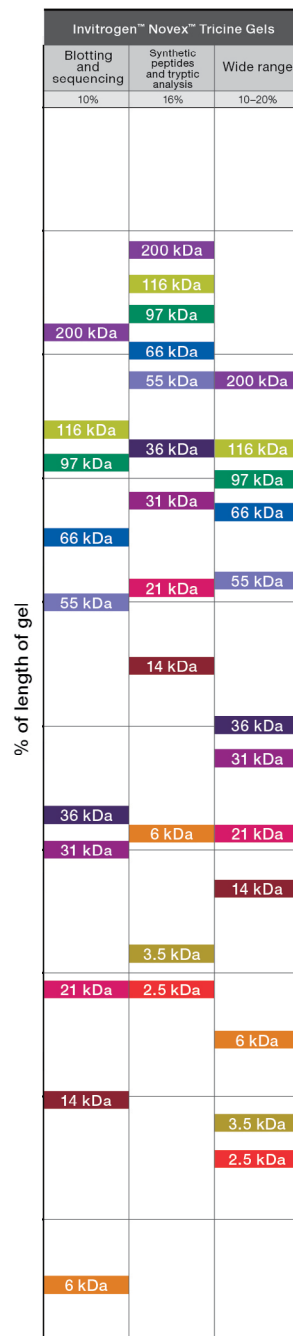


Figure 17. Novex Tricine gel migration chart. Migration patterns of the Mark12 Unstained Standard are shown.



Good to know

How Novex Tricine gels work

In the traditional Tris-glycine protein gel system, the resolution of smaller proteins (<10 kDa) is hindered by the continuous accumulation of free dodecyl sulfate (DS) ions from the SDS contained in the sample and running buffers in the stacking gel, which causes mixing of the DS ions with smaller proteins and results in fuzzy bands and decreased resolution. The mixing also interferes with the fixing and staining of smaller proteins. The Novex Tricine gel system uses a low pH in the gel buffer and substitutes tricine for glycine in the running buffer. The smaller proteins and peptides that migrate with the stacked DS ions in the Tris-glycine gel system are well separated from DS ions in the Novex Tricine gel system, offering sharper bands and higher resolution.

Did you know



Sample preparation is not the only factor that can result in poorly resolved bands. You can minimize protein degradation by using gels with neutral-pH chemistry.

Recommended products

Use Novex Tricine gels with the [Thermo Scientific™ In-Gel Tryptic Digestion Kit](#) for separation and digestion of peptides for mass spectrometry.

Review the protocol for Novex Tricine gels [here](#).

Learn more at thermofisher.com/tricine

NativePAGE Bis-Tris gels

Excellent resolution of native proteins and protein complexes

The Invitrogen™ NativePAGE™ Bis-Tris gel system is based on the blue native polyacrylamide gel electrophoresis (BN PAGE) technique that uses Coomassie G-250 dye as a charge shift molecule that binds to proteins and confers a negative charge without denaturing the proteins (Figure 18). This technique overcomes the limitations of traditional native electrophoresis by providing a near-neutral operating pH and detergent compatibility. The near-neutral (pH 7.5) environment of the NativePAGE gel system during electrophoresis results in maximum protein and gel matrix stability, enabling better band resolution than other native gel systems. A gel migration chart is shown in Figure 19.

The NativePAGE gel system is designed for:

- **A wide resolving range**—from 15 kDa to >10 MDa, regardless of isoelectric point
- **Neutral-pH separation**—the native state of protein complexes is better preserved
- **Excellent performance**—higher resolution than Tris-glycine native electrophoresis

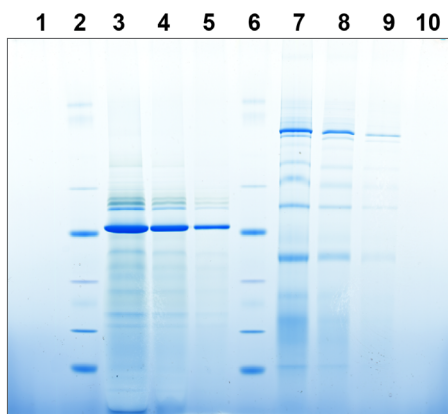


Figure 18. NativePAGE gel electrophoresis. Two-fold serial dilutions of protein extracts were run on an Invitrogen™ NativePAGE™ 3–12% Bis-Tris Protein Gel using a Mini Gel Tank. Following electrophoresis, the gel was stained with Coomassie dye and imaged using a flatbed scanner. **Lanes 1, 10:** blank; **lanes 2, 6:** 5 µL NativeMark Unstained Protein Standard; **lanes 3–5:** 10, 5, and 2.5 µg spinach chloroplast extract; **lanes 7–9:** 10, 5, and 2.5 µg bovine mitochondrial extract.

Review the protocol for NativePAGE Bis-Tris gels [here](#).

Learn more at thermofisher.com/nativepage

NativePAGE gels

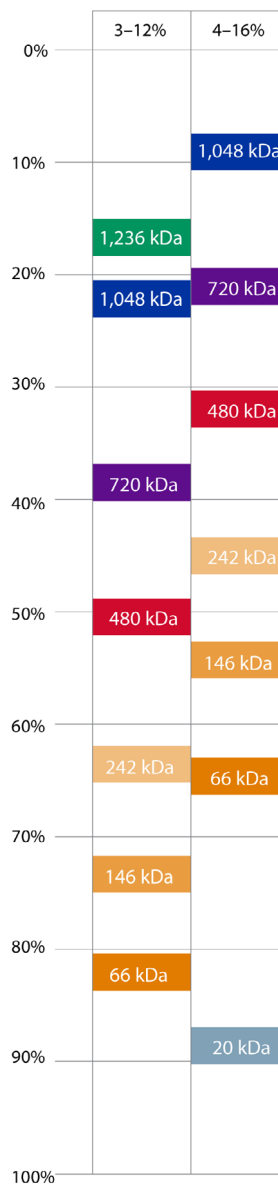


Figure 19. NativePAGE gel migration chart. Migration patterns of the NativeMark Unstained Protein Standard on NativePAGE gels are shown.

Recommended products

The [NativeMark Unstained Protein Standard](#) is recommended for use with native gel chemistries, including our Tris-glycine, Tris-acetate, and NativePAGE gel systems. This standard offers a wide molecular weight range of 20–1,200 kDa, and the 242 kDa β-phycoerythrin is visible as a red band after electrophoresis for reference (prior to staining).



Did you know

The blue native polyacrylamide gel electrophoresis technique was developed by Hermann Schägger and Gebhard von Jagow in 1991.

Novex IEF gels

Precast gels for isoelectric point determination

Isoelectric focusing (IEF) is an electrophoresis technique that separates proteins based on their isoelectric point (pI). The pI is the pH at which a protein has no net charge and does not move in an electric field. Invitrogen™ Novex™ IEF gels effectively create a pH gradient so proteins separate according to their unique pI (Figures 20 and 21). These gels can be used for pI determination or for detection of minor changes in a protein due to deamination, phosphorylation, or glycosylation, and can resolve different proteins of similar size that cannot be resolved on standard SDS-PAGE gels.

When used with our convenient, preoptimized buffers, solubilizers, and molecular weight markers, Novex IEF gels can provide:

- **Accurate pI determination**
- **Clear, sharp bands** for easy identification of protein modifications
- **Higher resolution** of slight differences in size when used in combination with SDS-PAGE for 2D electrophoresis

Specifications

- Shelf life: 6 months
- Run time: 2.5 hours
- Separation range:
 - pH 3–10 gels: pI performance range is 3.5–8.0
 - pH 3–7 gels: pI performance range is 3.0–7.0
- Polyacrylamide concentration: fixed 5%
- Gel dimensions: 8 x 8 cm (1 mm thick)
- Maximum sample volume per 10-well gel: 20 µL

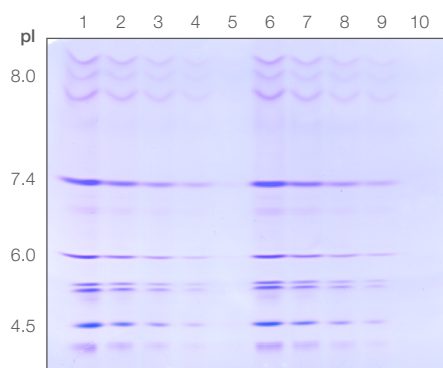


Figure 20. Novex IEF gel electrophoresis. A 2-fold dilution series of Invitrogen™ IEF Marker 3–10 was run in duplicate on an Invitrogen™ Novex™ pH 3–10 IEF Protein Gel using a Mini Gel Tank. The IEF Marker 3–10 consists of proteins with a variety of isoelectric points; these proteins include lectin (pI = 7.8, 8.0, and 8.3), myoglobin from horse muscle (pI = 6.9 and 7.4), carbonic anhydrase from bovine erythrocytes (pI = 6.0), β -lactoglobulin from bovine milk (pI = 5.2 and 5.3), soybean trypsin inhibitor (pI = 4.5), and glucose oxidase (pI = 4.2). After electrophoresis, the gel was fixed and stained using Coomassie R-250 dye. Gel imaging was performed with a flatbed scanner. Volumes of IEF Marker 3–10 loaded: **Lanes 1, 6:** 20 µL; **lanes 2, 7:** 10 µL; **lanes 3, 8:** 5 µL; **lanes 4, 9:** 2.5 µL; **lanes 5, 10:** blank.

Learn more at thermofisher.com/ief

Separated on precast
vertical gel (slab)

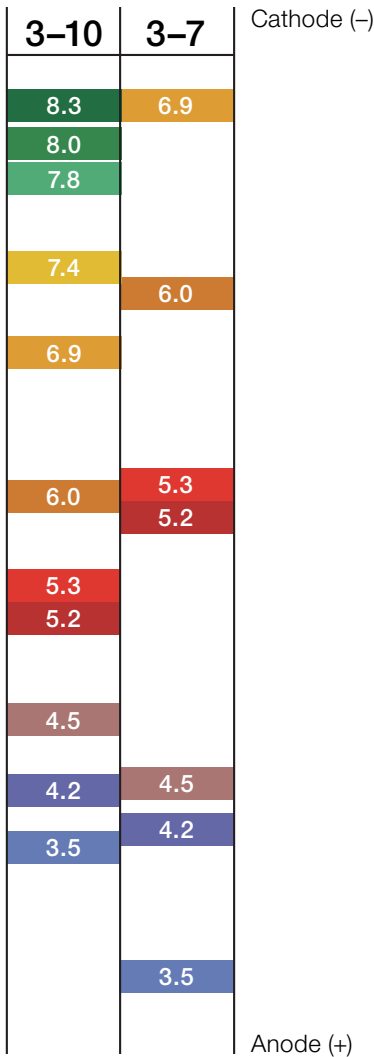


Figure 21. Novex IEF gel migration chart using the IEF marker. Proteins shown are amyloglucosidase (*Aspergillus niger*), pI = 3.5; glucose oxidase (*Aspergillus niger*), pI = 4.2; trypsin inhibitor (soybean), pI = 4.5; β-lactoglobulin (bovine, milk), pI = 5.2 and 5.3; carbonic anhydrase (bovine, erythrocytes), pI = 6.0; myoglobin (horse, muscle), pI = 6.9 and 7.4; lectin (*Lens culinaris*), pI = 7.8, 8.0, and 8.3; ribonuclease A (bovine, pancreas), pI = 9.5; and cytochrome c (horse, heart), pI = 10.7.

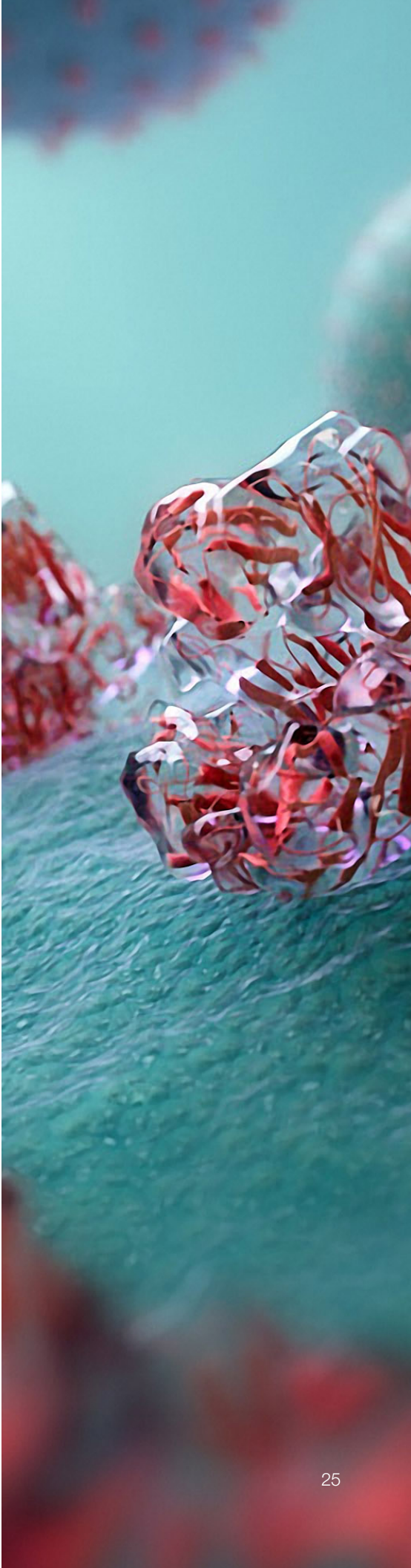
Recommended products

[Invitrogen™ Novex™ IEF buffer kits](#) include optimized cathode, anode, and sample buffers to help reduce variability and enable consistent results.

[IEF Marker 3-10](#) is ready to use and gives accurate results.

Did you know

Harry Svensson-Rilbe and his student Olof Vesterberg first described the theory of separation of amphoteric proteins along a pH gradient by applying an electric field in the 1960s.



Zymogram gels

Easy in-gel protease analysis

Invitrogen™ Novex™ 10% Zymogram Plus (gelatin) gels are useful for the detection and characterization of proteases that use gelatin as a substrate. The proteases are run under denaturing conditions and visualized as clear bands against a dark background using a simple renaturing, developing, and staining protocol. Zymogram gels are commonly used to detect matrix metalloproteases. Novex 10% Zymogram Plus gels are highly sensitive, detecting as little as 5×10^{-6} units of collagenase.

Novex Zymogram Plus (gelatin) gel characteristics.

Zymogram Plus gelatin gel	
Gel composition	10% Tris-glycine gel
Substrate	0.1% gelatin
Sensitivity	5×10^{-6} units of collagenase
Post-staining required?	Yes
Separation range	20–220 kDa



Good to know

How do Novex zymogram gels work?

Protease samples are denatured in SDS buffer under nonreducing conditions and without heating, and run on a Novex Zymogram Plus gel in Tris-Glycine SDS Running Buffer. After electrophoresis, the proteases are renatured by incubating the gel in Invitrogen™ Novex™ Zymogram Renaturing Buffer, which contains a nonionic detergent. The gels are then equilibrated in Invitrogen™ Novex™ Zymogram Developing Buffer to add divalent metal cations required for enzymatic activity, and then stained and destained. Regions of protease activity appear as clear bands against a dark blue background where the protease has digested the substrate.

Specifications

- Shelf life: 16 weeks
- Average run time: 90 minutes
- Separation range: 20–220 kDa (Figure 22)
- Polyacrylamide concentrations: fixed 10% (with gelatin)
- Gel dimensions: 8 x 8 cm (1 mm thick)
- Maximum sample volume per well: 20 μ L

Learn more at [thermofisher.com/zymogram](https://www.thermofisher.com/zymogram)

Novex Zymogram gel

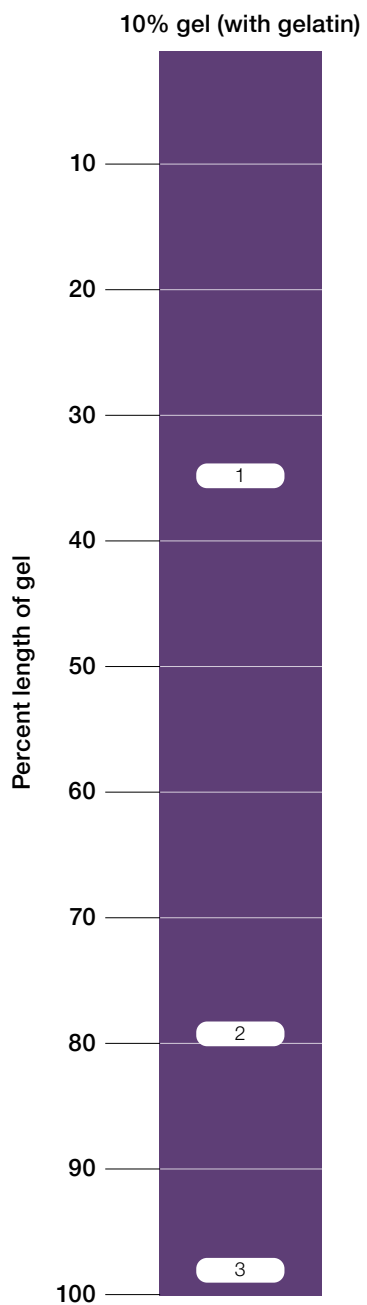


Figure 22. Novex Zymogram Plus (gelatin) gel migration chart.

The numbered bands refer to the following proteases:

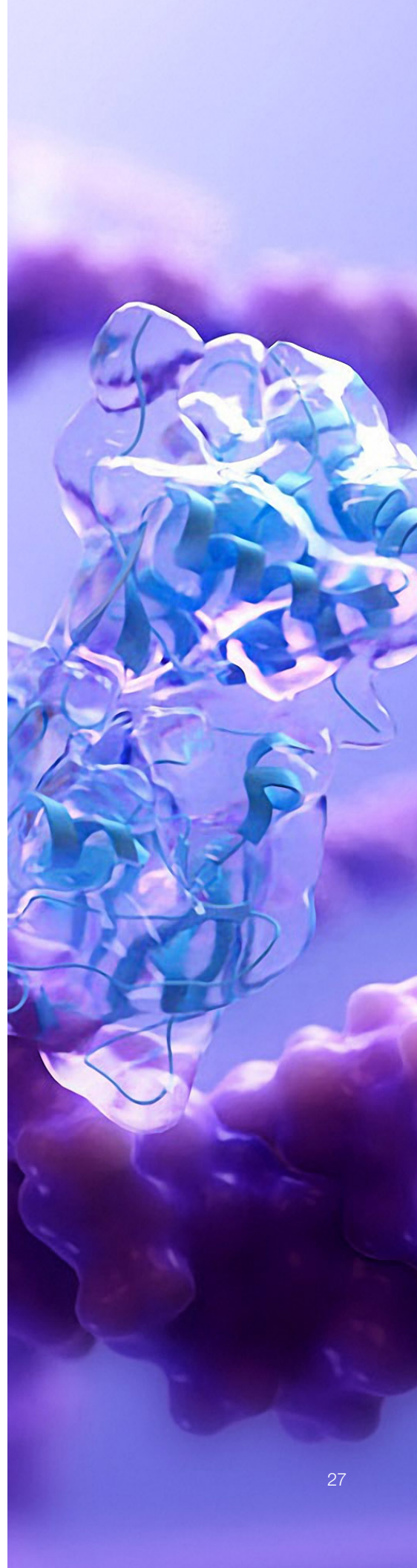
Band 1: Collagenase type I (140 kDa)

Band 2: Thermolysin (37 kDa)

Band 3: Trypsin (19 kDa)

Recommended products

After electrophoresis, incubate the gel in [Novex Zymogram Renaturing Buffer \(10X\)](#) to renature the enzyme. The gel is then equilibrated in [Novex Zymogram Developing Buffer \(10X\)](#) to add divalent metal cations required for enzymatic activity.



E-PAGE High-Throughput Precast Gel System

Protein separation and analysis for increased sample throughput

The Invitrogen™ E-PAGE™ High-Throughput Precast Gel System is designed for fast, bufferless medium- and high-throughput protein analysis. Invitrogen™ E-PAGE™ 48-well and 96-well precast gels consist of a buffered gel matrix and electrodes packaged inside a disposable, UV-transparent cassette. Each cassette is labeled with a unique barcode to facilitate identification of the gel using commercial barcode readers. These gels can be loaded with a multichannel pipettor or automated loading system. The E-PAGE system is compatible with the Invitrogen™ E-Gel™ Power Snap Plus Electrophoresis System, which integrates electrophoresis and real-time gel imaging into a single benchtop instrument for streamlined gel loading, running, and analysis.

Advantages of using the E-PAGE High-Throughput Precast Gel System include:

- **Ease of use**—quick setup and fast protein separation in about 23 minutes
- **Fast loading**—compatible with multichannel pipettors and robotic loading
- **Efficient western blotting and staining**—optimized protocols and reagents



Specifications

- Shelf life: 6 months
- Average run time: 23 minutes
- Separation range: 10–200 kDa (Figure 24)
- Polyacrylamide concentrations:
 - E-PAGE 48 gel: fixed 8%
 - E-PAGE 96 gel: fixed 6%
- Gel dimensions: 13.5 x 10.8 cm (3.7 mm thick)
- Maximum sample volume per well:
 - E-PAGE 48 gel: 20 µL
 - E-PAGE 96 gel: 15 µL



Good to know

How do E-PAGE gels work?

E-PAGE gels are run in the E-Gel Power Snap Plus Electrophoresis System, which is designed to save time and streamline the protein electrophoresis workflow by enabling a simple three-step process: load, run, and analyze (Figure 23). Use of E-PAGE gels eliminates gel preparation, while preprogrammed protocols support fast and reproducible runs.



Figure 23. The E-Gel Power Snap Plus Electrophoresis System offers highly reproducible results with 3 easy steps.

Learn more at thermofisher.com/epage

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Did you know

SureCast Gel Handcast System

100% leak-free*—avoid pouring another gel because of leaks

The Invitrogen™ SureCast™ Gel Handcast System is designed for leak-free, confident gel casting. The SureCast system is fully compatible with the Mini Gel Tank.

Benefits offered by the SureCast Gel Handcast System include:

- **Leak-free design**—less time wasted recasting after gels have leaked
- **Excellent glass plate durability**—up to 20 times more durable than other suppliers' plates**
- **Unique tilt feature**—helps minimize spillage when pouring acrylamide solutions
- **Simple assembly of casting components**—a single-motion, load-and-lock mechanism
- **Optional multi-use tools**—all-in-one tools to guide gel loading, help open gel cassettes, and trim gels

* For details, go to thermofisher.com/surecastterms.

** Based on internal testing.



SureCast gel handcast reagents

SureCast Stacking Buffer and Resolving Buffer

Invitrogen™ SureCast™ Stacking Buffer and Resolving Buffer are pouches of dry-blend powder, each sufficient to make 500 mL of stacking gel buffer (0.5 M Tris-HCl buffer, pH 6.8) or 500 mL of resolving gel buffer (1.5 M Tris buffer, pH 8.8) for handcasting polyacrylamide gels.

