

For further information refer to our website
www.miltenyibiotec.com

For technical questions, please contact your local
subsidiary or distributor.

Technical Support Team, Germany:
E-mail: macstec@miltenyibiotec.de
Phone: +49 2204 8306-830



Miltenyi Biotec GmbH
Friedrich-Ebert-Straße 68
51429 Bergisch Gladbach
Germany
Phone +49 2204 8306-0
Fax +49 2204 85197
macs@miltenyibiotec.de

Miltenyi Biotec Inc.
2303 Lindbergh Street
Auburn CA 95602
USA
Phone 800 FOR MACS, +1 530 888 8871
Fax +1 530 888 8925
macs@miltenyibiotec.com

140-000-956.06



μMACS™ Epitope Tag Protein Isolation Kits

μMACS™ HA Isolation Kit	130-091-122
μMACS c-myc Isolation Kit	130-091-123
μMACS His Isolation Kit	130-091-124
μMACS GFP Isolation Kit	130-091-125
μMACS GST Isolation Kit	130-091-370
μMACS DYKDDDDK Isolation Kit	130-101-591

Unless otherwise specifically indicated,
Miltenyi Biotec products and services are for research use only
and not for diagnostic or therapeutic use.

The cover photo shows a replica of the DNA model built in 1953 by James D. Watson and Francis Crick at the Cavendish Laboratory in Cambridge. This model is located at Heureka, the Finnish Science Centre. Photography by Alexander Budde; © Miltenyi Biotec GmbH, Germany. Detailed information on the history of the Watson-Crick model can be found in: de Chadarevian, S. (2003) Relics, replicas and commemorations. Endeavour 27: 75–79.

Contents

1. Description
 - 1.1 Components
 - 1.2 An introduction to epitope tags
 - 1.3 MACS® Technology for epitope-tagged protein isolation
 - 1.4 Background information
 - 1.5 Product applications
 - 1.6 Reagent and instrument requirements
2. Protocol
 - 2.1 Before starting
 - 2.2 Supplied buffers
 - 2.3 Lysis of cells
 - 2.4 Magnetic labeling and separation
3. Tips for special applications
 - 3.1 Lysis buffers for different protein sources
 - 3.2 Native protein elution
 - 3.3 Enzymatic reactions on the column
 - 3.4 Tips & hints
4. Troubleshooting
5. Appendix
 - 5.1 Protease inhibitors
 - 5.2 Preparation of nuclear extracts from cells
6. References

1. Description

1.1 Components

Components	2x50 mL Lysis Buffer 50 mL Wash Buffer 1 5 mL Wash Buffer 2 5 mL Elution Buffer 2 mL of one of the following μMACS™ Anti-Tag MicroBeads: Anti-HA MicroBeads 130-091-122 Anti-c-myc MicroBeads 130-091-123 Anti-His MicroBeads 130-091-124 Anti-GFP MicroBeads 130-091-125 Anti-GST MicroBeads 130-091-370 Anti-DYKDDDDK MicroBeads* 130-101-591 <small>*DYKDDDDK is also known as FLAG* tag</small>
Capacity	For 40 reactions, each for the isolation of up to 20 pmol protein (e.g. equivalent to 0.5–1 μg of a 50 kDa protein)
Product format	All Anti-Tag MicroBeads are supplied in a solution containing 0.05% sodium azide. For buffer compositions refer to section 2.2.
Storage	Store all components protected from light at 2–8 °C. Do not freeze. The expiration date is indicated on the vial label.

1.2 An introduction to epitope tags

An epitope (also called an antigenic determinant) is any structure or sequence that is recognized by the adaptive part of the immune system, for example an antibody. When such an epitope is introduced into a protein, this protein is described as being “epitope-tagged” and can be detected by an epitope specific antibody.^{1,2}

It is important that the addition of a tag sequence does not affect the function, intracellular transport, modification or location of the target protein. The use of epitope tags of only 6–20 amino acids, combined with introducing the epitope at the amino- or carboxyl-terminus of the protein, normally allows successful tagging of most proteins without loss of function.

Tags are normally added to a protein of interest by cloning the gene into commercially available expression vectors that contain one or more tag sequences. These vectors can then be introduced into a cell and the expression, localisation, and function of the tagged protein can be studied.

The expression of epitope-tagged proteins offers several advantages in comparison to conventional expression methods. The most important is that proteins of interest can be studied without having to carry out the difficult and time-consuming task of producing and characterizing a protein specific antibody: well characterized and highly specific monoclonal antibodies against the expressed tag, such as those coupled to the Anti-Tag MicroBeads, are available.

Epitope tagging of proteins is especially useful when no protein specific monoclonal antibodies can be made; e.g., for the study of highly conserved

proteins, isoforms of a gene family, splice variants, or post-translational modifications of a protein. In addition, because the interactions between the epitope tag and the monoclonal antibodies are specific and are of high affinity, it makes it much easier to optimize conditions for the isolation of the tagged protein, its interaction partners or of whole complexes. In this way the expression, screening, and characterization of new gene sequences can be greatly simplified.