Benefits include:

- **Convenient pouches of dry-blend powder**—dissolve contents of a single packet in water and the buffer is ready to use
- **Time-and space-saving**—no weighing, no calculations, no pH adjustment, and no need to stock individual components
- **Long shelf life**—easy stocking and storage, as dry powder minimizes concerns about long-term stability of stock solutions

SureCast Acrylamide Solution, 40%

Invitrogen™ SureCast™ Acrylamide Solution (40%) can be used to prepare single-percentage and gradient gels using the SureCast Gel Handcast System or other handcast systems.

Features include:

- Room-temperature storage
- Long shelf life
- High purity
- Safer alternative to powdered acrylamide
- Concentrated to enable a broader range of gel percentages to cast



See the SureCast Gel Handcast System in action at thermofisher.com/surecast



Protein extraction and sample preparation for electrophoresis

Good sample preparation is critical for successful separation of protein bands in electrophoresis. No single sample preparation method or buffer will work for all sample types due to the diversity of protein samples. However, the following general guidelines below should help when preparing samples for protein electrophoresis.

- To minimize sample variability, keep sample preparation workflows simple, and use reagents optimized for the specific sample type and target proteins.
- Cell lysis disrupts cell membranes and organelles, resulting in unregulated enzymatic activity that can reduce protein yield and lead to degraded proteins. To prevent these negative effects, protease and phosphatase inhibitors should be added to the lysis reagents.
- Some buffer components may interfere with the chosen gel electrophoresis chemistry system (e.g., Tris-glycine, Bis-Tris) and cause a variety of artifacts when running the gel. Selecting a gel electrophoresis chemistry that is compatible with the buffer one's sample is prepared in is

the simplest route. However, if one cannot change the gel electrophoresis chemistry system, one may need to perform sample clean-up to render the sample compatible with the given system (see "Protein clean-up methods" section). Certain clean-up methods are more favorable than others for reducing or removing specific interfering substances.

- To avoid under- or overloading samples, determine the protein concentration of each sample prior to electrophoresis with a compatible protein assay (see "Protein quantitation" section). Note that certain buffer components can interfere with the chemistry of a given protein assay, and these components may need to be reduced or removed from the sample prior to determining sample concentration. These interfering substances can cause artificially high or low concentration readings, depending on the substance and the given protein assay.

Protein sample preparation for electrophoresis

Step 1

Cellular disruption and protein extraction

Different samples (e.g., plant vs. mammalian cells) will require different disruption and extraction strategies. Use reagents that have been optimized for specific sample types. In addition, use protease and phosphatase inhibitors to minimize activity of proteases that can modify and reduce protein yields. For long-term storage of samples, we recommend freezing them to further inhibit protein degradation.

Step 2

Contaminant removal, desalting, concentration

Remove or reduce interfering substances that can negatively impact electrophoresis.

Step 3

Quantitation

Quantitate protein samples using a compatible protein assay. Concentrate or dilute samples if necessary.

Protein extraction and clean-up methods

Gentle formulations designed to maximize protein yield and activity

Obtain high protein yields from tissues, cells, or subcellular fractions using reagents and kits that are optimized for mammalian, bacterial, yeast, insect (baculovirus), and plant samples. These gentle formulations have been verified in multiple tissue types and cell lines, and generally eliminate the need for mechanical cell disruption.

Overview of sample types and recommended protein extraction reagents and kits.

Sample type	Goal	Recommended Thermo Scientific™ reagents or kits
Primary cultured or mammalian cells or tissues	Total protein extraction	M-PER™ Mammalian Protein Extraction Reagent T-PER™ Tissue Protein Extraction Reagent N-PER™ Neuronal Protein Extraction Reagent RIPA Lysis and Extraction Buffer Pierce™ IP Lysis Buffer
Cultured mammalian cells or tissues	Subcellular fractionation or organelle isolation	NE-PER™ Nuclear and Cytoplasmic Extraction Reagents Subcellular fractionation kits Mitochondria isolation kits Pierce™ Cell Surface Protein Isolation Kit Syn-PER™ Synaptic Protein Extraction Reagent Lysosome Enrichment Kit for Tissues and Cultured Cells
Bacterial cells	Total protein extraction	B-PER™ Complete Bacterial Protein Extraction Reagent
Yeast cells	Total protein extraction	Y-PER™ Yeast Protein Extraction Reagent Y-PER™ Plus Dialyzable Yeast Protein Extraction Reagent
Insect cells (baculovirus)	Total protein extraction	I-PER™ Insect Cell Protein Extraction Reagent
Plant tissue (leaf, stem, root, flower)	Total protein extraction	Pierce™ Plant Total Protein Extraction Kit



Did you know

Although RIPA buffer is a common lysis buffer used for preparing samples for SDS-PAGE and western blot analysis, RIPA buffer is a strong lysis buffer than contains components that may interfere with certain protein assays and gel electrophoresis chemistries. Cross reference your RIPA buffer recipe to the interfering substances lists for both gel electrophoresis and protein assays, as multiple variants on the traditional RIPA buffer recipe exist.

Learn more at thermofisher.com/proteinextraction

Protein electrophoresis interfering substances

Interfering substance	Potential issues	Solution
Excess salt	High salt results in increased conductivity that causes uneven sample lanes and lane widening	<ul style="list-style-type: none"> Perform a sample clean-up method to lower salt concentration (see “Protein clean-up methods”) Make sure that the salt concentration does not exceed 50–100 mM
DNA contamination	Excess DNA causes the sample to become viscous resulting in protein clumping, which can result in narrow lanes that cannot be interpreted	Shear genomic DNA to reduce viscosity before loading the sample
High detergent concentration	Detergents can form mixed micelles with SDS and migrate through the gel. This can lead to lane widening, uneven sample lanes, and streaks in lower regions of lanes, limiting the ability to analyze proteins less than 40 kDa	<ul style="list-style-type: none"> Dilute the sample to reduce the final concentration of detergents in the samples loaded Remove excess detergent with detergent removal columns or SDS-PAGE sample prep kits
Sample type and protein load	High protein loads can cause several issues, such as loss of protein band resolution, lane streaking, and non-straight lanes	The maximum recommended sample load for optimal resolution in mini gels with 10, 12, 15, or 17 wells is 0.5 µg per band or about 10–15 µg of cell lysate per lane
Excess/incorrect reducing agent	Excess reducing reagent can cause shadows at lane edges	The final concentration of reducing agents for SDS-PAGE should be less than 50 mM for dithiothreitol (DTT) and Tris(2-carboxyethyl)phosphine (TCEP), and less than 2.5% for β-mercaptoethanol (β-ME)
Excess guanidine-HCl	Guanidine-HCl has high ionic strength and results in increased conductivity that causes uneven sample lanes and lane widening	Perform sample clean-up method

Protein clean-up methods

Many detergents and salts used in protein extraction formulations may have adverse effects on downstream analysis by protein electrophoresis. Therefore, it may be necessary to remove or reduce these contaminants following cell lysis or subsequent sample processing such as protein purification. Listed below are the different techniques that can be used to limit these interfering substances.

Dialysis

Dialysis is a classic separation technique that facilitates the removal of small, unwanted compounds from proteins in solution by selective diffusion through a semipermeable membrane. Proteins that are larger than the membrane pores are retained on the sample side of the membrane, but low molecular weight contaminants diffuse freely through the membrane and can be removed over multiple buffer exchanges. Thermo Scientific™ Slide-A-Lyzer™ dialysis cassettes and devices are ready to use and designed to minimize potential sample leakage and maximize ease of use for specific applications.

Desalting

Size exclusion chromatography (also known as gel filtration) can be effectively utilized for protein desalting. A resin is selected with pores that are large enough for small contaminants (e.g., salts) to penetrate, but too small for the protein of interest to enter. This causes the migration of small contaminants to slow as they get trapped in the resin, while the larger, faster proteins emerge from the column first, allowing the protein of interest to be recovered separately from the small molecules retained on the column. Thermo Scientific™ Zeba™ desalting products contain a unique resin and are specifically designed to provide consistent performance over a wide range of protein concentrations and sample sizes. High recovery of protein can be achieved even for dilute protein samples.

Concentration

Protein concentration and diafiltration, similar to dialysis, uses a semipermeable membrane to separate macromolecules from low molecular weight compounds. Unlike dialysis, which relies on passive diffusion, concentration is achieved by forcing both liquid (buffers) and low molecular weight solutes through the membrane by centrifugation, where they are collected on the other side (filtrate). Macromolecules remain on the sample side of the membrane, where they become concentrated to a smaller volume (retentate). For buffer exchange, the retentate is diluted to the original volume with exchange buffer and centrifuged multiple times until the desired level of exchange has been achieved. Our high-performance Thermo Scientific™ Pierce™ Protein Concentrators enable rapid sample processing with high protein recovery.

Precipitation

Protein precipitation removes interfering substances by selectively precipitating proteins using trichloroacetic acid (TCA) or acetone. The solution containing the interfering substance is removed, and the protein is then resolubilized in an assay-compatible buffer. Commercially available kits simplify sample pretreatment for protein assays. Small molecules may be separated from large proteins in a sample via precipitation with acetone. When used in combination with 96-well centrifuge filter plates, this method is ideal for processing many samples at once.

Comparison of protein sample clean-up methods

Technique	Dialysis	Desalting	Concentration	Precipitation
Best for	Buffer exchange, desalting	Desalting, buffer exchange	Sample concentration, desalting, buffer exchange	Complete buffer replacement
Advantages	Maximum flexibility in processing volume, wide range of molecular weight cutoffs	Speed	Best for low- to medium-volume samples; fast compared to traditional dialysis	Low cost, good for small volumes
Disadvantages	Slow and multiple rounds of dialysis may be required	Limited sample volume can be processed at a time	Potential protein loss	Higher protein loss
Sample processing time	~2–24 hr	~5–10 min	~5–30 min	~5 min
Sample volume processing ranges	10 µL–250 mL	2 µL–4 mL	100 µL–100 mL	Any
Recommended sample type	Purified protein	Lysate or purified protein	Lysate or purified protein	Lysate or purified protein
Recommended product	Thermo Scientific™ Slide-A-Lyzer™ Cassettes	Thermo Scientific™ Zeba™ Spin Desalting Columns	Thermo Scientific™ Pierce™ Protein Concentrators	Thermo Scientific™ Pierce™ SDS-PAGE Sample Prep Kit

Download the [protein clean-up handbook](#) to learn more

Protein quantitation

Determining your sample's protein concentration

Protein quantitation is a necessary step before conducting analysis that compares one sample to another and to prevent under- or overloading of the gel. There are many different factors to consider when choosing the optimal protein

quantification method. Two important considerations are the compatibility with common substances in the sample (detergents, reducing agents, inhibitors, salts, chaotropic agents) and the sensitivity needed. See the table below for the recommend assay based on common lysis buffers.

Recommended assays based on common lysis buffers

Lysis/extraction buffer	Recommended protein assay	If adding reducing agents or metal chelators (e.g., DTT above 1 mM, EDTA above 10 mM)
RIPA Lysis and Extraction Buffer (25 mM Tris-HCl, pH 7.6, 150 mM NaCl, 1% NP-40, 1% sodium deoxycholate, 0.1% SDS)	<ul style="list-style-type: none"> Pierce Dilution-Free Rapid Gold BCA Protein Assay Kit Pierce BCA Protein Assay Kit with Dilution-Free BSA Protein Standards 	Pierce BCA Protein Assay Kit – Reducing Agent Compatible
Cell Extraction Buffer (10 mM Tris, pH 7.4, 100 mM NaCl, 1 mM EDTA, 1 mM EGTA, 1 mM NaF, 20 mM Na ₂ P ₂ O ₇ , 2 mM Na ₃ VO ₄ , 1% Triton™ X-100, 10% glycerol, 0.1% SDS, 0.5% deoxycholate)	<ul style="list-style-type: none"> Pierce BCA Protein Assay Kit – Reducing Agent Compatible 	Pierce BCA Protein Assay – Reducing Agent Compatible
M-PER Mammalian Protein Extraction Reagent	<ul style="list-style-type: none"> Pierce Dilution-Free Rapid Gold BCA Protein Assay Kit Pierce BCA Protein Assay Kit with Dilution-Free BSA Protein Standards 	Pierce Bradford Plus Protein Assay Kit with Dilution-Free BSA Protein Standards
B-PER Bacterial Protein Extraction Reagents	<ul style="list-style-type: none"> Pierce Dilution-Free Rapid Gold BCA Protein Assay Kit Pierce BCA Protein Assay Kit with Dilution-Free BSA Protein Standards 	Pierce BCA Protein Assay Kit – Reducing Agent Compatible
NE-PER Nuclear and Cytoplasmic Extraction Reagents	<ul style="list-style-type: none"> Pierce Dilution-Free Rapid Gold BCA Protein Assay Kit Pierce BCA Protein Assay Kit with Dilution-Free BSA Protein Standards 	Pierce Bradford Plus Protein Assay Kit with Dilution-Free BSA Protein Standards

Good to know



BCA protein assays have a unique advantage over Coomassie dye-based assays (Bradford assays), as they are compatible with samples that contain up to 5% surfactants (detergents), and are affected much less by protein compositional differences, providing greater protein-to-protein uniformity and accuracy.

Tip



For quantitation of low-volume or very dilute samples, fluorescent assays like the [Invitrogen™ NanoOrange™ Protein Quantitation Kit](#) can provide working ranges down to 10 ng/mL compared to 500 ng/mL for enhanced colorimetric assays and 2,000 ng/mL for standard colorimetric protocols.

Download the [technical reference guide](#) for all available protein assays
Learn more at thermofisher.com/proteinassays

Protein assay guide

	Thermo Scientific™ Pierce™ Dilution-Free™ Rapid Gold BCA Protein Assay Kit	Thermo Scientific™ Pierce™ BCA Protein Assay Kit with Dilution- Free™ BSA Protein Standards	Thermo Scientific™ Pierce™ BCA Protein Assay Kit – Reducing Agent Compatible	Thermo Scientific™ Pierce™ Bradford Plus Protein Assay Kit with Dilution-Free™ BSA Protein Standard
Choose when	Accuracy, reproducibility, speed, and ease of use are important	Accuracy and reproducibility are important	Sample contains reducing agent; accuracy and reproducibility are important	Speed and ease of use are important
Minimum sample volume	10 µL	25 µL	25 µL	10 µL
Working range	20–10,000 µg/mL	20–2,000 µg/mL	125–2,000 µg/mL	100–1,500 µg/mL
Compatibility	Detergents	Detergents	Detergents and reducing agents	Reducing agents
Incubation temperature	RT	37°C	37°C	RT
Assay incubation time	5 min	30 min	50 min	10 min
Assay wavelength	480 nm	562 nm	562 nm	595 nm

Preparing PAGE samples for gel loading

Before a sample can be loaded onto a gel for analysis, it must be properly prepared. Depending on the gel type, this may involve denaturing the proteins, reducing any disulfide bonds, and adding a sample buffer. Sample buffers contain glycerol so that they are heavier than water and sink neatly to the bottom of the buffer-submerged well when loaded onto a gel. If suitable, negatively charged, low molecular weight dye is also included in the sample buffer; it will migrate at the buffer front, enabling one to monitor the progress of electrophoresis. The most common tracking dye for sample buffers is bromophenol blue. General guidelines for preparing samples are provided below.

General guidelines for preparing samples

for separation: Prepare your sample in the appropriate sample buffer, sometimes referred to as loading buffer, such that the final concentration of the sample buffer is 1X. Recommended sample buffers are listed on [page 38](#).

Running reduced and nonreduced samples: For optimal results, we do not recommend running reduced and nonreduced samples on the same gel. If you do choose to run reduced and nonreduced samples on the same gel, do not run reduced and nonreduced samples in adjacent lanes. The reducing agent may have a carry-over effect on the nonreduced samples if they are in close proximity.

Heating samples: Heating the sample at 100°C in SDS-containing buffer results in proteolysis [3]. We recommend heating samples for denaturing electrophoresis (reduced or nonreduced) at 70°C for 2–10 minutes for optimal results. Do not heat the samples for nondenaturing (native) electrophoresis or Invitrogen™ Novex™ Zymogram Plus gels.

Electrophoresis buffers

We offer reliable premixed SDS-PAGE buffers and reagents, including sample buffers, running buffers, reducing agents, and antioxidants.

Buffer and reagent selection guide

Gel type	Sample buffers optimized for use with the gel	Running buffers optimized for use with the gel
Bolt Bis-Tris Plus gel	<ul style="list-style-type: none"> • Bolt Sample Reducing Agent (10X) • 4X Bolt LDS Sample Buffer (nonreducing) • Bolt Antioxidant 	<ul style="list-style-type: none"> • 20X Bolt MES SDS Running Buffer (3.5–160 kDa separations) • 20X Bolt MOPS SDS Running Buffer (15–260 kDa separations)
NuPAGE Bis-Tris gel	<ul style="list-style-type: none"> • NuPAGE Sample Reducing Agent (10X) • 4X NuPAGE LDS Sample Buffer (nonreducing) • NuPAGE Antioxidant 	<ul style="list-style-type: none"> • NuPAGE MES SDS Running Buffer (20X liquid or powder) (3.5–160 kDa separations) • NuPAGE MOPS SDS Running Buffer (20X liquid or powder) (15–260 kDa separations)
NuPAGE Tris-Acetate gel	<ul style="list-style-type: none"> • 4X NuPAGE LDS Sample Buffer (nonreducing) • NuPAGE Sample Reducing Agent (10X) • Novex Tris-Glycine Native Sample Buffer (2X)* 	<ul style="list-style-type: none"> • NuPAGE Tris-Acetate SDS Running Buffer (20X) • Novex Tris-Glycine Native Running Buffer (10X)*
Novex Tris-Glycine gel	<ul style="list-style-type: none"> • Novex Tris-Glycine SDS Sample Buffer (2X) • NuPAGE Sample Reducing Agent (10X) • Novex Tris-Glycine Native Sample Buffer (2X)* 	<ul style="list-style-type: none"> • Novex Tris-Glycine SDS Running Buffer (10X) • Novex Rapid Tris-Glycine SDS Running Buffer (10X liquid or powder) • Novex Tris-Glycine Native Running Buffer (10X)* • Pierce Tris-Glycine SDS Buffer (10X) • BupH Tris-Glycine Buffer Packs
Novex Tricine gel	<ul style="list-style-type: none"> • Novex Tricine SDS Sample Buffer (2X) 	<ul style="list-style-type: none"> • Novex Tricine SDS Running Buffer (10X)
NativePAGE gel	<ul style="list-style-type: none"> • NativePAGE Sample Buffer (4X) • NativePAGE 5% G-250 Sample Additive 	<ul style="list-style-type: none"> • NativePAGE Running Buffer (20X) • NativePAGE Cathode Buffer Additive (20X)
Novex IEF gel	<ul style="list-style-type: none"> • Novex IEF Sample Buffer, pH 3–10 (2X) • IEF Sample Buffer, pH 3–7 (2X) 	<ul style="list-style-type: none"> • Novex IEF Anode Buffer (50X) • Novex IEF Cathode Buffer, pH 3–10 (10X) • Novex IEF Cathode Buffer, pH 3–7 (10X)
Novex Zymogram Plus gel**	<ul style="list-style-type: none"> • Novex Tris-Glycine SDS Sample Buffer (2X) 	<ul style="list-style-type: none"> • Novex Tris-Glycine SDS Running Buffer (10X)

* Use this buffer when performing a native separation with this gel.

** Novex Zymogram Developing Buffer (10X) and Novex Zymogram Renaturing Buffer (10X) are available for visualizing the Zymogram Plus gels.

MES vs. MOPS running buffer

- Use MES SDS running buffers to resolve small molecular weight proteins.
- Use MOPS running buffers to resolve medium-sized proteins.
- MES has a lower pKa than MOPS, enabling gels with MES running buffer to run faster than gels with MOPS SDS running buffer. The difference in ion migration affects stacking and results in a difference in protein separation range between these buffers.

Reducing agent

When preparing samples for reducing gel electrophoresis, any of the following reducing agents may be used:

- Bolt Sample Reducing Agent
- NuPAGE Sample Reducing Agent
- Dithiothreitol (DTT), 50 mM final concentration
- β -mercaptoethanol (β -ME), 2.5% final concentration
- Tris-(2-carboxyethyl)phosphine (TCEP), 50 mM final concentration

Add the reducing agent to the sample up to an hour before loading the gel. Avoid storing reduced samples for long periods, even if they are frozen. Reoxidation of samples can occur during storage and produce inconsistent results.

Learn more at thermofisher.com/electrophoresisbuffers

Buffer recipes

Bolt Bis-Tris buffer recipes

Buffer	Storage	Component	Concentration (1X)
Bolt LDS Sample Buffer	4–25°C	Glycerol Tris base Tris-HCl LDS EDTA SERVA™ Blue G-250 Phenol red	10% 141 mM 106 mM 2% 0.51 mM 0.22 mM 0.175 mM (pH 8.5)
Bolt MOPS SDS Running Buffer	4–25°C	MOPS Tris base SDS EDTA	50 mM 50 mM 0.1% 1 mM (pH 7.7)
Bolt MES SDS Running Buffer	4–25°C	MES Tris base SDS EDTA	50 mM 50 mM 0.1% 1 mM (pH 7.3)
Bolt Transfer Buffer	4–25°C	Bicine Bis-Tris (free base) EDTA Chlorobutanol	25 mM 25 mM 1.0 mM 0.05 mM (pH 7.2)



NuPAGE Bis-Tris and Tris-acetate buffer recipes

Buffer	Storage	Component	Concentration (1X)
NuPAGE LDS Sample Buffer	4–25°C	Glycerol Tris base Tris-HCl LDS EDTA SERVA Blue G-250 Phenol red	10% 141 mM 106 mM 2% 0.51 mM 0.22 mM 0.175 mM (pH 8.5)
NuPAGE MOPS SDS Running Buffer*	4–25°C	MOPS Tris base SDS EDTA	50 mM 50 mM 0.1% 1 mM (pH 7.7)
NuPAGE MES SDS Running Buffer*	4–25°C	MES Tris base SDS EDTA	50 mM 50 mM 0.1% 1 mM (pH 7.3)
NuPAGE Tris-Acetate SDS Running Buffer	4–25°C	Tris base Tricine SDS	50 mM 50 mM 0.1% (pH 8.24)
NuPAGE Transfer Buffer	4–25°C	Bicine Bis-Tris (free base) EDTA Chlorobutanol	25 mM 25 mM 1.0 mM 0.05 mM (pH 7.2)

* The premixed buffers (Cat. Nos. NP0001 and NP0002) also contain trace amounts of the proprietary NuPAGE Antioxidant (Cat. No. NP0005) for stability. Additional antioxidant may be required with specific protocols.

Novex Tris-Glycine buffer recipes

Buffer	Storage	Component	Concentration (1X)
Novex Tris-Glycine SDS Sample Buffer	4°C	Tris-HCl* Glycerol SDS Bromophenol blue Deionized water	63 mM 10% 2% 0.0025% — (pH 6.8)
Novex Tris-Glycine Native Sample Buffer	4°C	Tris-HCl* Glycerol Bromophenol blue Deionized water	100 mM 10% 0.0025% — (pH 8.6)
Novex Tris-Glycine SDS Running Buffer	Room temperature	Tris base Glycine SDS Deionized water	25 mM 192 mM 0.1% — (pH 8.3)
Novex Tris-Glycine Native Running Buffer	Room temperature	Tris base Glycine Deionized water	25 mM 192 mM — (pH 8.3)
Novex Tris-Glycine Transfer Buffer	Room temperature	Tris base Glycine Deionized water	12 mM 96 mM — (pH 8.3)

* Tris-HCl solutions are prepared from Tris base and pH-adjusted with 6 N HCl.

Novex Tricine buffer recipes

Buffer	Storage	Component	Concentration (1X)
Novex Tricine SDS Sample Buffer	+4°C	Tris-HCl* Glycerol SDS Coomassie Blue G Phenol red Deionized water	450 mM 12% 4% 0.0075% 0.0025% — (pH 8.45)
Novex Tricine SDS Running Buffer	Room temperature	Tris base Tricine SDS Deionized water	100 mM 100 mM 0.1% — (pH 8.3)

* Tris-HCl solutions are prepared from Tris base and pH-adjusted with 6 N HCl.

Zymogram buffer recipes

Buffer	Storage	Component	Concentration (1X)
Novex Zymogram Plus Renaturing Buffer	Room temperature	Triton X-100 solution Deionized water	2.7% (w/v) in H ₂ O —
Novex Zymogram Plus Developing Buffer	Room temperature	Tris-HCl* NaCl CaCl ₂ ·2H ₂ O Brij 35 Deionized water	50 mM 200 mM 5 mM 0.006% (w/v) — (pH 7.6)

* Tris-HCl solutions are prepared from Tris base and pH-adjusted with 6 N HCl.

Isoelectric focusing buffer recipes

Buffer	Storage	Component	Concentration (1X)
Novex IEF Sample Buffer pH 3–7	4°C	Lysine (free base) Glycerol Deionized water	40 mM 15% —
Novex IEF Sample Buffer pH 3–10	4°C	Arginine (free base) Lysine (free base) Glycerol Deionized water	20 mM 20 mM 15% —
Novex IEF Cathode Buffer pH 3–7 (upper buffer chamber)	4°C	Lysine (free base) Deionized water	40 mM —
Novex IEF Cathode Buffer pH 3–10 (upper buffer chamber)	4°C	Arginine (free base) Lysine (free base) Deionized water	20 mM 20 mM — (pH 10.1)
Novex IEF Anode Buffer (for both pH ranges) (lower buffer chamber)	Room temperature	Phosphoric acid 85% Deionized water	7 mM — (pH 2.4)
Urea-thiourea-CHAPS (rehydration buffer for IPG strips)	–20°C	Deionized urea Deionized thiourea CHAPS Ampholytes Bromophenol blue Ultrapure water DTT	7 M 2 M 2–4% 0.2–2.0% 0.002% — 20 mM

Estimating protein sizes

Protein ladders and standards

Protein ladders, also known as protein markers or protein standards, are used to help estimate the size of proteins separated during electrophoresis. They serve as points of reference because they contain mixtures of highly purified proteins with known molecular weights and characteristics.

Protein ladders are loaded onto gels alongside samples and migrate during electrophoresis at a rate that is inversely proportional to their molecular sizes. When the run is complete, the proteins will appear as separate bands in the gel. A standard curve can be constructed from the distance each marker protein migrates through the gel versus the log of its molecular weight. After measuring the migration distance that an unknown protein travels through the same gel, its molecular weight can be determined from the standard curve. Modern gel documentation instruments may have software algorithms that can make these mathematical calculations significantly more convenient. More often, however, protein ladders are used as a reference to help confirm the identity of proteins of interest whose sizes are already known.

Protein ladders are available with various protein molecular weight ranges and can be prestained, unstained, or labeled for different modes of detection and downstream applications. Read on to learn which protein ladder is best for your applications.

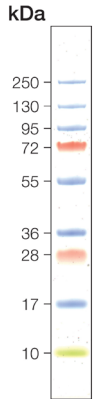
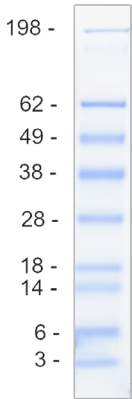
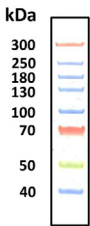
Learn more at thermofisher.com/proteinladders

Prestained protein ladders

Prestained protein ladders contain proteins prelabeled with various dyes that allow them to be visible without additional staining. Prestained ladders are visible during electrophoresis, enabling the ability to monitor the progress of separation for the range of protein sizes that are most relevant to the particular experiment. Prestained markers and ladders also remain visible after gel staining or transfer to membranes for detection by western blotting.

Prestained protein ladders can be used to:

- Monitor protein separation during polyacrylamide gel electrophoresis
- Quickly check visually whether protein transfer has occurred from gel to membrane (prestained protein ladder should transfer to membrane but should not be used to determine transfer efficiency; see “Good to know” notes)
- Estimate the approximate size of your target protein

Broad range		High range	
 <p>kDa</p> <p>250 -</p> <p>130 -</p> <p>95 -</p> <p>72 -</p> <p>55 -</p> <p>36 -</p> <p>28 -</p> <p>17 -</p> <p>10 -</p>	 <p>198 -</p> <p>62 -</p> <p>49 -</p> <p>38 -</p> <p>28 -</p> <p>18 -</p> <p>14 -</p> <p>6 -</p> <p>3 -</p>	 <p>kDa</p> <p>300 -</p> <p>250 -</p> <p>180 -</p> <p>130 -</p> <p>100 -</p> <p>70 -</p> <p>50 -</p> <p>40 -</p>	 <p>kDa</p> <p>460 -</p> <p>268 -</p> <p>238 -</p> <p>171 -</p> <p>117 -</p> <p>71 -</p> <p>55 -</p> <p>41 -</p> <p>31 -</p>
Thermo Scientific™ PageRuler™ Plus Prestained Protein Ladder, 10–250 kDa	Invitrogen™ SeeBlue™ Prestained Protein Standard, 3–198 kDa	Thermo Scientific™ Spectra™ Multicolor High Range Protein Ladder, 10–260 kDa	Invitrogen™ HiMark™ Prestained Protein Standard 31–460 kDa
Cat. No. 26619	Cat. No. LC5625	Cat. No. 26625	Cat. No. LC5699





Good to know

How can protein transfer efficiency and consistency be assessed?

Transfer efficiency refers to the efficiency of transfer of protein out of the protein gel and onto the western blotting membrane. Specifically, the amount of protein that binds to the membrane will be the foundation for the immunoblotting steps. If very little protein transfers out of the gel and binds to the membrane, then the subsequent immunoblotting steps will be challenging.

Transfer efficiency is sometimes evaluated by visually assessing the amount of prestained protein ladder that is visible on the membrane post-transfer. However, this is not necessarily the best practice. Prestained ladder proteins are stained with dyes that allow for visualization during electrophoresis. These dyes affect the transfer of the ladder proteins out of the gel. Sample proteins, however, are not stained and thus can have a different mobility rate out of the gel.

Visual assessment of the transfer of ladder can be a useful quick process check for whether transfer occurred (sometimes electrodes may be reversed, or the transfer stack may not be assembled correctly). Not observing any prestained marker transfer to the membrane could indicate an issue with the transfer setup. A more favorable strategy to determine transfer efficiency is to use a reversible membrane stain, which will stain the total protein that successfully transferred to the membrane. Some choose to take this a step further and back-stain the gel, post-transfer, which can give an assessment of how much protein transferred out of the gel. It is not unusual to see ladder protein or sample protein remaining in the gel, as no transfer method is completely 100% efficient. What really matters is how much protein is bound to the membrane.

Transfer consistency refers to the evenness of protein transfer from gel to membrane. Ideally, protein is transferred evenly from side to side and top to bottom on the membrane. However, improper assembly of a transfer stack and failure to roll the transfer stack may lead to air bubbles, creases, and dead spots on the membrane. These artifacts make the subsequent immunoblotting steps challenging, as an uneven transfer of protein will lead to an uneven immunoblot and signal production. Transfer consistency cannot be assessed simply by the appearance of transferred prestained ladder proteins on the membrane. Instead, the use of a reversible membrane stain permits a more accurate picture of protein transfer efficiency across the entire membrane.



Good to know

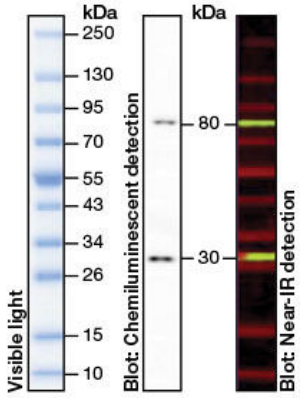
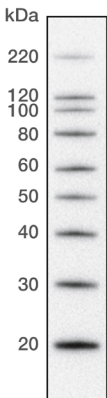
Why do molecular weights change between the different gel chemistries?

Slight differences in protein mobilities will occur when the same proteins are run in different SDS-PAGE buffer systems (e.g., Bis-Tris vs. Tris-glycine). Each SDS-PAGE buffer system has a different pH, which affects the charge of a protein and its binding capacity for SDS. The degree of change in protein mobility is usually small in natural proteins but is more pronounced with atypical or chemically modified proteins, such as prestained standards. Apparent molecular weight values for prestained standards will vary between gel systems—it is important to use the apparent molecular weights that match your gel for the most accurate calibration of your sample proteins.

Western blot protein ladders

Western blot-specific protein ladders are designed for easy and convenient protein molecular weight estimation directly on western blots or indirectly by using various blotting detection systems (e.g., chemiluminescent, fluorescent, or chromogenic). The protein markers consist of recombinant proteins with an IgG binding site. The IgG binding site binds the primary or secondary antibody used for detection of the target protein, allowing visualization of the standard on the western blot.

- Recommended for:
- Approximate molecular weight determination directly on western blots or indirectly through chemiluminescent, fluorescent, or chromogenic detection systems
 - Qualitatively assessing transfer efficiency

Western blot	
	
Invitrogen™ iBright™ Prestained Protein Ladder, 11–250 kDa	Invitrogen™ MagicMark™ XP Western Protein Standard, 20–220 kDa
Cat. No. LC5615	Cat. No. LC5602

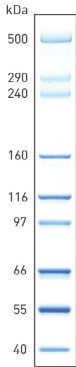
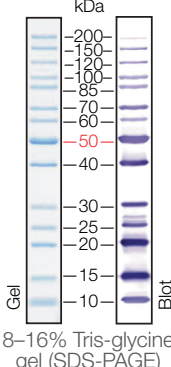
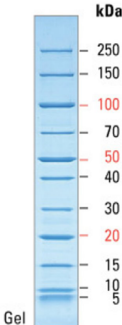


Unstained protein ladders

Unstained protein ladders are useful when you need to accurately determine the size of your protein. However, the proteins can only be visualized after staining with a Coomassie stain or other nonspecific protein stain. The dyes in prestained protein ladders add additional molecular weight to the ladder proteins and thus affect their migration. Each dye molecule may not bind equally to a given protein or proteins, and some prestained protein ladders utilize multiple different types of colored dyes (for easier tracking of specific proteins in the ladder). Because of the dyes in prestained protein ladders, a given ladder protein's true molecular weight is altered and thus is an apparent molecular weight. Unstained protein ladders do not have this issue because the migration of the proteins in the ladder are not affected by added

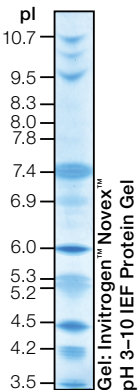
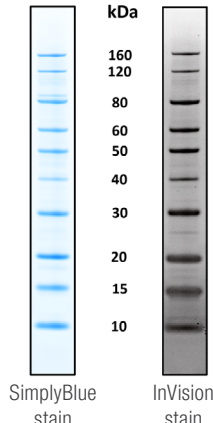
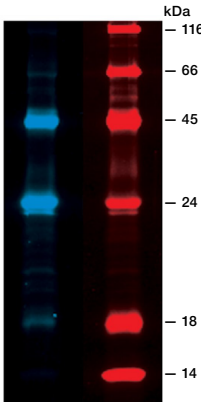
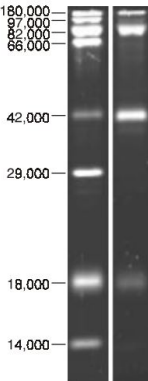
dye, and thus migrate as normal (although one can observe differences from one gel chemistry to the next), and as such are suitable for the most accurate determination of molecular weights in a protein sample.

These ready-to-use ladders include proteins of known molecular weight. Visualize them on SDS-PAGE gels by staining with Coomassie Brilliant Blue R250 or after western transfer using Ponceau S or a similar stain.

High range	Broad range	Broad range
		
Invitrogen™ HiMark™ Unstained Protein Standard Cat. No. LC5688	Thermo Scientific™ PageRuler™ Unstained Protein Ladder Cat. No. 26614	Thermo Scientific™ PageRuler™ Unstained Broad Range Protein Ladder Cat. No. 26630

IEF and specialty protein ladders

Protein ladders are available for use in isoelectric focusing (IEF) and for use when the experiment involves the detection of His-tagged, phosphorylated, or glycosylated proteins.

IEF	His-tagged proteins	Phosphorylated proteins	Glycosylated proteins
 <p> pI 10.7 9.5 8.3 8.0 7.8 7.4 6.9 6.0 5.3 5.2 4.5 4.2 3.5 Gel: Invitrogen™ Novex™ pH 3–10 IEF Protein Gel </p>	 <p> kDa 160 120 80 60 50 40 30 20 15 10 SimplyBlue stain InVision stain </p>	 <p> kDa 116 66 45 24 18 14 </p>	 <p> 180,000 87,000 82,000 66,000 42,000 29,000 18,000 14,000 </p>
Invitrogen™ IEF Marker 3–10	Invitrogen™ BenchMark™ His-Tagged Protein Standard	Invitrogen™ PeppermintStick™ Phosphoprotein Molecular Weight Standards	Invitrogen™ CandyCane™ Glycoprotein Molecular Weight Standards
Cat. No. 39212-01	Cat. No. LC5606	Cat. No. P33350	Cat. No. C21852
Uses: IEF applications	Uses: positive control and for molecular weight sizing in His-tagged fusion protein detection	Uses: positive and negative controls for detection of phosphorylated proteins	Uses: positive and negative controls for detection of glycosylated proteins
Visualization: colorimetric stain	Visualization: Invitrogen™ InVision™ His-Tag In-Gel Stain or Invitrogen™ 6x-His Tag Monoclonal Antibody	Visualization: colorimetric stain or methods that detect phosphorylated proteins, such as Invitrogen™ Pro-Q™ Diamond phosphoprotein gel stains	Visualization: colorimetric stain or methods that detect glycosylated proteins, such as Invitrogen™ Pro-Q™ Emerald glycoprotein stain kits

Choosing the electrophoresis chamber and power supply

In electrical terms, the process of electrophoresis is closely associated with the following equations derived from Ohm's law:

Voltage = current $\times$ resistance ($V = IR$)

Wattage = current $\times$ voltage ($W = IV$)

Resistance

The electrical resistance of the assembled electrophoresis cell is dependent on buffer conductivity, gel thickness, temperature, and the number of gels being run. Although the resistance is determined by the gel system, the resistance varies over the course of the run.

- In discontinuous buffer systems (and to a lesser extent in continuous buffer systems) resistance increases over the course of electrophoresis. This occurs in the Tris-glycine buffer system as highly conductive chloride ions in the gel are replaced by less conductive glycine ions from the running buffer.
- Resistance decreases as the temperature increases.

Voltage

The velocity of an ion in an electric field varies in proportion to the field strength (volts per unit distance). The higher the voltage, the faster an ion moves. For most applications, **we recommend a constant voltage setting.**

- A constant voltage setting allows the current and power to decrease over the course of electrophoresis, providing a safety margin in case of a break in the system.
- The constant voltage setting does not need adjustment to account for differences in number or thickness of gels being electrophoresed.

Current

For a given gel/buffer system, at a given temperature, current varies in proportion to the field strength (voltage) and cross-sectional area (thickness and number of gels). When using a constant current setting, migration starts slow, and accelerates over time, thus favoring stacking in discontinuous gels.

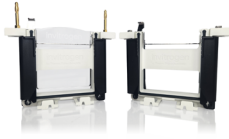
When running under constant current, set a voltage limit on the power supply at or slightly above the maximum expected voltage to avoid unsafe conditions. At constant current, voltage increases as resistance increases. If a local fault condition occurs (e.g., a bad connection), high local resistance may cause the voltage to reach the maximum for the power supply, leading to overheating and damage of the electrophoresis cell.

Power

Wattage measures the rate of energy conversion, which is manifested as heat generated by the system. Using constant power allows the total amount of heat generated by the system to remain constant throughout the run, but results in variable mobility since voltage increases and current decreases over the course of the run. Constant power is typically used when running IEF strips. When using constant power, set the voltage limit slightly above the maximum expected for the run. High local resistance can cause a large amount of heat to be generated over a small distance, damaging the electrophoresis cell and gels.

Electrophoresis chamber system selection guide

Our electrophoresis chamber systems are designed for compatibility with the full range of Invitrogen gel offerings. Refer to the table below to find which system is right for you.

	Mini Gel Tank	XCell SureLock Mini-Cell	SureLock Tandem Midi Gel Tank	XCell4 SureLock Midi-Cell	Tetra Electrophoresis Cores
					
Gel capacity	Up to 2 mini gels	Up to 2 mini gels	Up to 2 midi gels	Up to 4 midi gels	Up to 4 mini gels
Cell dimensions (L x W x H; height with lid on)	32 x 11.5 x 16 cm	14 x 13 x 16 cm	25 x 17.9 x 17.3 cm	21 x 19 x 16 cm	
Advantages	<ul style="list-style-type: none"> The Mini Gel Tank is versatile and compatible with all Invitrogen precast and handcast mini gels; the unique tank design enables convenient side-by-side gel loading and enhanced viewing during use Mini Blot Module is available for wet protein transfers 	<ul style="list-style-type: none"> Instrument incorporates a gel tension wedge in place of the rear wedge used on earlier models XCell II Blot Module is available for semi-wet protein transfers 	<ul style="list-style-type: none"> Easy-to-use apparatus, with separate chambers for each gel, enabling scalable buffer usage SureLock Tandem Midi Blot Module is available for wet protein transfers 	<ul style="list-style-type: none"> Advanced apparatus for easier, more reliable electrophoresis with midi gels 	<ul style="list-style-type: none"> Tetra Electrophoresis Cores allow high-performance Invitrogen precast gels to be run in the Bio-Rad Mini-PROTEAN Tetra Cell tank Easy to assemble and use with one or up to 4 mini gels

Mini Gel Tank

One tank, over 150 gels

The Mini Gel Tank is designed for more intuitive use and greater convenience compared to traditional electrophoresis tanks. The unique, side-by-side tank design allows you to perform electrophoresis of 1 or 2 mini gels.

The Mini Gel Tank offers:

- **Versatility**—compatible with all of our mini gels, including Invitrogen™ NuPAGE™, Novex™, Bolt™, and specialty gels
- **Easy sample loading**—forward-facing well configuration
- **Simultaneous visualization of both gels**—streamlined, side-by-side tank configuration
- **Simple monitoring of gels**—white tank stand permits easy visualization of prestained markers
- **Less running buffer required**—gel chambers are separated, so you only need to load sufficient buffer for each gel to the specified fill line
- **Engineered to stand the test of time**—made of durable polycarbonate, it undergoes a rigorous stress-relieving process that helps prevent cracking



Specifications

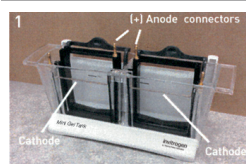
- Gel capacity: up to 2 mini gels
- Cell size (L x W x H): 32 x 11.5 x 16 cm (height with lid on)
- Buffer requirement: 400 mL for each mini gel chamber
- Material: polycarbonate
- Chemical resistance: not compatible with acetone, chlorinated hydrocarbons (e.g., chloroform), or aromatic hydrocarbons (e.g., toluene, benzene)



Watch our Mini Gel Tank [video](#)

Learn more at thermofisher.com/minigeltank

Figure 25. How to use the Mini Gel Tank.



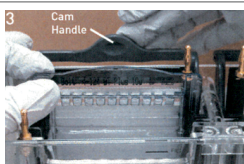
1. Snap the electrophoresis tank into the base, and place the cassette clamp(s) into the chamber(s) with the anode connector(s) (+) aligned to the center.

Fill the chamber(s) with 1X buffer to the level of the cathode.



2. Remove the comb, and peel away the tape at the bottom of the gel cassette.

Rinse the wells 3 times with 1X buffer.



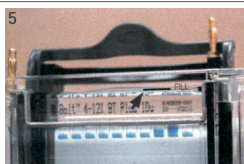
3. Place the cassette in the chamber with the wells facing towards you.

Hold the cassette in a raised position and close the clamp by moving the cam handle forward.



4. Make sure the wells are completely filled with 1X buffer.

Load your samples and markers.



5. Hold the cassette and release the cassette clamp.

Gently lower the cassette so that it rests on the bottom of the chamber, and close the cassette clamp. Add 1X buffer to the level of the fill line.



6. Make sure the power supply is off.

If only running one gel, remove the cassette clamp from unused chamber.

Place the lid on the tank and plug the electrode cords into the power supply.

Turn the power supply on to begin electrophoresis.

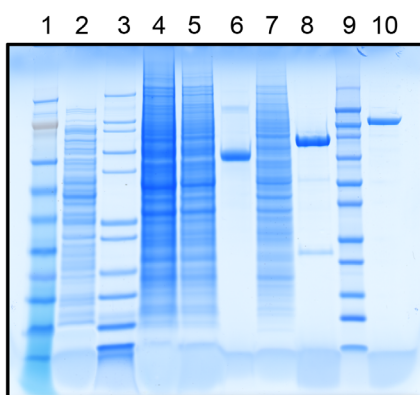


Figure 26. Electrophoresis of Bolt gel using the Mini Gel Tank.

Protein standards and samples were loaded at 10 µL sample volumes on an Invitrogen™ Bolt™ 4–12% Bis-Tris Plus gel. Electrophoresis was performed using the Mini Gel Tank at 200 V (constant). Sharp, straight bands with consistent migration patterns were observed after staining with Invitrogen™ SimplyBlue™ SafeStain. Images were acquired using a flatbed scanner. **Lane 1:** SeeBlue Plus2 Prestained Standard; **lane 2:** 10 µg *E. coli* lysate; **lane 3:** Invitrogen™ Mark12™ Unstained Standard (blend of 12 purified proteins); **lane 4:** 40 µg HeLa cell lysate; **lane 5:** 20 µg HeLa cell lysate; **lane 6:** 5 µg BSA; **lane 7:** 40 µg Jurkat cell lysate; **lane 8:** 5 µg GST fusion protein; **lane 9:** Invitrogen™ Novex™ Sharp Unstained Protein Standard; **lane 10:** 5 µg β-galactosidase.



Recommended products

The [Invitrogen™ Mini Blot Module](#) is a wet transfer apparatus that conveniently fits into the chambers of the Mini Gel Tank to easily transfer proteins from mini gels to nitrocellulose or PVDF membranes.

XCell SureLock Mini-Cell

Simultaneous electrophoresis of up to 2 mini gels



The unique design of the Invitrogen™ XCell SureLock™ Mini-Cell allows you to run mini gels quickly and easily without any clamps or grease (Figure 27). The tight seal provided by the gel tension wedge results in consistent performance. The XCell SureLock Mini-Cell is compatible with Bolt, NuPAGE, Novex, and specialty gels (Figure 28).