1.3 MACS® Technology for tagged proteins

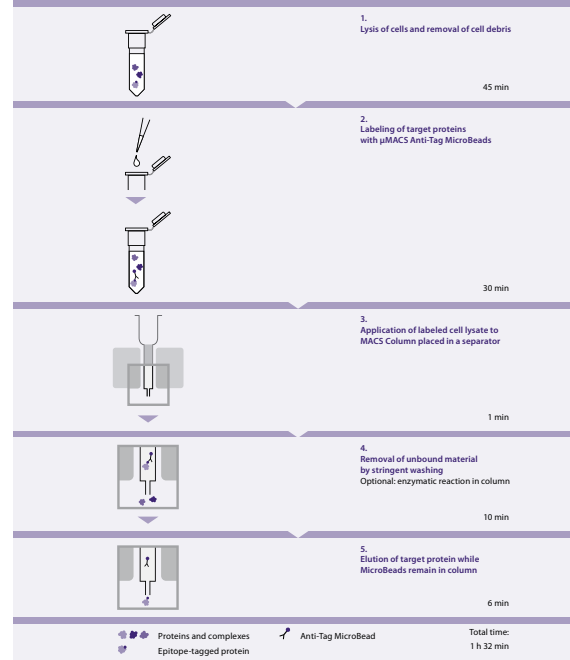
All μMACS Anti-Tag MicroBeads have been developed for the magnetic labeling and direct isolation of tagged proteins from different protein sources. The μMACS MicroBeads contained in this kit are a colloidal suspension of extremely small (50 nm in diameter) super-paramagnetic MicroBeads. They are conjugated to epitope tag specific antibodies, allowing fast and effective binding to target molecules.

The MicroBeads bind specifically to the epitope of the target protein. The magnetically-labeled proteins are retained on a μ Column placed in the magnetic field of a μMACS Separator. Stringent washing steps can easily be applied to remove non-specific interacting molecules. The target molecules can then be eluted with high purity by using the supplied Elution Buffer; the eluate is then ready for direct SDS-PAGE analysis.

For downstream assays that require a functional, native protein, it is also possible to leave the target protein bound within the column. A solid phase enzymatic assay can then be carried out during which the MACS® Column Technology permits efficient substrate/enzyme exchange and wash steps.

For an overview and a general working scheme refer to following figure.

Protein isolation with μMACS™ Technology



1.3 Products and background

- **μMACS Anti-c-myc MicroBeads**
Target sequence: EQKLISEEDL⁴
Tag origin: Human *c-myc* protooncogene
- **μMACS Anti-HA MicroBeads**
Target sequence: YPYDVPDYA^{5,6}
Tag origin: Influenza virus hemagglutinin
- **μMACS Anti-His MicroBeads**
Target sequence: HHHHHH⁷
Tag origin: synthetic
- **μMACS Anti-GFP MicroBeads**
Target sequence: whole green fluorescent protein (238-residue polypeptide)⁸
Tag origin: *Aequorea victoria* jellyfish
- **μMACS Anti-GST MicroBeads**
Target sequence: whole glutathione-S-transferase (220-residue polypeptide)⁹
Tag origin: *Schistosoma japonicum*
- **μMACS Anti-DYKDDDDK MicroBeads**
Target sequence: DYKDDDDK (FLAG[®] tag)¹⁰
Tag origin: synthetic

GST and GFP, although full-length proteins, are often used as a protein tag. GFP has the additional property of inherent fluorescence when

excited by 400 nm wavelength light. GFP-fusion proteins can therefore be located and studied within living cells by fluorescent microscopy.

For a current overview of all available μMACS Epitope Tag Protein Isolation Kits refer to www.miltenyibiotec.com.

1.5 Product applications

- μMACS Anti-Tag MicroBeads have been developed for the direct analytical immunoprecipitation of proteins from cell lysates. The immunoprecipitated proteins can be analyzed by SDS polyacrylamide gel electrophoresis (SDS-PAGE) or in consecutive enzymatic reactions performed on the column. For this application the thermoMACS™ Separator, a heatable magnet, can be used.
- μMACS Anti-Tag MicroBeads can be used for analytical co-immunoprecipitations and subsequent SDS-PAGE analysis or enzymatic reactions performed on the column.

1.6 Reagent and instrument requirements

- Protease inhibitors (refer to 5. Appendix)
- μ Columns (# 130-042-701)
- μMACS Separator (# 130-042-602)
- MultiStand (# 130-042-303)
- Heated block (95 °C)
- (Optional, for enzymatic reactions on the column) thermoMACS Separator (# 130-091-136)

2. General protocol

2.1 Before starting

▲ To prevent protein degradation, it is best to perform the lysis on ice. Proteinase inhibitors should be added to the lysis buffer. For details, refer to a list with appropriate protease inhibitors and effective concentrations in the section 5. Appendix, A.