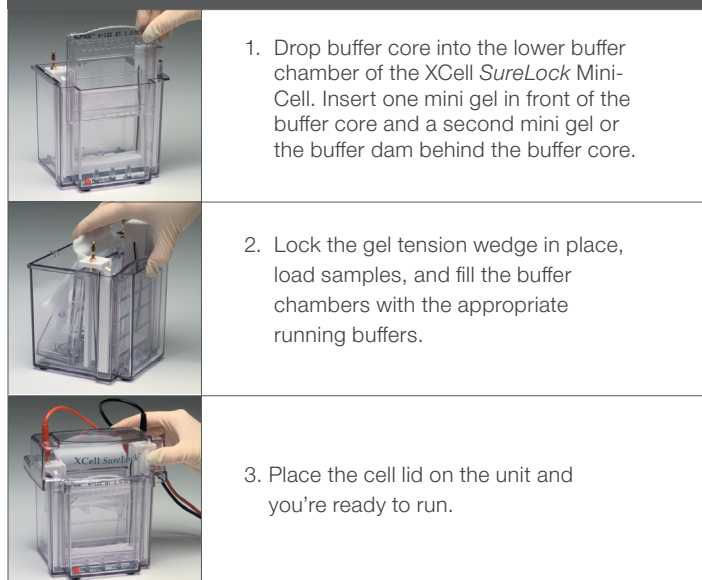
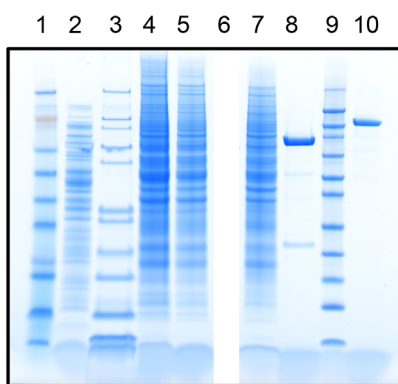
Key features of the XCell SureLock Mini-Cell:

- **User-friendly design**—uses single gel tension wedge with no clamps or grease
- **Flexibility**—perform electrophoresis of 2 mini gels simultaneously
- **Unique, heat dissipating design**—no need for a cooling device
- **Built-in usability features**—retractable plugs, recessed jacks, and a specially designed lid enhances user safety

Specifications

- Gel capacity: up to 2 mini gels
- Cell size (L x W x H): 14 x 13 x 16 cm (height with lid on)
- Buffer chamber requirement (Invitrogen mini gels):
 - Upper buffer chamber: 200 mL
 - Lower buffer chamber: 600 mL
- Chemical resistance: impervious to most alcohols but not compatible with acetone, chlorinated hydrocarbons (e.g., chloroform), or aromatic hydrocarbons (e.g., toluene, benzene)

Figure 27. How to use the XCell SureLock Mini-Cell.



NuPAGE Bis-Tris gel in XCell SureLock Mini-Cell

Figure 28. Electrophoresis of NuPAGE Bis-Tris gel with the XCell SureLock Mini-Cell. Lane 1: SeeBlue Plus2 Prestained Standard; lane 2: 10 µg *E. coli* lysate; lane 3: Mark12 Unstained Standard (blend of 12 purified proteins); lane 4: 40 µg HeLa cell lysate; lane 5: 20 µg HeLa cell lysate; lane 6: not used; lane 7: 40 µg Jurkat cell lysate; lane 8: 5 µg of a GST fusion protein; lane 9: Novex Sharp Unstained Protein Standard; lane 10: 5 µg β-galactosidase. Gel electrophoresis was performed at 200 V (constant), and gels were stained using SimplyBlue SafeStain. Image was acquired using a flatbed scanner.

Recommended products

The XCell SureLock Mini-Cell can be easily adapted for transfer of proteins from mini gels to membranes by simply inserting the [Invitrogen™ XCell II™ Blot Module](#) into the lower buffer chamber.



Learn more at thermofisher.com/surelockmini

SureLock Tandem Midi Gel Tank

2-in-1 midi gel electrophoresis and transfer tank

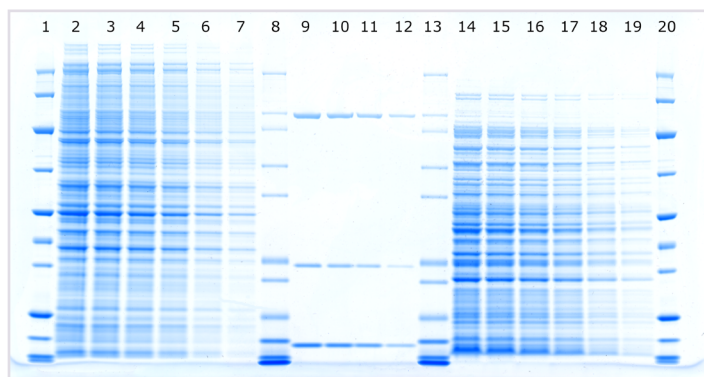
The Invitrogen™ SureLock™ Tandem Midi Gel Tank enables rapid electrophoresis of midi gels using minimal buffer (~520 mL/gel) in a leak-free system. With a setup time of ~30 seconds, the tank efficiently runs midi gels while also providing consistent performance. The tank features two independent chambers, allowing electrophoresis of one or two gels at a time, which saves on buffer and limits waste.

The SureLock Tandem Midi Gel Tank can be used for wet tank transfers when paired with the SureLock Tandem Midi Blot Module. The SureLock Tandem Midi Blot Module performs efficient, room-temperature wet protein transfers for downstream western blot analysis. The tank accommodates two blot modules, allowing transfer of one or two gels at a time, using considerably less transfer buffer (only ~300 mL per transfer) than other wet transfer systems. This lower buffer requirement keeps the amount of methanol waste (a hazardous material) to a minimum.



Key features of the SureLock Tandem Midi Gel Tank:

- **Double duty instrument**—enables electrophoresis and transfer of high-performance Invitrogen™ midi gels using the same tank
- **Two separate chambers**—run 1 or 2 gels or transfers using only the necessary amount of buffer for each gel, minimizing buffer cost and waste
- **Room-temperature transfer**—eliminate the need to prechill buffers and the hassle and messiness of ice baths
- **User-friendly design**—easy setup, sample loading, and simple workflow, without dummy cassettes or buffer dams
- **Compatible**—fits all Invitrogen precast midi gels and Invitrogen midi gel cassettes



NuPAGE Bis-Tris 4–12% gradient midi gel

Figure 29. Publication-quality protein electrophoresis gel results using a NuPAGE Bis-Tris 4–12% gradient midi gel and the SureLock Tandem Midi Gel Tank. The gel was loaded as follows: **Lanes 1, 20:** 5 µL PageRuler Broad Range Unstained Protein Ladder (Cat. No. 26630); **lanes 2–7:** 10 µg, 8 µg, 6 µg, 4 µg, 2 µg, 1 µg HeLa lysate; **lanes 8, 13:** 5 µL Novex Mark12 Unstained Standard (Cat. No. LC5677); **lanes 9–12:** 240 ng, 180 ng, 120 ng, 60 ng of protein mix containing β-galactosidase, lactate dehydrogenase, and lysozyme; **lanes 14–19:** 10 µg, 8 µg, 6 µg, 4 µg, 2 µg, 1 µg *E. coli* lysate. Electrophoresis was conducted with NuPAGE MOPS running buffer and stained with SimplyBlue Safe Stain.

Specifications

- Gel capacity: up to 2 midi gels (8 x 13 mm)
- Cell size (L x W x H): 25 x 17.9 x 17.3 cm (height with lid on)
- Buffer chamber requirement:
 - Upper chamber: 170 mL (per gel)
 - Lower chamber: 350 mL (per gel)
- Chemical resistance: impervious to most alcohols but not compatible with chlorinated hydrocarbons (e.g., chloroform), aromatic hydrocarbons (e.g., toluene, benzene), acetone, or isopropyl alcohol

View performance data and a how-to video at thermofisher.com/surelocktandem

XCell4 SureLock Midi-Cell

Simultaneous electrophoresis of up to 4 midi gels



The Invitrogen™ XCell4 SureLock™ Midi-Cell allows simultaneous electrophoresis of 1–4 midi gels without leaking, enabling consistent performance. The system is designed to dissipate heat effectively and evenly, and enable high-resolution results when using Invitrogen™ Novex™ midi gels (Figures 30 and 31).

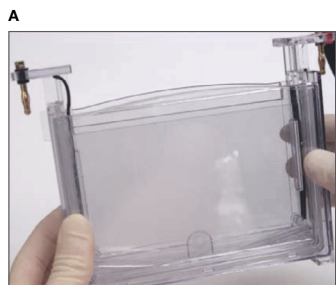
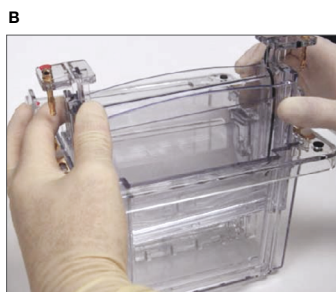
Key features of the XCell4 SureLock Midi-Cell:

- **User-friendly design**—electrophoresis without clamps or grease
- **Flexibility**—perform electrophoresis of 1–4 midi gels
- **Unique, heat-dissipating design**—no need for a cooling device
- **Built-in safety features**—specially designed lid enhances safety

Specifications

- Gel capacity: up to 4 midi gels (8 x 13 cm)
- Cell size (L x W x H): 21 x 19 x 16 cm (height with lid on)
- Buffer chamber requirement:
 - Upper buffer chamber: 175 mL x 4
 - Lower buffer chamber: 540–700 mL
- Chemical resistance: not compatible with acetone, chlorinated hydrocarbons (e.g., chloroform), or aromatic hydrocarbons (e.g., toluene, benzene)

Figure 30. How to use the XCell4 SureLock Midi-Cell with 4 gels.



1. Insert the XCell4 SureLock Midi-Cell assembly in its unlocked position into the center of the midi-cell base. The XCell4 SureLock assembly slides down over the protrusion in the midi-cell base.
 2. Place one cassette on each side of the buffer core for each of the two cores. For each cassette, the shorter "well" side of the cassette must face out towards the lower buffer chamber.
 3. While holding the assembly together with your hands (A), insert the buffer cores with the gel cassettes into the lower buffer chamber such that the negative electrode fits into the opening in the gold plate on the lower buffer chamber (B). Always hold the cassette assembly by its edges as shown in the figure.
- Note: If you are having difficulty inserting the assembly into the lower buffer chamber, make sure the cathode (black polarity indicator) of the buffer core is aligned with the cathode (black polarity indicator) of the lower buffer chamber.
4. The upper buffer chamber (cathode) is the void formed between a gel and the buffer core at the center of each core.
 5. Lock the XCell4 SureLock assembly by moving the tension lever to the locked position (indicated on the XCell4 SureLock Assembly). This will squeeze the gels and buffer cores together, creating leak-free seals.
 6. Proceed to loading samples and buffers.

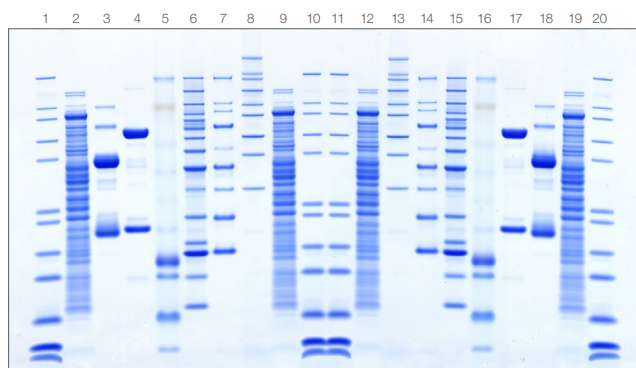


Figure 31. Quality of a precast Invitrogen™ NuPAGE™ 4–12% Bis-Tris Midi Gel with a variety of protein standards, lysates, and purified proteins. Lanes 1, 10, 11, 20: 5 μ L of Mark12 Unstained Standard (blend of 12 purified proteins); lanes 2, 9, 12, 19: 10 μ g of *E. coli* lysate; lanes 3, 18: 6 μ g of human IgG; lanes 4, 17: 6 μ g of human IgM; lanes 5, 16: 5 μ L of SeeBlue Plus2 Prestained Protein Standard; lanes 6, 15: 5 μ L of Invitrogen™ BenchMark™ Protein Ladder; lanes 7, 14: 15 μ L of Invitrogen™ MagicMark™ XP Western Protein Standard; lanes 8, 13: 5 μ L of Invitrogen™ HiMark™ Unstained Protein Standard.

Tetra Electrophoresis Cores

Invitrogen™ Tetra Electrophoresis Cores allow you to run high-performance Invitrogen™ precast protein gels in your Bio-Rad™ Mini-PROTEAN™ Tetra Cell tank. The Tetra Electrophoresis Cores are easy to assemble and use. The set includes:

- **Tetra Electrophoresis Primary Core**—run up to 2 gels
- **Tetra Electrophoresis Companion Core**—run two additional gels when combined with the primary core
- **Buffer dam**—run 1 gel when used in combination with the primary core or 3 gels when used in combination with the primary and companion cores
- **Fast run times**—shorten the electrophoretic run to 14 minutes with rapid protocols



Watch the Tetra Electrophoresis Cores [video](#)

Discover Tetra Electrophoresis Cores and precast gels bundles at thermofisher.com/tetracore

Different tank, same exceptional performance

Invitrogen precast mini gels show excellent separation whether the electrophoretic separation is performed with the Tetra Electrophoresis Cores in the Bio-Rad Mini-PROTEAN Tetra Cell or in the Invitrogen Mini Gel Tank (Figure 32). Tetra Electrophoresis Cores allow the adoption of rapid protocols that reduce the overall separation time of Bolt Bis-Tris Plus and Novex Tris-Glycine Plus mini gels (Figure 33).

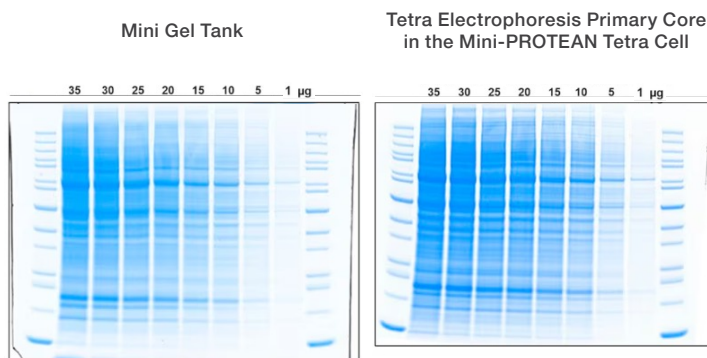


Figure 32. Equivalent performance of NuPAGE Bis-Tris 4–12% gels run with the Mini Gel Tank and with Tetra Electrophoresis Cores in the Bio-Rad Mini-PROTEAN Tetra Cell. Gels were loaded with Thermo Scientific™ PageRuler™ Unstained Protein Ladder and dilutions of HEK293 lysate. After electrophoresis in MES running buffer, gels were stained with SimplyBlue SafeStain.

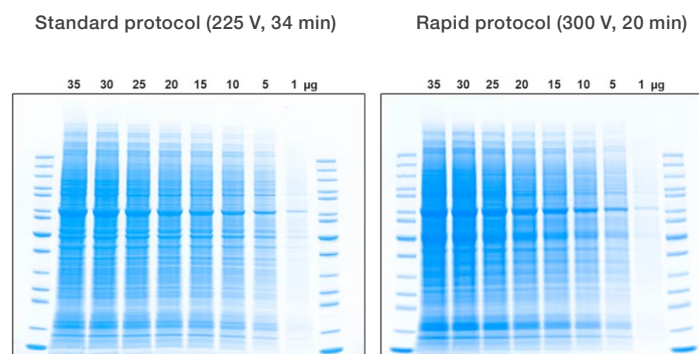
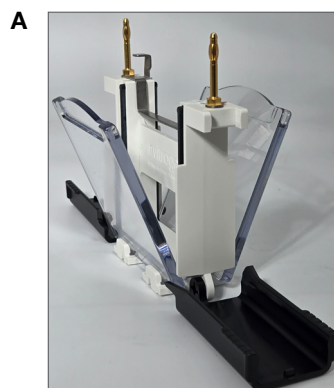


Figure 33. Similar performance between rapid and standard protocols. Novex Tris-Glycine Plus 4–20% gels were loaded with PageRuler Unstained Protein Ladder and dilutions of HEK293 lysate. After electrophoresis, gels were stained with SimplyBlue SafeStain.

Figure 34. How to use the Tetra Electrophoresis Cores with 4 gels.

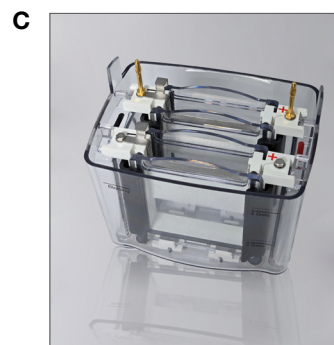


1. Insert the gel into the core with the short plate facing forward. Insert a second gel or the buffer dam on the opposite side **(A)**.

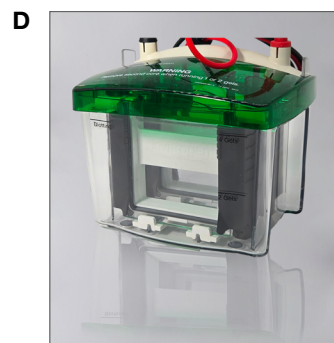
Note: remove the comb and the tape at the bottom of the gel before placing it in the core.



2. Using both hands, close the clamping frame wings onto the core to lock them in place **(B)**. Repeat steps 1 and 2 for the companion core.



3. Insert the assembled cores into the Mini-PROTEAN Tetra Cell electrophoresis tank **(C)**.



4. Fill the tank with 1X running buffer: 170 mL per core for the inner chamber and 550 mL or 800 mL for one or both cores, respectively, for the outer chamber.
5. Load samples, then place the lid on the tank aligning the polarity signs. Connect the cables to the power supply and start the run **(D)**.

For recommended run conditions with different gel types, download the [quick reference card](#).

PowerEase Touch Power Supplies

Easy touchscreen programming and operation



The Invitrogen™ PowerEase™ Touch Power Supplies make setting up custom protocols or selecting one of the several preprogrammed gel electrophoresis and transfer methods a breeze with an improved 4.3-inch backlit LCD touchscreen display and user interface. The power supplies are ideal for DNA or RNA electrophoresis, SDS-PAGE, and native PAGE. The PowerEase Touch Power Supplies offer four sets of output jacks that can be used simultaneously and three modes: constant voltage, constant current, and constant power for flexibility of use and efficiency. The sturdy polyurethane feet and stackable housing design allow stacking of power supplies for a reduced footprint on the lab bench.

- **Ease of use**—LCD touchscreen display and user interface show clear menu prompts for easy use by hand or stylus and convenient monitoring of run progress
- **Convenient**—four sets of output terminals allow running of multiple electrophoresis units
- **Customizable**—program up to 100 custom methods, 20 steps per method, 999 minutes per step, or select one of several preprogrammed Invitrogen gel electrophoresis and transfer methods
- **Safety**—features automatic No Load, Over Temperature, Over Voltage, Over Current, Load Change, and Ground Leak detection

Use the following table to choose the power supply that works best for your application.

Recommended power supplies for protein electrophoresis applications.

Model	Mini gel runs	Mini gel transfers	Midi gel runs	Midi gel transfers	IEF gels
PowerEase Touch 120W Power Supply	4	2	2	No	No
PowerEase Touch 350W Power Supply	12	8	8	4	No
PowerEase Touch 600W Power Supply	16	8	14	4	8
PowerEase Touch HV Power Supply	4	2	2	No	8

Learn more at thermofisher.com/powerease

Running gels

Mini gel running conditions in Invitrogen mini gel electrophoresis chamber systems.

Gel type	Voltage (V)	Approximate run time (min)
Bolt Bis-Tris Plus gel (MES buffer)	200	20
Bolt Bis-Tris Plus gel (MOPS buffer)	200	35
NuPAGE Bis-Tris gel (MES buffer)	200	30
NuPAGE Bis-Tris gel (MOPS buffer)	200	42
Novex Tris-Glycine gel, WedgeWell format (denatured)	225	25–40
Novex Tris-Glycine gel, WedgeWell format (native)	125	60–90
NuPAGE 3–8% Tris-Acetate gel (denatured)	150	50
NuPAGE 3–8% Tris-Acetate gel (native)	150	100
Novex 10–20% Tricine gel	125	65
NativePAGE 3–12% gel	150	80
Novex IEF gel, pH 3–10	100	60
	200	60
	500	30
Novex Zymogram Plus gel (gelatin)	125	90

Note: Run times may vary depending on the power supply and gel percentage.

Midi gel running conditions in Invitrogen midi gel electrophoresis chamber systems.

Gel type	Voltage (V, constant)	Estimated run time (min)
Bolt Bis-Tris Plus gel (MES buffer)	200	20
Bolt Bis-Tris Plus (MOPS buffer)	200	28
NuPAGE Bis-Tris gel (MES buffer)	200	25
NuPAGE Bis-Tris gel (MOPS buffer)	200	38
Novex Tris-Glycine Plus gel (denatured)	225	33
Novex Tris-Glycine Plus gel (native)	225	90
NuPAGE Tris-Acetate gel (denatured)	150	54
NuPAGE Tris-Acetate gel (native)	150	120
Novex Tricine gel (denatured)	125	63
NativePAGE Bis-Tris gel	150	120

Note: Run times may vary depending on the power supply and gel percentage..

Run conditions for rapid protocols to achieve faster electrophoresis times.

Gel type	Voltage (V, constant)	Estimated run time (min)
Bolt Bis-Tris gel (MES buffer)	250	14
Novex Tris-Glycine gel (denatured)	300	20

Power output for rapid protocols.

Number of mini gels	100 W	200 W	300 W
Up to 4	✓	✓	✓
Up to 8	X	✓	✓
Up to 12	X	✓	✓
Up to 16	X	X	✓

Note: Run time may vary depending on gel percentage and the power supply used for electrophoresis. For the fastest run time, equilibrate gels to room temperature if stored at 4°C. Use caution when discarding the running buffer after the run is complete as rapid protocols will result in hotter buffer temperatures. To reduce the heat generated during the rapid run, always fill the tank to the 4-gel fill line even if running only 2 gels.

Staining gels

Protein stains

Once protein bands have been separated by electrophoresis, they can be directly visualized using different methods of in-gel detection. Over the past several decades, demand for improved sensitivity and compatibility with downstream applications and detection instrumentation has driven the development of several basic staining methods. Each method has particular advantages and disadvantages, and a number of specific formulations for each type of method helps provide optimal performance for various situations.

Typically, these stains can be classified broadly based on the molecules that help visualize the proteins:

Coomassie stains

- Thermo Scientific™ PageBlue™ Protein Staining Solution
- Invitrogen™ SimplyBlue™ SafeStain
- Thermo Scientific™ Imperial™ Protein Stain

Silver stains

- Thermo Scientific™ Pierce™ Silver Stain Kit
- Invitrogen™ SilverXpress™ Silver Staining Kit
- Thermo Scientific™ Pierce™ Silver Stain for Mass Spectrometry

Fluorescent and specialty stains

- Invitrogen™ SYPRO™ Orange, SYPRO Red, SYPRO Ruby gel stains
- Thermo Scientific™ Pierce™ Reversible Protein Stain Kit for Nitrocellulose or PVDF Membranes
- Invitrogen™ Pro-Q™ Emerald glycoprotein stain
- Invitrogen™ Pro-Q™ Diamond phosphoprotein stain

To visualize the proteins, a protein-specific, dye-binding or color-producing chemical reaction must be performed on the proteins within the gel. Depending on the particular chemistry of the stain, various steps are necessary to hold the proteins in the matrix and to facilitate the necessary chemical reaction. Most staining methods involve some version of the same general incubation steps:



- A water wash to remove electrophoresis buffers from the gel matrix
- An acid or alcohol wash to condition or fix the gel to limit diffusion of protein bands from the matrix
- Treatment with the stain reagent to allow the reagent to diffuse into the gel and bind to (or react with) the proteins
- Destaining to remove excess dye from the background gel matrix

Depending on the particular staining method, two or more of these functions can be accomplished with one step. For example, a dye reagent that is formulated in an acidic buffer can effectively fix and stain in one step. Conversely, certain functions require several steps. For example, silver staining requires both a staining reagent step and a development step to produce the colored reaction product.

Learn more at thermofisher.com/proteinstains

Coomassie dye–based protein gel stains

Convenient, ready-to-use reagents with no permanent chemical modification

The most common methods of in-gel protein detection use stains with Coomassie dye. These stains use either the G-250 (colloidal) or R-250 form of the dye. Colloidal Coomassie stain can be formulated to effectively stain proteins within one hour and require only water (no methanol or acetic acid) for destaining.

Key features:

- **Simple**—Coomassie dye–based formulations are easy to formulate and are widely used
- **Easy to use**—simply soak the gel in staining solution, and destain to observe protein bands
- **Economical**—Coomassie dye–based formulations are cost-effective
- **Flexible**—useful for qualitative visualization, quantitative densitometry, and gel excision and analysis by mass spectrometry



Our Coomassie stains provide sensitive protein detection along with simplified protocols. Staining protocols and example data are shown for SimplyBlue SafeStain (Figures 35, 38, 39), Imperial Protein Stain (Figures 36, 40), and PageBlue Protein Staining Solution (Figure 37).

Coomassie dye–based protein gel stains.

	SimplyBlue SafeStain	Imperial Protein Stain	PageBlue Protein Staining Solution
Type	G-250	R-250	G-250
Limit of detection	>7 ng	3 ng	5 ng
Time to stain*	12 min	12 min	30 min
Compatible with:			
PVDF membranes	Yes	Yes	Yes
Nitrocellulose membranes	No	No	No
Reusable	No	No	Yes (up to 3 times)
Mass spectrometry compatible	Yes	Yes	Yes
Color	Purple	Purple	Blue-green
Feature	Free of methanol and acetic acid	Photographs better than Coomassie G-250 dye	Free of methanol and acetic acid
Advantages	Rapid, sensitive, completely nonhazardous staining (does not require methanol or acetic acid fixatives or destains)	Fast, ultrasensitive protein detection	Cost-effective option for fast, sensitive staining

* Approximate staining time using microwave oven.

Learn more at thermofisher.com/coomassiestains

Protocols

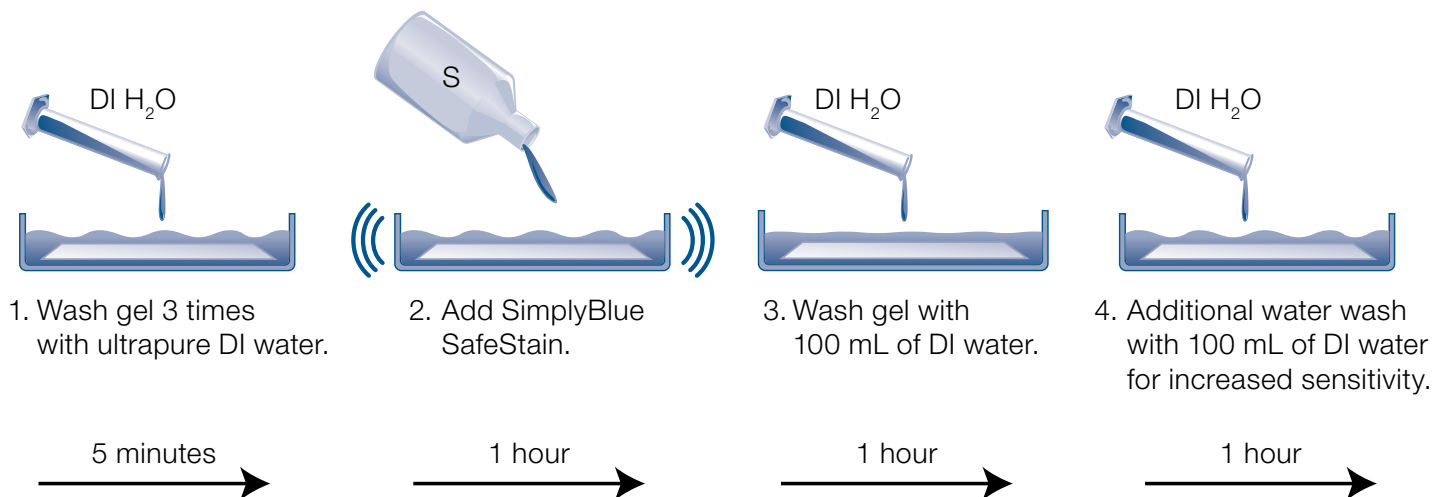


Figure 35. SimplyBlue SafeStain protocol.

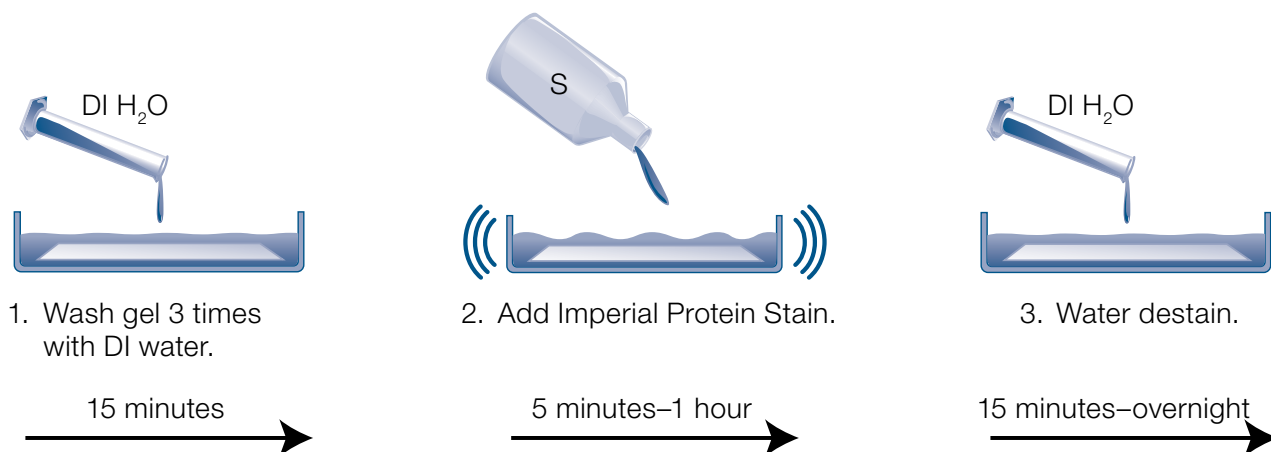


Figure 36. Imperial Protein Stain protocol.

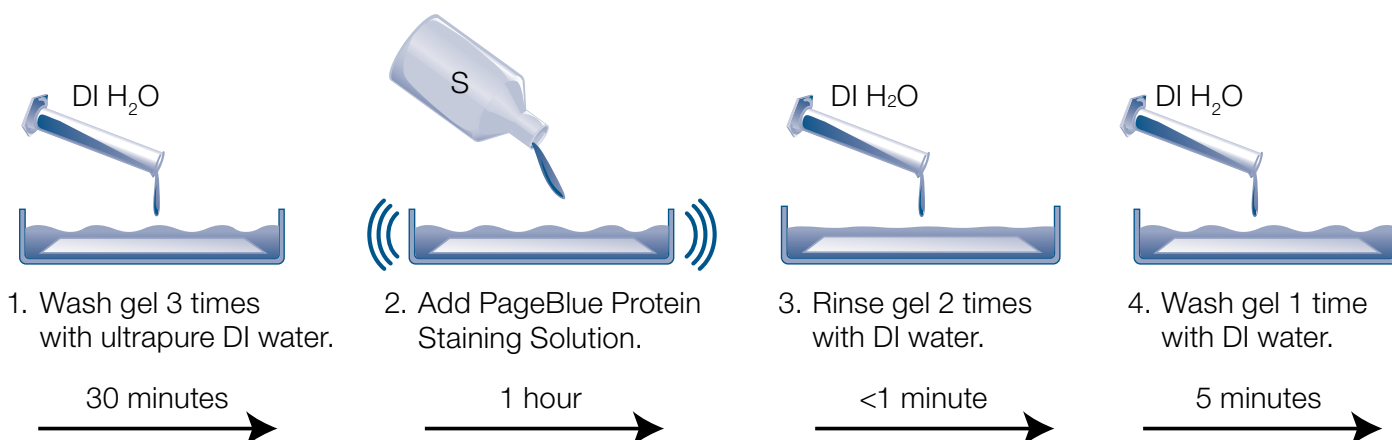


Figure 37. PageBlue Protein Staining Solution protocol.

Example data

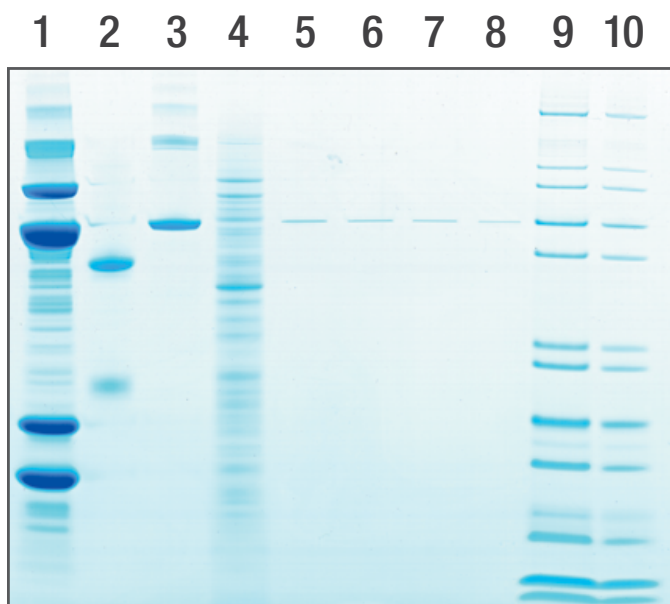


Figure 38. Sensitive staining results with SimplyBlue SafeStain. The following samples were separated on an Invitrogen™ NuPAGE™ 4–12% Bis-Tris gel and then stained with SimplyBlue SafeStain. **Lane 1:** 6 µg protein mix; **lane 2:** 1 µg rabbit IgG; **lane 3:** 1 µg reduced BSA; **lane 4:** 5 µg *E. coli* lysate; **lane 5:** 20 ng reduced BSA; **lane 6:** 10 ng reduced BSA; **lane 7:** 7 ng reduced BSA; **lane 8:** 3 ng reduced BSA; **lane 9:** 10 µL Invitrogen™ Mark12™ Unstained Standard (blend of 12 purified proteins); **lane 10:** 5 µL Mark12 Unstained Standard.

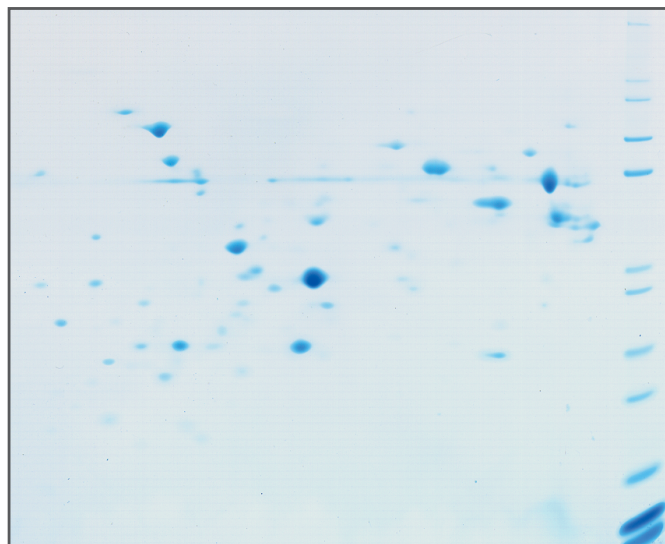


Figure 39. Two-dimensional electrophoresis analysis of spinach chloroplast extract; staining with SimplyBlue SafeStain. A spinach chloroplast extract was prefractionated in the Invitrogen™ ZOOM™ IEF Fractionator, and the individual fractions were then separated by 2D electrophoresis using narrow pH-range Invitrogen™ ZOOM™ IPG strips and an Invitrogen™ NuPAGE™ 4–12% Bis-Tris ZOOM™ gel. Gels were stained using SimplyBlue SafeStain.

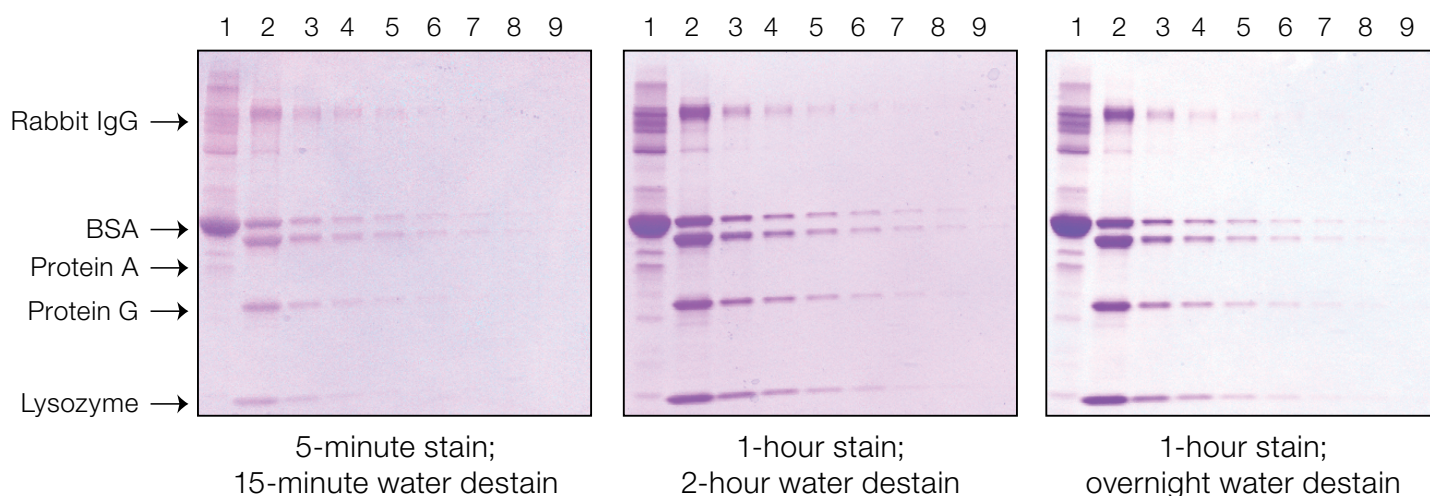


Figure 40. Enhanced sensitivity and clear background using Imperial Protein Stain. For even greater sensitivity and reduced background, gels can be stained with Imperial Protein Stain for 1 hour and washed with water from 1 hour to overnight. **Lane 1:** BSA only (6 µg); **lanes 2–9:** loaded with 1,000, 200, 100, 50, 25, 12, 6, and 3 ng protein.



Did you know

Staining with a Coomassie stain prior to silver staining allows for more uniform staining of certain proteins since silver ions can interact with certain functional groups such as carboxylic acid groups, imidazole, sulfhydryls, and amines.

Silver stains

Ultrasensitive stains with optimized protocols and manufactured for minimal variability

Silver staining is the most sensitive colorimetric method for detecting total protein, and functions by the deposition of metallic silver at the location of protein bands. Silver ions (from silver nitrate in the stain reagent) interact and bind with certain protein functional groups. The strongest interactions occur with carboxylic acid groups (Asp and Glu), imidazole (His), sulfhydryl groups (Cys), and amines (Lys). Various sensitizer and enhancer reagents are important for controlling the specificity and efficiency of silver ion binding to proteins and effective conversion (development) of the bound silver to metallic silver.

Key features:

- **Sensitive**—silver stains are highly sensitive stains that allow for visualization of proteins at subnanogram levels
- **Easy to use and flexible**—silver stains are optimized for minimal steps and have the flexibility to accommodate shorter or longer protocols
- **Workflow compatible**—our mild chemical formulations help ensure compatibility with mass spectrometry and sequencing
- **Robust performance**—detailed protocol enables consistent results with clear background



We offer highly sensitive silver stains with short protocol times that are also compatible with mass spectrometry. The Invitrogen™ SilverXpress™ Silver Staining Kit provides nanogram-level sensitivity with minimal background (Figures 41, 42), while the Thermo Scientific™ Pierce™ Silver Stain Kit provides protocol flexibility (Figures 43, 44).

Learn more at thermofisher.com/silverstains

Silver stain kits.

	Pierce Silver Stain for Mass Spectrometry	Pierce Silver Stain Kit	SilverXpress Silver Staining Kit
Components (steps)	6 (7)	4 (7)	5 (9)
Time required	1 hr 13 min	1 hr 30 min	2 hr
Limit of detection	0.25 ng	0.25 ng	0.86 ng
Mass spectrometry compatible	Yes	Yes	Yes
Storage	Room temperature	Room temperature	4°C
Stability	1 year	1 year	6 months
Advantages	<ul style="list-style-type: none"> Fast and sensitive staining and destaining of protein gels Optimized for peptide recovery after in-gel trypsin digestion for mass spectrometry Flexible gel fixation (15–30 min to overnight) and staining (1–30 min) 	<ul style="list-style-type: none"> Rapid, ultrasensitive, and versatile silver stain system Flexible gel fixation (30 min–overnight) and staining (5 min–20 hr) 	<ul style="list-style-type: none"> Nanogram-level sensitivity for silver staining with minimal background

Protocols and example data

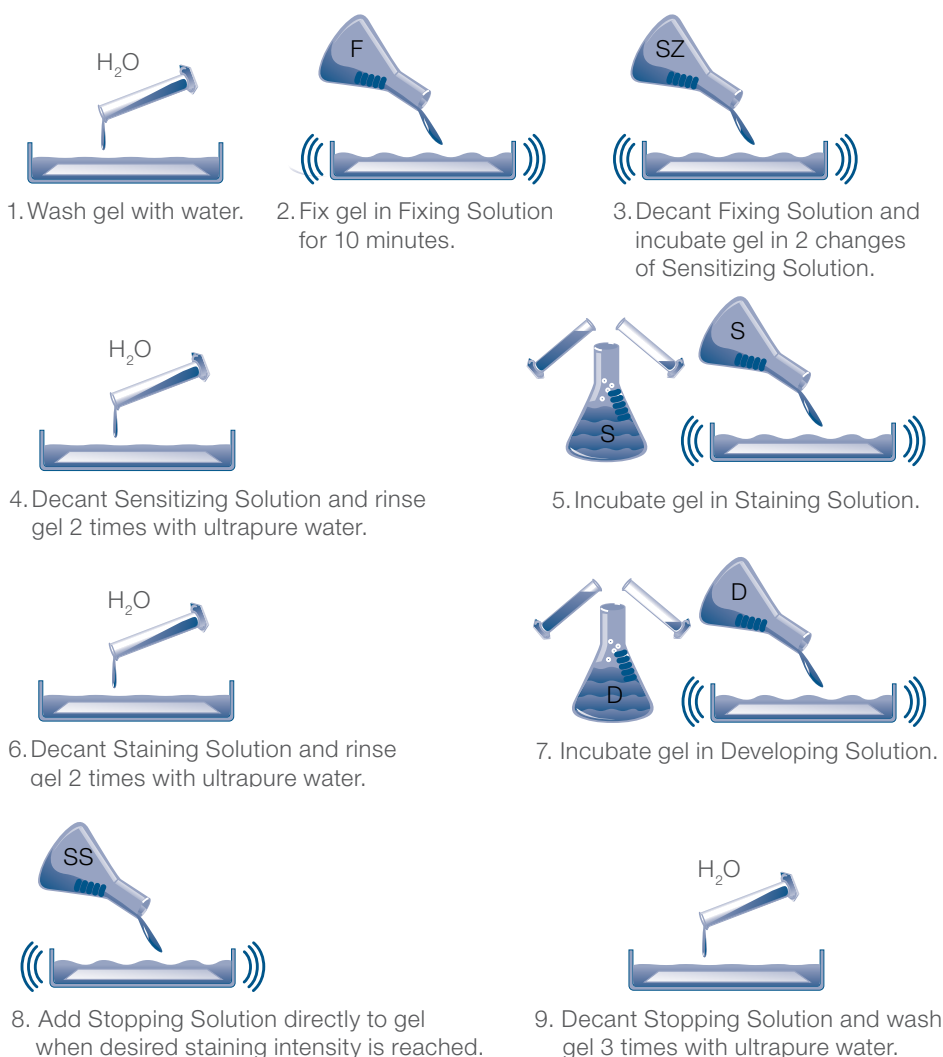


Figure 41. SilverXpress Silver Staining Kit protocol.

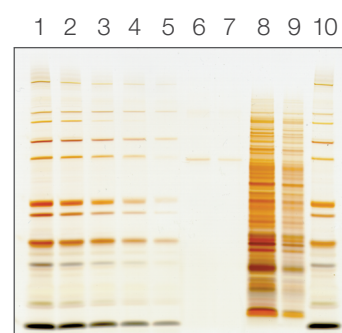


Figure 42. Crystal clear background with the SilverXpress Silver Staining Kit. Samples were separated on a NuPAGE 4–12% Bis-Tris gel and stained using the SilverXpress kit. **Lanes 1, 10:** Mark12 Unstained Standard (blend of 12 purified proteins) diluted 1:4; **lane 2:** Mark12 Unstained Standard diluted 1:8; **lane 3:** Mark12 Unstained Standard diluted 1:16; **lane 4:** Mark12 Unstained Standard diluted 1:32; **lane 5:** Mark12 Unstained Standard diluted 1:64; **lane 6:** 1.6 ng BSA; **lane 7:** 0.8 ng BSA; **lane 8:** *E. coli* lysate diluted 1:20; **lane 9:** *E. coli* lysate diluted 1:80.

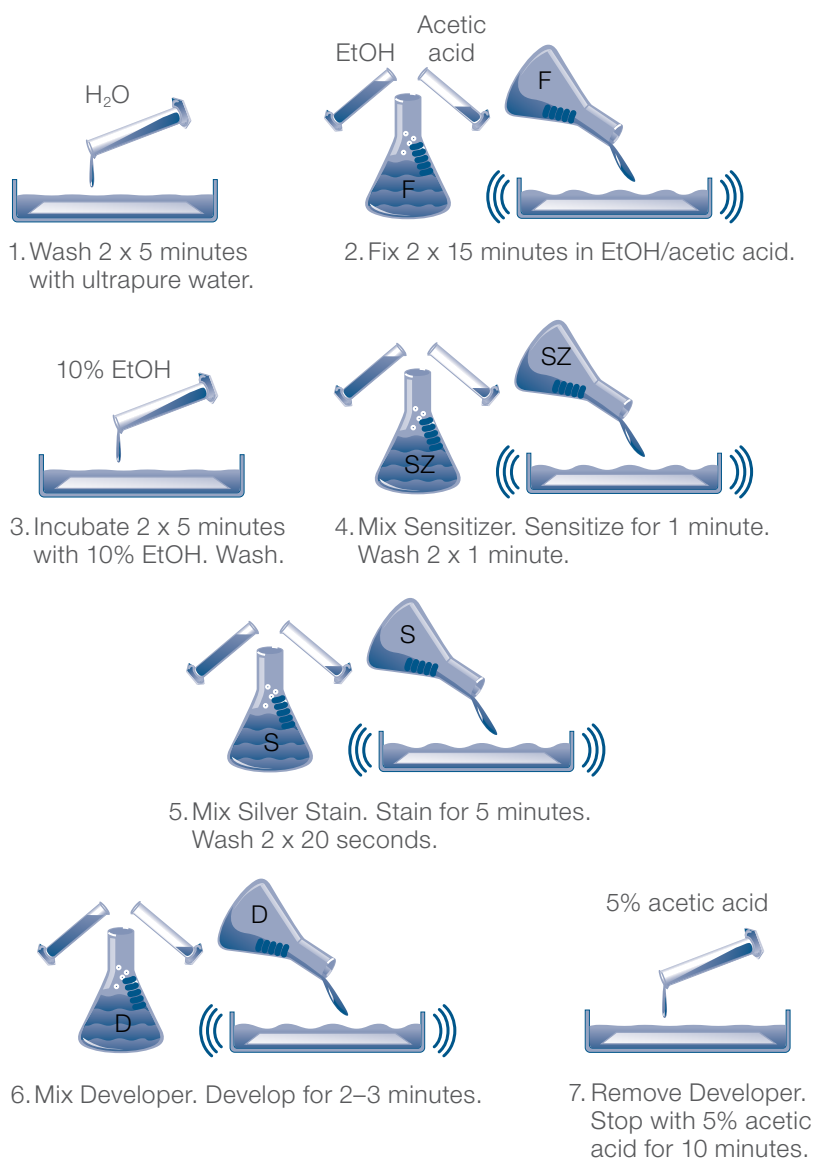


Figure 43. Pierce Silver Stain Kit protocol.

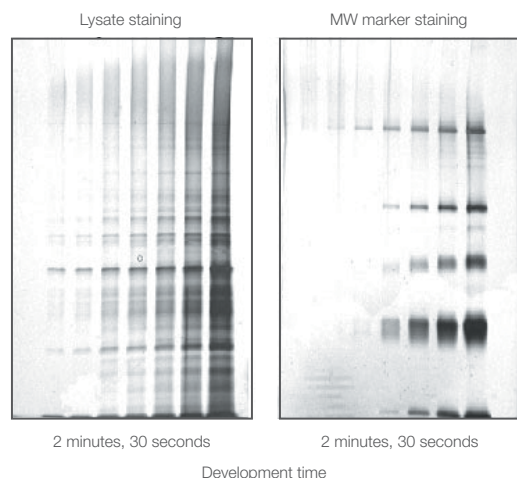


Figure 44. The Pierce Silver Stain Kit exhibits excellent sensitivity. In standard mini gels, proteins are detectable at greater than 0.25 ng per band or spot.

Fluorescent protein gel stains

Rapid, highly sensitive fluorescent stains for total protein detection after electrophoresis

Fluorescent gel stains are designed for use in 1D and 2D PAGE and offer sensitivities similar to those of silver staining techniques. Invitrogen™ SYPRO™ protein stains are easy-to-use fluorescent stains for the detection of proteins separated by PAGE. Stained proteins can be viewed with a standard UV or blue-light transilluminator or with a laser scanner.

Features:

- **Simple**—no destaining or timed steps required; minimal hands-on time
- **Quantitative**—linear quantitation range over two orders of magnitude with low protein-to-protein variability
- **Highly sensitive**—typically more sensitive than Coomassie dye-based stains and equivalent to silver stains

SYPRO protein stains.

	SYPRO Ruby stain	SYPRO Orange stain	SYPRO Red stain
Limit of detection	0.25 ng	4–8 ng	4–8 ng
Stain and destain time	90 min microwave; 18 hr standard	~1 hr	~1 hr
Ex/Em	280 nm, 450/610 nm	300 nm, 470/510 nm	300 nm, 550/630 nm
Ease of use	Ready to use	Supplied as stock solution	Supplied as stock solution
Compatible applications	Mass spectrometry, IEF, 2D gels, on-membrane staining	Mass spectrometry, IEF, 2D gels, on-membrane staining	Mass spectrometry, IEF, 2D gels, on-membrane staining

Learn more at thermofisher.com/fluorescentstains

Specialty protein stains

Our specialty protein stains include in-gel phosphoprotein and glycoprotein detection staining kits.

Specialty protein stains.

	Pro-Q Emerald 488 Glycoprotein Gel and Blot Stain Kit	Pro-Q Emerald 300 Glycoprotein Gel and Blot Stain Kit	Pro-Q Diamond Phosphoprotein Gel Staining Kit
Detects	Glycoproteins	Glycoproteins	Phosphoproteins
Sensitivity	4 ng glycoprotein per band	0.5 ng glycoprotein per band	1–16 ng phosphoprotein per band
Stain and destain time	~6 hr	~5 hr	4–5 hr
Ex/Em	510/520 nm	280/530 nm	555/580 nm
Advantages	Selective staining of glycoproteins	Selective staining of glycoproteins	Selective staining of phosphoproteins

Learn more at thermofisher.com/specialtystains

No-Stain Labeling Reagent

Instant visualization of proteins in gels

The Invitrogen™ No-Stain™ Protein Labeling Reagent offers a flexible, accurate, rapid, and reliable method to visualize and normalize proteins in a gel or on a membrane (post-transfer). It forms covalent bonds with lysine residues in proteins in gels or on membranes within 10 minutes without the need for destaining. Increasing incubation time or doubling the reagent concentration produces a proportionally stronger signal for improved detection of low-abundance proteins. The results can be instantly visualized using any commonly available imager, with nanogram-level sensitivity (Figure 45).

Features:

- **Versatile**—compatible with all gel chemistries and with downstream gel staining, protein transfer, immunoblotting, and mass spectrometry analysis
- **Flexible visualization**—use a wide range of excitation sources, including UV and green fluorescence light (optimal imaging conditions: Ex. max: ~488 nm, Em. max: 590 nm)
- **Broad linear dynamic range**—1–80 µg total protein loaded per well
- **Sensitive**—protein bands are detected down to 20 ng, and the signal is compatible with downstream antibody detection

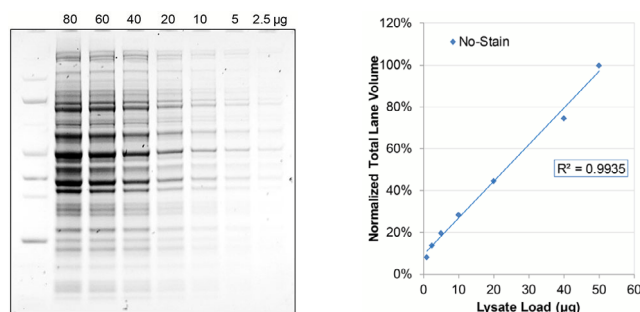
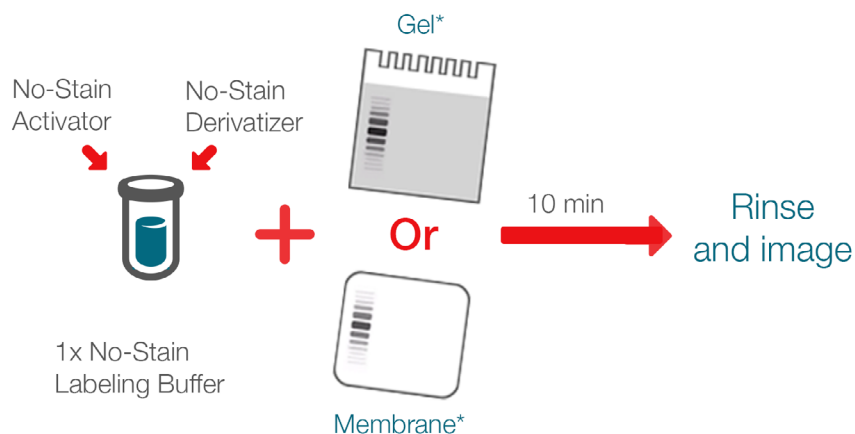


Figure 45. Quantitative gel staining with No-Stain Protein Labeling Reagent. A Bolt 4–12% Bis-Tris Plus gel was loaded with HeLa cell lysate containing 2.5 to 80 µg of protein, and electrophoresed with MES running buffer. After electrophoresis, the proteins were labeled in-gel with No-Stain Protein Labeling Reagent, and the gel was imaged using an Invitrogen™ iBright™ imager with the transilluminator for excitation (490–520 nm) and the 565–615 nm emission filter.

No-Stain protocol for labeling protein on gels or transferred blots



* For Tris-glycine gels and membranes derived from Tris-glycine gels, washing for two minutes with ultrapure water, 4 and 2 times, respectively, is necessary to remove glycine before performing labeling with the No-Stain Protein Labeling Reagent.

For details on total protein normalization for quantitative western blots using No-Stain Labeling Reagent, go to [thermofisher.com/nostain](https://www.thermofisher.com/nostain)

Gel imaging and documentation

Simply brilliant one-touch gel imaging

Capture, analyze, and share images of your protein and nucleic acid gels with ease. The Invitrogen™ iGlow™ Gel Documentation System supports one-touch gel imaging with an intuitive touchscreen interface and free, integrated software—making it quick and easy to visualize, enhance, and export high-quality images. Featuring a high-resolution camera and an advanced LED light source, the iGlow system is compatible with the most common polyacrylamide and agarose gel stains. The versatile imaging toolkit is composed of UV, blue, and white light trays, along with a safety guard screen designed for safe and efficient excision of DNA bands.



Key features

- **Automated tray recognition**—the iGlow system identifies the tray and activates only the matching light source
- **Programmable imaging methods**—save capture settings for automated routine imaging
- **Onboard image editing**—make quick adjustments right after capture, and export or print your updated image
- **Safe gel excision**—blue LED light provides a safer alternative than UV band excision
- **Quick and simple installation**—easy to set up and get started

Discover how the iGlow Gel Documentation System simplifies everyday gel imaging in our [video overview](#).

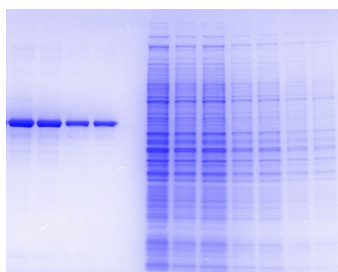


Gel stains compatible with the iGlow system

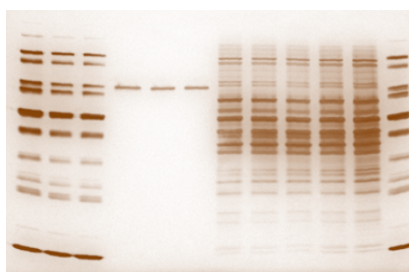
Application	Gel stain	Excitation source		
		UV	Blue	White
DNA	Ethidium bromide	✓		
	Invitrogen™ SYBR™ Safe		✓	
	Invitrogen™ SYBR™ Gold		✓	
	Invitrogen™ SYBR™ Green		✓	
	Biotium™ GelRed™	✓		
	Biotium™ GelGreen™		✓	
	Midori Green		✓	
Protein	Invitrogen™ SYPRO™ Ruby	✓		
	Invitrogen™ SYPRO™ Orange	✓		
	Invitrogen™ SYPRO™ Red	✓		
	Invitrogen™ SYPRO™ Tangerine	✓		
	Invitrogen™ Pro-Q™ Diamond Phosphoprotein		✓	
	Invitrogen™ Coomassie Fluor™ Orange		✓	
	Bio-Rad™ Oriole™	✓		
	Bio-Rad™ Flamingo™		✓	
	Invitrogen™ SimplyBlue™ SafeStain			✓
	Thermo Scientific™ Pierce™ Silver Stain			✓

* Most blue-light excitable dyes can also be visualized under UV illumination, and many UV-excitable dyes are compatible with blue-light imaging, though signal intensity may vary.

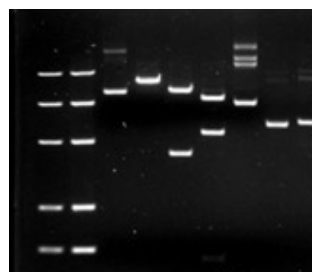
Example protein and DNA gel images captured with the iGlow Gel Documentation System



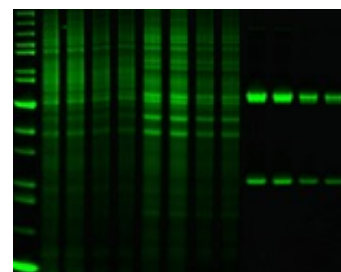
SDS-PAGE gel, Invitrogen™
SimplyBlue™ SafeStain



SDS-PAGE gel,
Thermo Scientific™
Pierce™ Silver Stain Kit



Agarose gel, Invitrogen™
UltraPure™
Ethidium Bromide



SDS-PAGE gel, Invitrogen™
SYPRO™ Red Protein
Gel Stain

Learn more about the iGlow Gel Documentation System at thermofisher.com/iglow

Western blotting

Key products for western blot transfer:

Wet	Semi-dry	Dry
		
Mini Blot Module	Invitrogen™ Power Blotter	Invitrogen™ iBlot™ 3 Dry Blotting System

Key products for western blot detection:

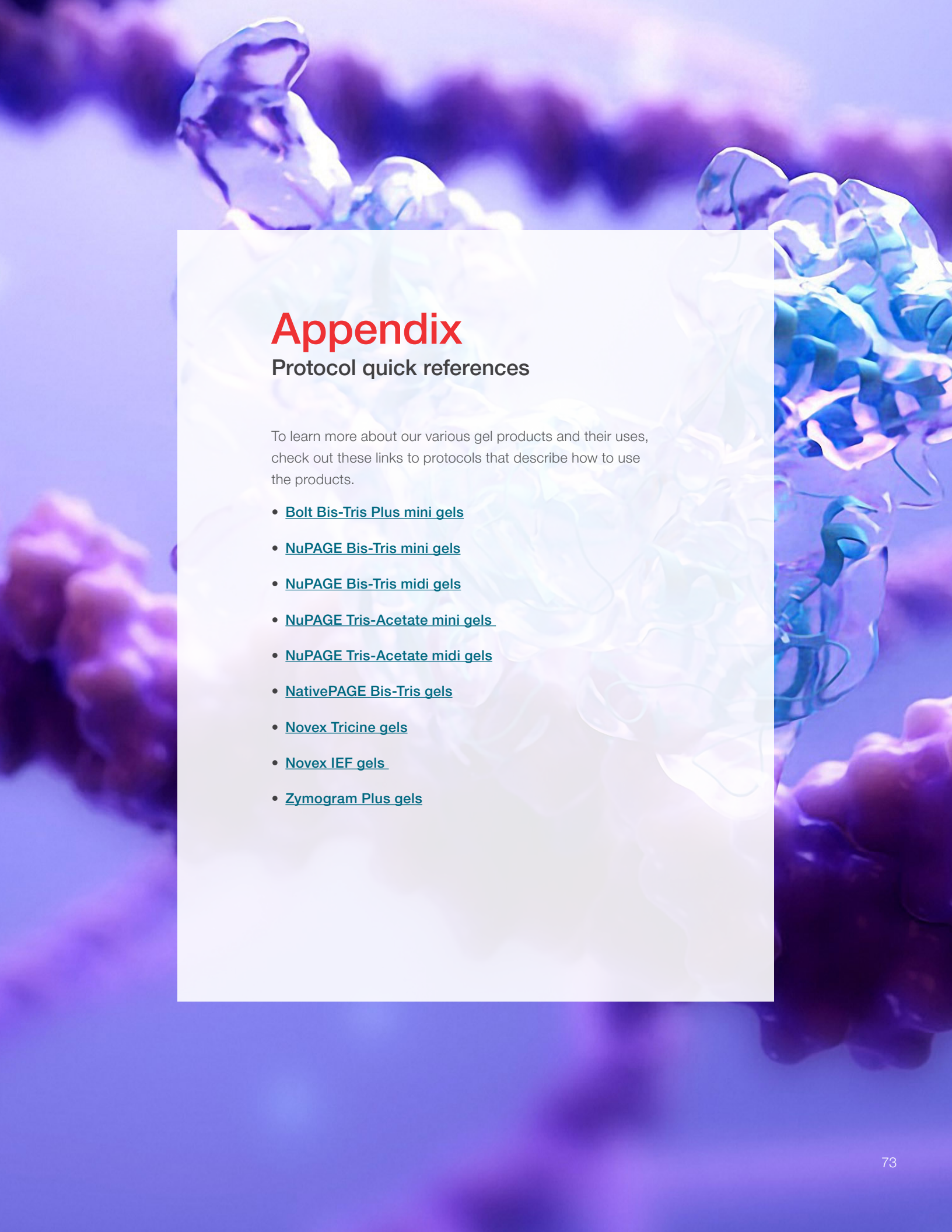
Automated detection		
		
Invitrogen™ iBind™ Flex Western Device	Invitrogen™ Bandmate™ Automated Western Blot Processor	Invitrogen™ iBright™ Imaging Systems

Manual detection

- Blocking buffers
- Wash buffers
- Detergents
- Enhancers
- Substrates
- Stripping buffers
- X-ray film



Learn more at thermofisher.com/western

The background of the page is a detailed 3D molecular model of a protein, rendered in shades of blue and purple. The protein's complex structure, including various loops and helices, is visible. Overlaid on the right side of the image is a semi-transparent white rectangular box that contains the text for the Appendix section.

Appendix

Protocol quick references

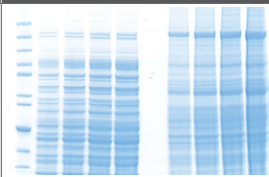
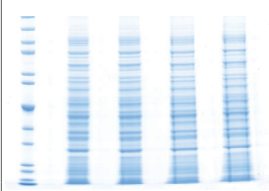
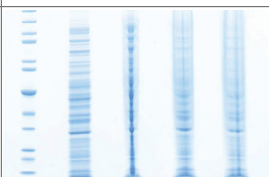
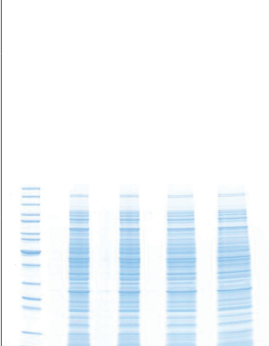
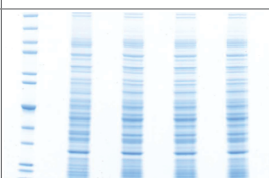
To learn more about our various gel products and their uses, check out these links to protocols that describe how to use the products.

- [Bolt Bis-Tris Plus mini gels](#)
- [NuPAGE Bis-Tris mini gels](#)
- [NuPAGE Bis-Tris midi gels](#)
- [NuPAGE Tris-Acetate mini gels](#)
- [NuPAGE Tris-Acetate midi gels](#)
- [NativePAGE Bis-Tris gels](#)
- [Novex Tricine gels](#)
- [Novex IEF gels](#)
- [Zymogram Plus gels](#)

Troubleshooting tips

Protein gel electrophoresis

Gel electrophoresis troubleshooting

Observation		Possible cause	Suggested solution
Protein bands lose resolution, lanes have streaks and are not straight		Too much protein loaded per lane	Reduce the sample loads. The maximum recommended sample load for optimal resolution in mini gels with 10, 12, 15, or 17 wells is 0.5 µg per band or about 10–15 µg of cell lysate per lane.
Viscous samples, streaks at sample lane edges, dumbbell-shaped bands, lane widening		Excess salt (ammonium sulfate) in sample during gel electrophoresis	<p>Perform dialysis to decrease salt concentration. Use a small dialysis device such as the Thermo Scientific™ Slide-A-Lyzer™ MINI Dialysis Device, 0.5 mL (Cat. No. 88401).</p> <p>Concentrate and resuspend samples in lower-salt buffer prior to electrophoresis. Use small-volume concentrators such as Thermo Scientific™ Pierce™ Protein Concentrators PES, 0.5 mL (Cat. No. 88513).</p> <p>Make sure that the salt concentration does not exceed 100 mM.</p>
Protein aggregation resulting in narrow lanes that cannot be interpreted		DNA contamination—genomic DNA in the cell lysate may cause the sample to become viscous, resulting in protein aggregation, which can affect protein migration patterns and resolution	Shear genomic DNA to reduce viscosity before loading the sample.
Uneven sample lanes, lane widening		<p>Excess salt (sodium chloride) in sample during gel electrophoresis. High salt concentrations result in increased conductivity, which affects protein migration and can result in protein bands spreading into adjacent lanes containing samples with normal salt concentrations</p> <p>High detergent concentration (e.g., SDS or Triton X-100 detergent) in gel electrophoresis. Detergents form mixed micelles with the anionic detergent SDS in the gel and migrate down into the gel; they interfere with the SDS–protein binding equilibrium</p> <p>High concentration of RIPA (radioimmunoprecipitation assay) buffer results in widening of lanes and significant streaking during electrophoresis</p>	<p>Perform dialysis to decrease salt concentration. Use a small dialysis device such as the Slide-A-Lyzer MINI Dialysis Device, 0.5 mL (Cat. No. 88401).</p> <p>Concentrate and resuspend samples in lower-salt buffer prior to electrophoresis. Use small-volume concentrators such as Pierce Protein Concentrators PES, 0.5 mL (Cat. No. 88513).</p> <p>Make sure that the salt concentration does not exceed 100 mM.</p> <p>Most of the nonionic detergents (e.g., Triton X-100, NP-40, and Tween 20 detergents) interfere with SDS-polyacrylamide gel electrophoresis (SDS-PAGE). Keep the ratio of SDS to nonionic detergent at 10:1 or greater to minimize these effects.</p> <p>Use detergent removal columns or the Thermo Scientific™ Pierce™ SDS-PAGE Sample Prep Kit (Cat. No. 89888) to remove excess detergent.</p> <p>Dilute samples before electrophoresis to lower the final concentration of lysis buffer to prevent buffer-related defects.</p>
Shadow at lane edges		Excess reducing agent in the lysis or sample buffer	The final concentration of reducing agents for SDS-PAGE should be less than 50 mM for DTT (dithiothreitol) and TCEP (tris(2-carboxyethyl) phosphine), and less than 2.5% for β-ME (β-mercaptoethanol).

Gel electrophoresis troubleshooting (cont.)

Observation	Possible cause	Suggested solution
Run taking longer time with recommended voltage	Running buffer too dilute	Make fresh running buffer and use a 1X dilution.
Current too high and excessive heat generated with recommended voltage	Running buffer too concentrated	Make fresh running buffer and use a 1X dilution.
Current too low or no current with recommended voltage	Incomplete circuit	Remove the tape from the bottom of the gel cassette prior to electrophoresis. Make sure the buffer covers sample wells; check the wire connections on the buffer core.
Streaking of proteins	Sample overload	Load less protein.
	High salt concentration in sample	Decrease the sample salt concentration by dialysis or gel filtration.
	Sample precipitates	Increase the concentration of SDS in the sample.
	Contaminants such as lipids or DNA complexes in sample	Centrifuge or clarify the sample to remove particulate contaminants. Treat sample with nuclease(s).
	Poorly poured gel	Make sure the gel is poured evenly and all at once.
Fuzzy bands	Protein sample only partially denatured	Fully denature the protein.
	Protein sample only partially reduced	Make sure a sufficient amount of DTT or β -mercaptoethanol is added.
	Gel runs for too long	Watch the dye front as an indicator for proper running time.
Dumbbell-shaped bands or “smiling” bands	Loading a large volume of sample causes incomplete stacking	Load appropriate volume of sample. If the sample is too dilute, concentrate it using ultrafiltration.
	Uneven electric field during run	Try to make sure the loading is symmetrical if the protein concentration is known.
	Uneven surface of the resolving gel	Try to make the resolving gel surface even while pouring the gel.
	Expired gels	Use the gels before the specified expiration date. Note: NuPAGE gels have an extended 12-month shelf life, minimizing the risk of having expired gels.

Protein gel electrophoresis chamber systems

Mini Gel Tank troubleshooting

Observation	Possible cause	Suggested solution
Run taking longer than usual	Buffers are too dilute	Check buffer recipe; dilute from concentrate or remake if necessary.
	Buffer chamber is leaking	Make sure the cassette clamp is firmly seated, the gaskets are in place, and the cassette clamp is locked.
	Current is set too low	Set correct current.
Current reading on power supply is zero or very low	Tape left on the bottom of the cassette	Remove tape from bottom of cassette.
	Connection to power supply not complete	Check all connections with a voltmeter for conductance.
	Insufficient buffer level	Make sure there is sufficient buffer in the electrophoresis tank to cover the wells of the gel.
Run is faster than normal with poor resolution	Buffers are too concentrated or incorrect	Check buffer recipe; dilute or remake if necessary.
	Current is set at a higher limit	Decrease current to recommended running conditions (see page 60).
Cannot see the sample wells to load sample	There is little contrast between the sample well and the rest of the gel	Mark cassette at the bottom of the wells with a marker pen prior to placing the cassette in the electrophoresis tank.

XCell SureLock Mini-Cell troubleshooting

Observation	Possible cause	Suggested solution
Run taking longer than usual	Buffers are too dilute	Check if buffer was diluted properly. Check buffer recipe; dilute from concentrate or remake if necessary.
	Upper buffer chamber is leaking	Make sure the buffer core is firmly seated, the gaskets are in place, and the gel tension lever is locked.
	Voltage is set too low	Set correct voltage.
Current reading on power supply is zero or very low	Tape left on the bottom of the cassette	Remove tape from bottom of cassette.
	Connection to power supply not complete	Check all connections with a voltmeter for conductance.
	Insufficient buffer level	Make sure the upper buffer (cathode) is covering the wells of the gel. Be sure there is sufficient buffer in the lower buffer chamber to cover the slot at the bottom of the gel.
Run is faster than normal with poor resolution	Buffers are too concentrated or incorrect	Check buffer recipe; dilute or remake if necessary.
	Voltage, current, or wattage is set at a higher limit	Decrease power conditions to recommended running conditions (see page 60).
Cannot see the sample wells to load sample	There is little contrast between the sample well and the rest of the gel	Mark cassette at the bottom of the wells with a marker pen prior to assembling the upper buffer chamber. Illuminate the bench area with a light source placed directly behind the XCell SureLock unit.

SureLock Tandem Midi Gel Tank troubleshooting

Observation	Possible cause	Suggested solution
Run takes longer than normal	Buffers were too dilute	Check buffer recipes. Do not reuse buffers. Remake buffer if necessary.
	Buffer chamber was leaking	Make sure the cassette clamp is firmly seated, the gaskets are in place, and the cassette clamps are locked.
	Voltage and/or current was set too low	Set the correct voltage and/or current. See "Running conditions" in the "Gel electrophoresis protocol" (p. 10) of the user guide for more details.
Run is faster than normal, with poor resolution	Incorrect running buffer was used or buffer was too concentrated	Check buffer recipe. Dilute or remake buffer if necessary.
	Voltage and/or current was set too high	Decrease voltage and/or current to recommended running conditions. See "Running conditions" in the "Gel electrophoresis protocol" (p. 10) of the user guide for more details.
Current reading on power supply is zero or very low	Tape was left on the bottom of the cassette	Remove the tape from the cassette.
	Connection to power supply was not complete	Check conductance on all connections using a voltmeter. Note: Do not check connections if not trained in this procedure. Contact Technical Support for further help.
	Insufficient buffer level	Make sure there is sufficient buffer in the tank. The cathode (inside) chamber needs to be filled to above the wells (~170 mL), and the anode (outside) chamber needs to be filled to the red fill line (~350 mL). See "Fill tank with running buffer and load samples" in the "Gel electrophoresis protocol" (p. 12) of the user guide for more details.
Cannot see the sample wells to load the sample	Difficult to see contrast between the sample well and the rest of the gel	Mark cassette at the bottom of the wells with a marker pen prior to placing the cassette in the electrophoresis tank.
Current reading on power supply is much higher than expected, or maxed out	Too many gels were being run at once using one power supply	Check the power limits of the power supply being used and use additional power supplies if needed.
	Cassette was not properly clamped	Ensure that the cassette clamp is firmly seated, the gaskets are in place, and the cassette clamps are in the locked position. See "Insert cassette" in the "Gel electrophoresis protocol" (p. 11) of the user guide for details.
	Tank was overfilled with running buffer	If the buffer level is above the height of the gel, the cathode and anode chambers are in direct contact, resulting in an electrical short circuit. Ensure correct buffer volumes. The cathode buffer level should be covering the wells but not above the height of the gel (~170 mL). The anode buffer level should be filled to the red fill line marked on the outside of the tank (~350 mL). See "Fill tank with running buffer and load samples" in the "Gel electrophoresis protocol" (p. 12) of the user guide for more details.
Proteins are not migrating into the gel	The cassette is installed backwards in the tank	Install the cassette in the correct orientation, with the well opening facing toward the cathode (center of the tank).
	The power cable is installed backwards into the power supply	Install the power cable in the correct orientation (red to red, black to black).

Ordering information

Product	Quantity	Cat. No.
Gel welcome packs		
Novex WedgeWell Welcome Pack, 6%, 10-well	1 kit	XP0006A
Novex WedgeWell Welcome Pack, 6%, 12-well	1 kit	XP0006B
Novex WedgeWell Welcome Pack, 6%, 15-well	1 kit	XP0006C
Novex WedgeWell Welcome Pack, 8%, 10-well	1 kit	XP0008A
Novex WedgeWell Welcome Pack, 8%, 12-well	1 kit	XP0008B
Novex WedgeWell Welcome Pack, 8%, 15-well	1 kit	XP0008C
Novex WedgeWell Welcome Pack, 10%, 10-well	1 kit	XP0010A
Novex WedgeWell Welcome Pack, 10%, 12-well	1 kit	XP0010B
Novex WedgeWell Welcome Pack, 10%, 15-well	1 kit	XP0010C
Novex WedgeWell Welcome Pack, 12%, 10-well	1 kit	XP0012A
Novex WedgeWell Welcome Pack, 12%, 12-well	1 kit	XP0012B
Novex WedgeWell Welcome Pack, 12%, 15-well	1 kit	XP0012C
Novex WedgeWell Welcome Pack, 14%, 10-well	1 kit	XP0014A
Novex WedgeWell Welcome Pack, 14%, 12-well	1 kit	XP0014B
Novex WedgeWell Welcome Pack, 14%, 15-well	1 kit	XP0014C
Novex WedgeWell Welcome Pack, 16%, 10-well	1 kit	XP0016A
Novex WedgeWell Welcome Pack, 16%, 12-well	1 kit	XP0016B
Novex WedgeWell Welcome Pack, 16%, 15-well	1 kit	XP0016C
Novex WedgeWell Welcome Pack, 4–12%, 10-well	1 kit	XP0412A
Novex WedgeWell Welcome Pack, 4–12%, 12-well	1 kit	XP0412B
Novex WedgeWell Welcome Pack, 4–12%, 15-well	1 kit	XP0412C
Novex WedgeWell Welcome Pack, 4–20%, 10-well	1 kit	XP0420A
Novex WedgeWell Welcome Pack, 4–20%, 12-well	1 kit	XP0420B
Novex WedgeWell Welcome Pack, 4–20%, 15-well	1 kit	XP0420C
Novex WedgeWell Welcome Pack, 8–16%, 10-well	1 kit	XP0816A
Novex WedgeWell Welcome Pack, 8–16%, 12-well	1 kit	XP0816B
Novex WedgeWell Welcome Pack, 8–16%, 15-well	1 kit	XP0816C
Novex WedgeWell Welcome Pack, 10–20%, 10-well	1 kit	XP1020A
Novex WedgeWell Welcome Pack, 10–20%, 12-well	1 kit	XP1020B
Novex WedgeWell Welcome Pack, 10–20%, 15-well	1 kit	XP1020C
Bolt Welcome Pack A (4–12%, 10-well)	1 kit	NW0412A
Bolt Welcome Pack B (4–12%, 15-well)	1 kit	NW0412B
Bolt Welcome Pack, 4–12%, 12-well	1 kit	NW0412C
Bolt Welcome Pack, 10%, 10-well	1 kit	NW0010A
Bolt Welcome Pack, 10%, 12-well	1 kit	NW0010B
Bolt Welcome Pack, 10%, 15-well	1 kit	NW0010C
Bolt Welcome Pack, 12%, 10-well	1 kit	NW0012A
Bolt Welcome Pack, 12%, 12-well	1 kit	NW0012B
Bolt Welcome Pack, 12%, 15-well	1 kit	NW0012C
Bolt Welcome Pack, 8%, 10-well	1 kit	NW0008A
Bolt Welcome Pack, 8%, 12-well	1 kit	NW0008B
Bolt Welcome Pack, 8%, 15-well	1 kit	NW0008C

Product	Quantity	Cat. No.
Gel welcome packs (cont.)		
NuPAGE Tris-Acetate Welcome Pack, 3–8%, 10-well	1 kit	EA0375A
NuPAGE Tris-Acetate Welcome Pack, 3–8%, 12-well	1 kit	EA0375B
NuPAGE Tris-Acetate Welcome Pack, 3–8%, 15-well	1 kit	EA0375C
NuPAGE Tris-Acetate Welcome Pack, 7%, 10-well	1 kit	EA0355A
NuPAGE Tris-Acetate Welcome Pack, 7%, 12-well	1 kit	EA0355B
NuPAGE Tris-Acetate Welcome Pack, 7%, 15-well	1 kit	EA0355C
NuPAGE Bis-Tris Welcome Pack, 10%, 10-well	1 kit	NP030A
NuPAGE Bis-Tris Welcome Pack, 10%, 12-well	1 kit	NP030B
NuPAGE Bis-Tris Welcome Pack, 10%, 15-well	1 kit	NP030C
NuPAGE Bis-Tris Welcome Pack, 12%, 10-well	1 kit	NP034A
NuPAGE Bis-Tris Welcome Pack, 12%, 12-well	1 kit	NP034B
NuPAGE Bis-Tris Welcome Pack, 12%, 15-well	1 kit	NP034C
NuPAGE Bis-Tris Welcome Pack, 4–12%, 10-well	1 kit	NP032A
NuPAGE Bis-Tris Welcome Pack, 4–12%, 12-well	1 kit	NP032B
NuPAGE Bis-Tris Welcome Pack, 4–12%, 15-well	1 kit	NP032C
Novex Tricine Welcome Pack, 10%, 10-well	1 kit	EC6675A
Novex Tricine Welcome Pack, 10%, 12-well	1 kit	EC6675B
Novex Tricine Welcome Pack, 16%, 10-well	1 kit	EC6695A
Novex Tricine Welcome Pack, 16%, 12-well	1 kit	EC6695B
Novex Tricine Welcome Pack, 16%, 15-well	1 kit	EC6695C
Novex Tricine Welcome Pack, 10–20%, 10-well	1 kit	EC6625A
Novex Tricine Welcome Pack, 10–20%, 12-well	1 kit	EC6625B
Novex Tricine Welcome Pack, 10–20%, 15-well	1 kit	EC6625C

Learn more at
thermofisher.com/proteingelwelcome

Product	Quantity	Cat. No.
Bolt Bis-Tris Plus gels (8 x 8 cm)		
Bolt 8% Bis-Tris Plus Gels, 10-well	10 gels	NW00080BOX
Bolt 8% Bis-Tris Plus Gels, 12-well	10 gels	NW00082BOX
Bolt 8% Bis-Tris Plus Gels, 15-well	10 gels	NW00085BOX
Bolt 8% Bis-Tris Plus Gels, 17-well	10 gels	NW00087BOX
Bolt 10% Bis-Tris Plus Gels, 10-well	10 gels	NW00100BOX
Bolt 10% Bis-Tris Plus Gels, 12-well	10 gels	NW00102BOX
Bolt 10% Bis-Tris Plus Gels, 15-well	10 gels	NW00105BOX
Bolt 10% Bis-Tris Plus Gels, 17-well	10 gels	NW00107BOX
Bolt 12% Bis-Tris Plus Gels, 10-well	10 gels	NW00120BOX
Bolt 12% Bis-Tris Plus Gels, 12-well	10 gels	NW00122BOX
Bolt 12% Bis-Tris Plus Gels, 15-well	10 gels	NW00125BOX
Bolt 12% Bis-Tris Plus Gels, 17-well	10 gels	NW00127BOX
Bolt 4–12% Bis-Tris Plus Gels, 10-well	10 gels	NW04120BOX
Bolt 4–12% Bis-Tris Plus Gels, 12-well	10 gels	NW04122BOX
Bolt 4–12% Bis-Tris Plus Gels, 15-well	10 gels	NW04125BOX
Bolt 4–12% Bis-Tris Plus Gels, 17-well	10 gels	NW04127BOX
Bolt Empty Mini Gel Cassettes	20 cassettes	NW2010
Bolt Empty Mini Gel Cassette Combs, 10-well	20 combs	NW3010
Bolt Empty Mini Gel Cassette Combs, 12-well	20 combs	NW3012

Product	Quantity	Cat. No.
NuPAGE Bis-Tris mini gels (8 x 8 cm)		
NuPAGE 10% Bis-Tris Protein Gels, 1.0 mm, 1-well	10 gels	NP0304BOX
NuPAGE 10% Bis-Tris Protein Gels, 1.0 mm, 10-well	10 gels	NP0301BOX
NuPAGE 10% Bis-Tris Protein Gels, 1.0 mm, 10-well	2 gels	NP0301PK2
NuPAGE 10% Bis-Tris Protein Gels, 1.0 mm, 12-well	10 gels	NP0302BOX
NuPAGE 10% Bis-Tris Protein Gels, 1.0 mm, 12-well	2 gels	NP0302PK2
NuPAGE 10% Bis-Tris Protein Gels, 1.0 mm, 15-well	10 gels	NP0303BOX
NuPAGE 10% Bis-Tris Protein Gels, 1.0 mm, 9-well	10 gels	NP0307BOX
NuPAGE 10% Bis-Tris Protein Gels, 1.5 mm, 10-well	10 gels	NP0315BOX
NuPAGE 10% Bis-Tris Protein Gels, 1.5 mm, 15-well	10 gels	NP0316BOX
NuPAGE 12% Bis-Tris Protein Gels, 1.0 mm, 1-well	10 gels	NP0344BOX
NuPAGE 12% Bis-Tris Protein Gels, 1.0 mm, 10-well	10 gels	NP0341BOX
NuPAGE 12% Bis-Tris Protein Gels, 1.0 mm, 10-well	2 gels	NP0341PK2
NuPAGE 12% Bis-Tris Protein Gels, 1.0 mm, 12-well	10 gels	NP0342BOX
NuPAGE 12% Bis-Tris Protein Gels, 1.0 mm, 12-well	2 gels	NP0342PK2
NuPAGE 12% Bis-Tris Protein Gels, 1.0 mm, 15-well	10 gels	NP0343BOX
NuPAGE 12% Bis-Tris Protein Gels, 1.0 mm, 17-well	10 gels	NP0349BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 1-well	10 gels	NP0324BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 10-well	10 gels	NP0321BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 10-well	2 gels	NP0321PK2
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 12-well	10 gels	NP0322BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 12-well	2 gels	NP0322PK2
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 15-well	10 gels	NP0323BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 15-well	2 gels	NP0323PK2
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 17-well	10 gels	NP0329BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 17-well	2 gels	NP0329PK2
NuPAGE 4–12% Bis-Tris Protein Gels, 1.0 mm, 9-well	10 gels	NP0327BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.5 mm, 10-well	10 gels	NP0335BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.5 mm, 10-well	2 gels	NP0335PK2
NuPAGE 4–12% Bis-Tris Protein Gels, 1.5 mm, 15-well	10 gels	NP0336BOX
NuPAGE 4–12% Bis-Tris Protein Gels, 1.5 mm, 15-well	2 gels	NP0336PK2

Product	Quantity	Cat. No.
NuPAGE Bis-Tris midi gels (8 x 13 cm)		
NuPAGE 10% Bis-Tris Midi Protein Gels, 12+2 well	10 gels	WG1201BOX
NuPAGE 10% Bis-Tris Midi Protein Gels, 12+2-well, w/ adapters	10 gels	WG1201A
NuPAGE 10% Bis-Tris Midi Protein Gels, 20-well	10 gels	WG1202BOX
NuPAGE 10% Bis-Tris Midi Protein Gels, 20-well, w/ adapters	10 gels	WG1202A
NuPAGE 10% Bis-Tris Midi Protein Gels, 26-well	10 gels	WG1203BOX
NuPAGE 10% Bis-Tris Midi Protein Gels, 26-well, w/ adapters	10 gels	WG1203A
NuPAGE 4–12% Bis-Tris Midi Protein Gels, 12+2-well	10 gels	WG1401BOX
NuPAGE 4–12% Bis-Tris Midi Protein Gels, 12+2-well, w/ adapters	10 gels	WG1401A
NuPAGE 4–12% Bis-Tris Midi Protein Gels, 20-well	10 gels	WG1402BOX
NuPAGE 4–12% Bis-Tris Midi Protein Gels, 20-well, w/ adapters	10 gels	WG1402A
NuPAGE 4–12% Bis-Tris Midi Protein Gels, 26-well	10 gels	WG1403BOX
NuPAGE 4–12% Bis-Tris Midi Protein Gels, 26-well, w/ adapters	10 gels	WG1403A
NuPAGE 8% Bis-Tris Midi Protein Gels, 12+2-well	10 gels	WG1001BOX
NuPAGE 8% Bis-Tris Midi Protein Gels, 12+2-well, w/ adapters	10 gels	WG1001A
NuPAGE 8% Bis-Tris Midi Protein Gels, 20-well	10 gels	WG1002BOX
NuPAGE 8% Bis-Tris Midi Protein Gels, 20-well, w/ adapters	10 gels	WG1002A
NuPAGE 8% Bis-Tris Midi Protein Gels, 26-well	10 gels	WG1003BOX
NuPAGE 8% Bis-Tris Midi Protein Gels, 26-well, w/ adapters	10 gels	WG1003A

Product	Quantity	Cat. No.
NuPAGE Bis-Tris midi gels (8 x 13 cm), WedgeWell format		
NuPAGE 10%, Bis-Tris Midi Protein Gels, 12+2-well, WedgeWell format	10 gels	WBT01012BOX
NuPAGE 10%, Bis-Tris Midi Protein Gels, 20-well, WedgeWell format	10 gels	WBT01020BOX
NuPAGE 10%, Bis-Tris Midi Protein Gels, 26-well, WedgeWell format	10 gels	WBT01026BOX
NuPAGE 4–12%, Bis-Tris Midi Protein Gels, 12+2-well, WedgeWell format	10 gels	WBT41212BOX
NuPAGE 4–12%, Bis-Tris Midi Protein Gels, 20-well, WedgeWell format	10 gels	WBT41220BOX
NuPAGE 4–12%, Bis-Tris Midi Protein Gels, 26-well, WedgeWell format	10 gels	WBT41226BOX
NuPAGE Tris-Acetate midi gels (8 x 13 cm), WedgeWell format		
NuPAGE 3–8% Tris-Acetate Midi Protein Gels, 12+2-well, WedgeWell format	10 gels	WTA03812BOX
NuPAGE 3–8% Tris-Acetate Midi Protein Gels, 20-well, WedgeWell format	10 gels	WTA03820BOX
NuPAGE 3–8% Tris-Acetate Midi Protein Gels, 26-well, WedgeWell format	10 gels	WTA03826BOX

Product	Quantity	Cat. No.
Novex Tris-Glycine mini gels (8 x 8 cm), WedgeWell format		
Novex 6% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP00060BOX
Novex 6% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP00062BOX
Novex 6% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP00065BOX
Novex 8% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP00080BOX
Novex 8% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP00082BOX
Novex 8% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP00085BOX
Novex 10% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP00100BOX
Novex 10% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP00102BOX
Novex 10% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP00105BOX
Novex 10% Tris-Glycine Mini Gel, WedgeWell format, 10-well	2 gels	XP00100PK2
Novex 12% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP00120BOX
Novex 12% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP00122BOX
Novex 12% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP00125BOX
Novex 14% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP00140BOX
Novex 14% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP00142BOX
Novex 14% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP00145BOX
Novex 16% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP00160BOX
Novex 16% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP00162BOX
Novex 16% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP00165BOX
Novex 4–12% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP04120BOX
Novex 4–12% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP04122BOX
Novex 4–12% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP04125BOX
Novex 4–12% Tris-Glycine Mini Gel, WedgeWell format, 10-well	2 gels	XP04120PK2
Novex 4–20% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP04200BOX
Novex 4–20% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP04202BOX
Novex 4–20% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP04205BOX
Novex 4–20% Tris-Glycine Mini Gel, WedgeWell format, 10-well	2 gels	XP04200PK2
Novex 8–16% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP08160BOX
Novex 8–16% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP08162BOX
Novex 8–16% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP08165BOX
Novex 10–20% Tris-Glycine Mini Gel, WedgeWell format, 10-well	10 gels	XP10200BOX
Novex 10–20% Tris-Glycine Mini Gel, WedgeWell format, 12-well	10 gels	XP10202BOX
Novex 10–20% Tris-Glycine Mini Gel, WedgeWell format, 15-well	10 gels	XP10205BOX

Product	Quantity	Cat. No.
Novex Tris-Glycine Plus midi gels (8 x 13 cm)		
Novex 10% Tris-Glycine Plus Midi Protein Gels, 12+2-well	10 gels	WPX01012BOX
Novex 10% Tris-Glycine Plus Midi Protein Gels, 20-well	10 gels	WXP01020BOX
Novex 10% Tris-Glycine Plus Midi Protein Gels, 26-well	10 gels	WXP01026BOX
Novex 10% Tris-Glycine Plus Midi Protein Gels, 26-well, w/ adapters	10 gels	WXP01026BOXA
Novex 12% Tris-Glycine Plus Midi Protein Gels, 12+2-well	10 gels	WXP01212BOX
Novex 12% Tris-Glycine Plus Midi Protein Gels, 12+2-well, w/ adapters	10 gels	WXP01212BOXA
Novex 12% Tris-Glycine Plus Midi Protein Gels, 20-well	10 gels	WXP01220BOX
Novex 12% Tris-Glycine Plus Midi Protein Gels, 20-well, w/ adapters	10 gels	WXP01220BOXA
Novex 12% Tris-Glycine Plus Midi Protein Gels, 26-well	10 gels	WXP01226BOX
Novex 12% Tris-Glycine Plus Midi Protein Gels, 26-well, w/ adapters	10 gels	WXP01226BOXA
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 12+2-well	10 gels	WXP41212BOX
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 12+2-well, w/ adapters	10 gels	WXP41212BOXA
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 20-well	10 gels	WXP41220BOX
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 20-well, w/ adapters	10 gels	WXP41220BOXA
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 26-well	10 gels	WXP41226BOX
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 26-well, w/ adapters	10 gels	WXP41226BOXA
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 12+2-well	10 gels	WXP42012BOX
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 12+2-well, w/ adapters	10 gels	WXP42012BOXA
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 20-well	10 gels	WXP42020BOX
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 20-well, w/ adapters	10 gels	WXP42020BOXA
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 26-well	10 gels	WXP42026BOX
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 26-well, w/ adapters	10 gels	WXP42026BOXA
Novex 8–16% Tris-Glycine Plus Midi Protein Gels, 12+2-well	10 gels	WXP81612BOX
Novex 8–16% Tris-Glycine Plus Midi Protein Gels, 12+2-well, w/ adapters	10 gels	WXP81612BOXA
Novex 8–16% Tris-Glycine Plus Midi Protein Gels, 20-well	10 gels	WXP81620BOX
Novex 8–16% Tris-Glycine Plus Midi Protein Gels, 20-well, w/ adapters	10 gels	WXP81620BOXA
Novex 8–16% Tris-Glycine Plus Midi Protein Gels, 26-well	10 gels	WXP81626BOX
Novex 8–16% Tris-Glycine Plus Midi Protein Gels, 26-well, w/ adapters	10 gels	WXP81626BOXA

Product	Quantity	Cat. No.
NativePAGE gels		
NativePAGE 3–12% Bis-Tris Protein Gels, 1.0 mm, 10-well	10 gels	BN1001BOX
NativePAGE 4–16% Bis-Tris Protein Gels, 1.0 mm, 10-well	10 gels	BN1002BOX
NativePAGE 3–12% Bis-Tris Protein Gels, 1.0 mm, 15-well	10 gels	BN1003BOX
NativePAGE 4–16% Bis-Tris Protein Gels, 1.0 mm, 15-well	10 gels	BN1004BOX
Novex Tricine gels		
Novex 10% Tricine Protein Gels, 1.0 mm, 10-well	10 gels	EC6675BOX
Novex 10% Tricine Protein Gels, 1.0 mm, 12-well	10 gels	EC66752BOX
Novex 16% Tricine Protein Gels, 1.0 mm, 10-well	10 gels	EC6695BOX
Novex 16% Tricine Protein Gels, 1.0 mm, 12-well	10 gels	EC66952BOX
Novex 16% Tricine Protein Gels, 1.0 mm, 15-well	10 gels	EC66955BOX
Novex 10–20% Tricine Protein Gels, 1.0 mm, 10-well	10 gels	EC6625BOX
Novex 10–20% Tricine Protein Gels, 1.0 mm, 12-well	10 gels	EC66252BOX
Novex 10–20% Tricine Protein Gels, 1.0 mm, 15-well	10 gels	EC66255BOX
Novex IEF gels		
Novex pH 3–7 IEF Protein Gels, 1.0 mm, 12-well	5 gels	EC66452BOX
Novex pH 3–7 IEF Protein Gels, 1.0 mm, 10-well	5 gels	EC6645BOX
Novex pH 3–10 IEF Protein Gels, 1.0 mm, 10-well	5 gels	EC6655BOX

Product	Quantity	Cat. No.
Novex Tris-Glycine Plus midi gels (8 x 13 cm), WedgeWell format		
Novex 10% Tris-Glycine Plus Midi Protein Gels, 12+2-well, WedgeWell format	10 gels	WTG01012BOX
Novex 10% Tris-Glycine Plus Midi Protein Gels, 20-well, WedgeWell format	10 gels	WTG01020BOX
Novex 10% Tris-Glycine Plus Midi Protein Gels, 26-well, WedgeWell format	10 gels	WTG01062BOX
Novex 12% Tris-Glycine Plus Midi Protein Gels, 12+2-well, WedgeWell format	10 gels	WTG01212BOX
Novex 12% Tris-Glycine Plus Midi Protein Gels, 20-well, WedgeWell format	10 gels	WTG01220BOX
Novex 12% Tris-Glycine Plus Midi Protein Gels, 26-well, WedgeWell format	10 gels	WTG01226BOX
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 12+2-well, WedgeWell format	10 gels	WTG41212BOX
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 20-well, WedgeWell format	10 gels	WTG41220BOX
Novex 4–12% Tris-Glycine Plus Midi Protein Gels, 26-well, WedgeWell format	10 gels	WTG41226BOX
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 12+2-well, WedgeWell format	10 gels	WTG42012BOX
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 20-well, WedgeWell format	10 gels	WTG42020BOX
Novex 4–20% Tris-Glycine Plus Midi Protein Gels, 26-well, WedgeWell format	10 gels	WTG42026BOX

Product	Quantity	Cat. No.
Novex Zymogram Plus gels		
Novex 10% Zymogram Plus (Gelatin) Protein Gels, 1.0 mm, 15-well	10 gels	ZY00105BOX
Novex 10% Zymogram Plus (Gelatin) Protein Gels, 1.0 mm, 12-well	10 gels	ZY00102BOX
Novex 10% Zymogram Plus (Gelatin) Protein Gels, 1.0 mm, 10-well	10 gels	ZY00100BOX
E-PAGE High-Throughput Gel System		
E-PAGE 8% Protein Gels, 48-well	8 gels	EP04808
E-Holder Platform	2 units	EH03
E-PAGE Loading Buffer 1	4.5 mL	EPBUF01
E-PAGE 6% Protein Gels, 96-well	8 gels	EP09606
E-Gel Power Snap Electrophoresis System	1 unit	G8300
Handcast polyacrylamide gels		
SureCast Gel Handcast Bundle A	Multiple	HC1000SR
SureCast Gel Handcast Bundle B	Multiple	HC1000S
SureCast Gel Handcast Station	1 casting station	HC1000
SureCast Glass Plates	2 sets	HC1001
SureCast Sealing Pads	2 pads	HC1002
SureCast Multi-Use Tool, 10-well	1 unit	HC1010
SureCast Multi-Use Tool, 12-well	1 unit	HC1012
SureCast Multi-Use Tool, 15-well	1 unit	HC1015
SureCast Gel Spacers	10 spacers	HC1003
SureCast Stacking Buffer	2 x 500 mL dry packs	HC2112
SureCast Stacking Buffer	5 x 500 mL dry packs	HC2115
SureCast Resolving Buffer	2 x 500 mL dry packs	HC2212
SureCast Resolving Buffer	5 x 500 mL dry packs	HC2215
SureCast APS	25 g	HC2005
SureCast Acrylamide Solution, 40%	450 mL	HC2040
SureCast TEMED	30 mL	HC2006

Product	Quantity	Cat. No.
SDS-PAGE buffers		
Pierce SDS-PAGE Sample Prep Kit	50 reactions	89888
Bolt Transfer Buffer (20X)	125 mL	BT0006
Bolt Transfer Buffer (20X)	1 L	BT00061
4X Bolt LDS Sample Buffer	10 mL	B0007
20X Bolt MES SDS Running Buffer	500 mL	B0002
20X Bolt MES SDS Running Buffer	5 L	B0002-02
20X Bolt MOPS SDS Running Buffer	500 mL	B0001
20X Bolt MOPS SDS Running Buffer	5 L	B0001-02
Bolt Antioxidant	15 mL	BT0005
NuPAGE Tris-Acetate SDS Running Buffer (20X)	500 mL	LA0041
NuPAGE MOPS SDS Running Buffer (20X)	500 mL	NP0001
NuPAGE MOPS SDS Running Buffer (20X)	5 L	NP000102
NuPAGE MOPS SDS Running Buffer (Powder)	5 packets	NP000205
NuPAGE MES SDS Running Buffer (20X)	5 L	NP000202
NuPAGE MES SDS Running Buffer (20X)	500 mL	NP0002
NuPAGE MES SDS Running Buffer (Powder)	5 packets	NP000105
Novex Tris-Glycine SDS Running Buffer (10X)	4 x 1 L	LC26754
Novex Tris-Glycine SDS Running Buffer (10X)	500 mL	LC2675
Novex Tris-Glycine SDS Running Buffer (10X)	5 L	LC26755
Novex Rapid Tris-Glycine SDS Running Buffer (Powder)	5 packets	LC2678
Novex Tricine SDS Running Buffer (10X)	500 mL	LC1675
NuPAGE LDS Sample Buffer (4X)	10 mL	NP0007
Novex Tricine SDS Sample Buffer (2X)	20 mL	LC1676
Novex Tris-Glycine SDS Sample Buffer (2X)	20 mL	LC2676
Novex Tris-Glycine Transfer Buffer (25X)	500 mL	LC3675
NuPAGE Transfer Buffer (20X)	125 mL	NP0006
NuPAGE Transfer Buffer (20X)	1 L	NP00061
NuPAGE Antioxidant	15 mL	NP0005
Novex Tris-Glycine SDS Buffer Kit	1 kit	LC2677
NuPAGE MOPS SDS Buffer Kit (for Bis-Tris Gels)	1 kit	NP0050
NuPAGE MES SDS Buffer Kit (for Bis-Tris Gels)	1 kit	NP0060
NuPAGE Tris-Acetate SDS Buffer Kit (for Tris-Acetate Gels), contains 1 each LA0041, NP0004, NP0005, and NP0007	1 kit	LA0050
Novex Tricine SDS Buffer Kit, includes LC1676 and LC1675	1 kit	LC1677
Pierce LDS Sample Buffer, Nonreducing (4X)	5 mL	84788
Pierce Lane Marker Nonreducing Sample Buffer	5 mL	39001
Pierce 10X Tris-Glycine SDS Buffer	1 L	28362
BupH Tris-Glycine Buffer Packs	40 packs	28380

Product	Quantity	Cat. No.
Native electrophoresis buffers		
Novex Tris-Glycine Native Running Buffer (10X)	500 mL	LC2672
Novex Tris-Glycine Native Sample Buffer (2X)	20 mL	LC2673
NativePAGE Running Buffer (20X)	1 L	BN2001
NativePAGE Running Buffer Kit	1 kit	BN2007
NativePAGE Cathode Buffer Additive (20X)	250 mL	BN2002
NativePAGE Sample Buffer (4X)	10 mL	BN2003
NativePAGE 5% G-250 Sample Additive	0.5 mL	BN2004
NativePAGE Sample Prep Kit	1 kit	BN2008
DDM (n-dodecyl β -D-maltoside) (10%)	1 mL	BN2005
Digitonin (5%)	1 mL	BN2006
Zymography buffers		
Novex Zymogram Developing Buffer (10X)	500 mL	LC2671
Novex Zymogram Renaturing Buffer (10X)	500 mL	LC2670
IEF buffers		
Novex IEF Anode Buffer (50X)	100 mL	LC5300
Novex IEF Cathode Buffer pH 3–10 (10X)	125 mL	LC5310
Novex IEF Cathode Buffer pH 3–7 (10X)	125 mL	LC5370
Novex pH 3–10 IEF Buffer Kit, includes LC5300, LC5310, LC5311	1 kit	LC5317
Novex pH 3–7 IEF Buffer Kit, includes LC5300, LC5370, LC5371	1 kit	LC5377
Novex IEF Sample Buffer pH 3–10 (2X)	25 mL	LC5311
Novex IEF Sample Buffer pH 3–7 (2X)	25 mL	LC5371

Product	Quantity	Cat. No.
Unstained standards		
HiMark Unstained Protein Standard	250 µL	LC5688
PageRuler Unstained Low Range Protein Ladder	2 x 250 µL	26632
PageRuler Unstained High Range Protein Ladder	2 x 250 µL	26637
PageRuler Unstained Protein Ladder	2 x 250 µL	26614
NativeMark Unstained Protein Standard	5 x 50 µL	LC0725
Prestained standards		
PageRuler Prestained Protein Ladder, 10–180 kDa	2 x 250 µL	26616
PageRuler Prestained Protein Ladder, 10–180 kDa	10 x 250 µL	26617
PageRuler Plus Prestained Protein Ladder, 10–250 kDa	2 x 250 µL	26619
PageRuler Plus Prestained Protein Ladder, 10–250 kDa	10 x 250 µL	26620
Spectra Multicolor Broad Range Protein Ladder	2 x 250 µL	26634
Spectra Multicolor Broad Range Protein Ladder	10 x 250 µL	26623
HiMark Prestained Protein Standard	250 µL	LC5699
Spectra Multicolor Low Range Protein Ladder	250 µL	26628
Spectra Multicolor High Range Protein Ladder	2 x 250 µL	26625
SeeBlue Prestained Protein Standard	500 µL	LC5625
SeeBlue Plus2 Prestained Protein Standard	500 µL	LC5925
Western standards		
iBright Prestained Protein Ladder	2 x 250 mL	LC5615
PageRuler Prestained NIR Protein Ladder	2 x 250 µL	26635
MagicMark XP Western Protein Standard	250 µL	LC5602
MagicMark XP Western Protein Standard	50 µL	LC5603
Specialty standards		
BenchMark Fluorescent Protein Standard	125 µL	LC5928
BenchMark His-Tagged Protein Standard	125 µL	LC5606
IEF Marker 3–10	500 µL	3921201
CandyCane Glycoprotein Molecular Weight Standards	400 µL	C21852
PeppermintStick Phosphoprotein Molecular Weight Standards	400 µL	P33350

Product	Quantity	Cat. No.
Electrophoresis chamber systems and power supplies		
Mini Gel Tank	1 unit	A25977
XCell SureLock Mini-Cell	1 unit	EI0001
SureLock Tandem Midi Gel Tank	1 each	STM1001
XCell4 SureLock Midi-Cell	1 each	WR0100
PowerEase Touch 350W Power Supply (115 VAC)	1 each	PS0350
PowerEase Touch 350W Power Supply (230 VAC)	1 each	PS0351
PowerEase Touch 120W Power Supply (115 VAC)	1 each	PS0120
PowerEase Touch 120W Power Supply (230 VAC)	1 each	PS0121

Product	Quantity	Cat. No.
Coomassie stains		
PageBlue Protein Staining Solution	1 L	24620
SimplyBlue SafeStain	1 L	LC6060
SimplyBlue SafeStain	3.5 L	LC6065
Imperial Protein Stain	1 L	24615
Imperial Protein Stain	3 x 1 L	24617
Silver stains		
Pierce Silver Stain Kit	1 L	24612
SilverXpress Silver Staining Kit	1 kit	LC6100
Pierce Silver Stain for Mass Spectrometry	1 L	24600
Fluorescent and specialty stains		
SYPRO Orange Protein Gel Stain	500 µL	S6650
SYPRO Orange Protein Gel Stain	10 x 50 µL	S6651
SYPRO Red Protein Gel Stain	500 µL	S6653
SYPRO Red Protein Gel Stain	10 x 50 µL	S6654
SYPRO Ruby Protein Gel Stain	1 L	S12000
SYPRO Ruby Protein Gel Stain	200 mL	S12001
SYPRO Ruby Protein Gel Stain	5 L	S21900
Pro-Q Emerald 488 Glycoprotein Gel and Blot Stain	1 kit	P21875
Pro-Q Diamond Phosphoprotein Gel Stain	1 L	P33300
Pro-Q Diamond Phosphoprotein Gel Stain	200 mL	P33301
Pro-Q Diamond Phosphoprotein Gel Stain	5 L	P33302
No-Stain Protein Labeling Reagent	10 reactions	A44717
No-Stain Protein Labeling Reagent	40 reactions	A44449

References

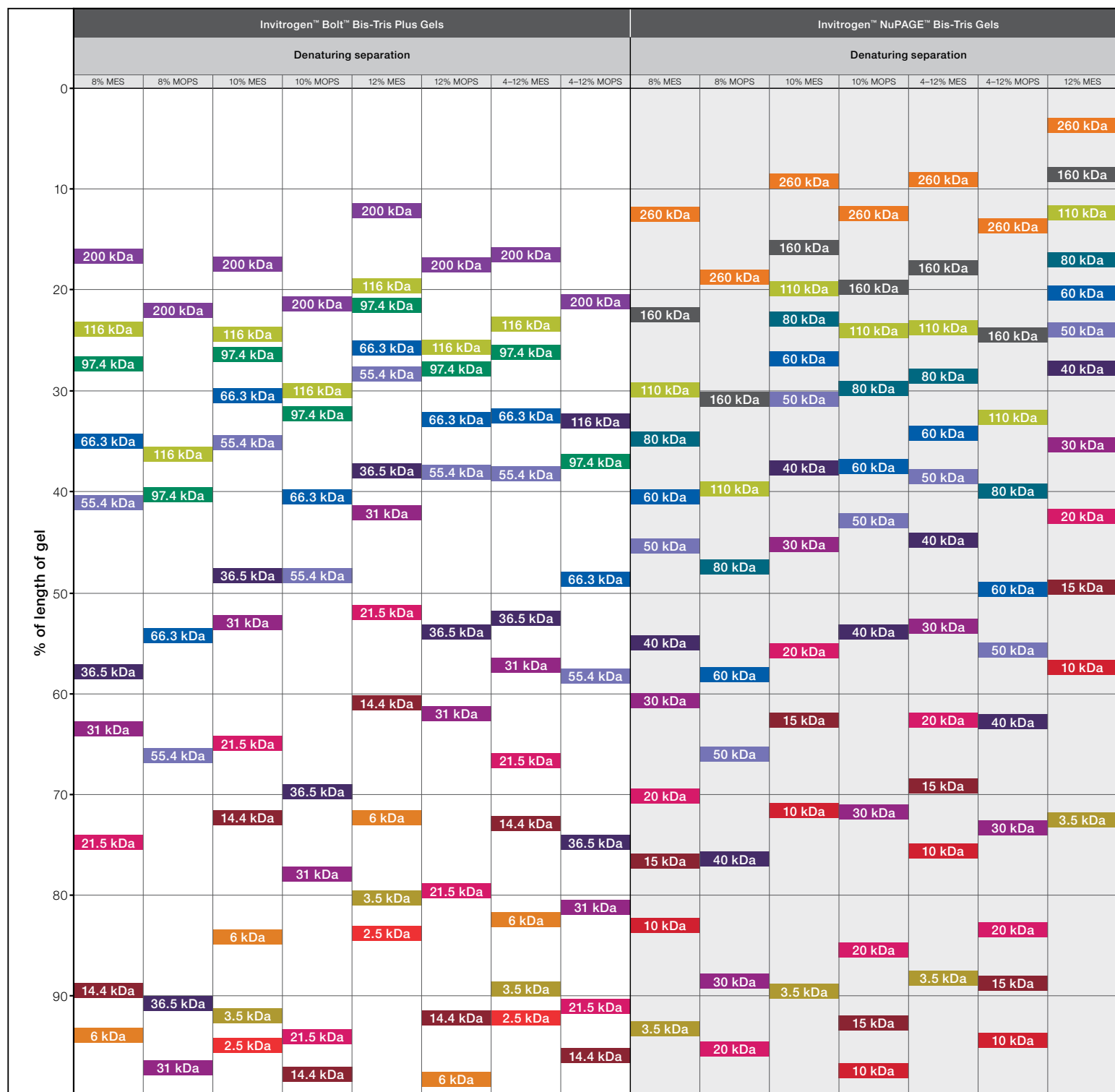
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Notes

[illegible]

Protein mini gel migration chart

Use this chart to compare migration patterns of proteins of various molecular weights across the Invitrogen™ precast gel product line.



	Invitrogen™ Novex™ Tris-Glycine Gels, WedgeWell™ format					Invitrogen™ NuPAGE™ Tris-Acetate Gels		Invitrogen™ Novex™ Tricine Gels			NuPAGE™ Tris-Acetate Gels		Invitrogen™ NativePAGE™ Gels	
	Denaturing separation					Denaturing separation		Blotting and sequencing	Synthetic peptides and tryptic analysis	Wide range	Native separation		Native separation	
12% MOPS	10%	12%	4–12%	8–16%	4–20%	3–8%	7%	10%	16%	10–20%	3–8%	7%	3–12%	4–16%
260 kDa														
														1,048 kDa
160 kDa							500 kDa		200 kDa			1,048 kDa		
							290 kDa		116 kDa					
110 kDa						500 kDa	240 kDa	200 kDa	97 kDa		1,048 kDa		1,236 kDa	
80 kDa		200 kDa							66 kDa					
	200 kDa								55 kDa	200 kDa			1,048 kDa	720 kDa
60 kDa					200 kDa		160 kDa	116 kDa						
				200 kDa		290 kDa		97 kDa	36 kDa	116 kDa		720 kDa		
50 kDa		116 kDa				240 kDa			31 kDa	66 kDa				480 kDa
	116 kDa	97 kDa			116 kDa		116 kDa	66 kDa		66 kDa				
40 kDa	97 kDa		200 kDa		97 kDa		97 kDa		21 kDa	55 kDa			720 kDa	
		66 kDa		116 kDa	66 kDa	160 kDa			14 kDa			480 kDa		
	66 kDa	55 kDa		97 kDa							720 kDa			242 kDa
30 kDa					55 kDa		66 kDa			36 kDa			480 kDa	
	55 kDa		116 kDa	66 kDa		116 kDa				31 kDa				146 kDa
			97 kDa	55 kDa	36 kDa	97 kDa		36 kDa	6 kDa	21 kDa				
		36 kDa					55 kDa							
20 kDa			66 kDa		31 kDa	66 kDa			3.5 kDa				242 kDa	66 kDa
											480 kDa			
		31 kDa	55 kDa	36 kDa				21 kDa	2.5 kDa					
15 kDa	36 kDa			31 kDa	21 kDa	55 kDa	40 kDa			6 kDa		242 kDa	146 kDa	
								14 kDa						
10 kDa			36 kDa	21 kDa	14 kDa	40 kDa				3.5 kDa			66 kDa	
	31 kDa	21 kDa			6 kDa					2.5 kDa				
			31 kDa	14 kDa							242 kDa			20 kDa
		14 kDa	21 kDa					6 kDa				146 kDa		

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