▲ The lysis is the most crucial step during an immunoprecipitation. The supplied lysis buffer works for a wide range of protein sources. For special applications the supplied Lysis Buffer can be replaced by a lysis buffer, which is adapted to your special needs. The lysis buffer must not impair the antigen-antibody binding. Therefore, the lysis buffer conditions must be carefully chosen. Factors such as ionic strength, the pH, the concentration and type of detergent, the presence of divalent cations, co-factors, and stabilizing ligands all influence the effectiveness of a lysis buffer. Generally, the lysis buffer should not contain SDS as it may disrupt the cell nuclei (refer also to section 3.4).

▲ The lysis of entire cells results only in the partial release of nuclear proteins. In order to obtain all nuclear proteins, we recommend lysing purified nuclei. For a protocol for nuclear extract preparation, refer to section 5. Appendix, B.

▲ For lysis of yeast cells or bacteria we refer to any of the common protocols found in the literature.¹

▲ In initial experiments the same buffer that was used for the lysis of the cells should be used for column washes. In order to reduce the background of unspecifically bound proteins, a more stringent wash

buffer can be chosen for subsequent experiments, e.g. Wash Buffer 1. Co-immunoprecipitates are much more sensitive to stringent wash buffers, therefore we recommend to use only Lysis Buffer for all column washes.

▲ For subsequent enzymatic reaction on the μ Column: use suitable buffers and solutions for the enzymatic reaction which is to be performed.

2.2 Supplied buffers

- **Lysis Buffer:**
150 mM NaCl, 1% Triton® X-100, 50 mM Tris HCl (pH 8.0)
- **Wash Buffer 1:**
150 mM NaCl, 1% Igepal CA-630 (formerly NP-40), 0.5% sodium deoxycholate, 0.1% SDS, 50 mM Tris HCl (pH 8.0)
- **Wash Buffer 2:**
20 mM Tris HCl (pH 7.5)
- **Elution Buffer for SDS-PAGE:**
50 mM Tris HCl (pH 6.8), 50 mM DTT, 1% SDS, 1 mM EDTA, 0.005% bromphenol blue, 10% glycerol

2.3 Lysis of cells

▲ Pre-cool appropriate lysis buffer and centrifuge to 4 °C. Prepare ice bucket.

Lysis of adherent cells

1. Remove medium from culture dish.

- Add 1 mL pre-cooled (4 °C) Lysis Buffer to a 9 cm culture dish containing 1–10×10⁶ cells. Scrape the lysate from the culture dish using a cell scraper and transfer to a 1.5 mL tube. Mix well and incubate for 30 minutes on ice with occasional mixing.
- Centrifuge for 10 minutes at 10,000×g at 4 °C to sediment the cell debris.
- Transfer the supernatant to a fresh 1.5 mL tube and proceed to 2.4 (magnetic labeling and separation).
- (Optional) The lysate can also be stored at this step at –20 °C or –70 °C. Thawing should be done on ice.

Lysis of suspension cells

- Transfer the cells of one 9 cm culture dish containing 1–10×10⁶ cells to a centrifugation tube and centrifuge for 5 minutes at 300×g at 4 °C.
- Remove supernatant and place the tube containing the cell pellet on ice. Add 1 mL of pre-cooled (4 °C) Lysis Buffer and mix well.
- Incubate on ice for 30 minutes with occasional mixing.
- Centrifuge for 10 minutes at 10,000×g at 4 °C to sediment the cell debris.
- Transfer the supernatant to a fresh 1.5 mL tube and proceed to section 2.4, Magnetic labeling and separation.
- (Optional) The lysate can also be stored at this step at –20 °C or at –70 °C. Thawing should be done on ice

2.4 Magnetic labeling and separation for subsequent analysis by SDS-PAGE

▲ Pre-heat a heated block to 95 °C.

- Add 50 µL Anti-Tag MicroBeads of choice to the lysate to magnetically label the epitope-tagged target protein. Mix well.
- Incubate for 30 minutes on ice.
- Place µ Column in the magnetic field of the µMACS Separator. Prepare the µ Column by applying 200 µL Lysis Buffer on the column.
- Pipette Elution Buffer (80 µL for each separation) into a fresh tube and place it in the pre-heated 95 °C block.
- After the labeling incubation has finished apply the cell lysate onto the column and let the lysate run through. Columns are “flow stop” and do not run dry.
- Rinse column with 4×200 µL of Wash Buffer 1 or any other suitable buffer (refer to section 2.1).
- Rinse column with 1×100 µL Wash Buffer 2.
 - ▲ **Note:** It is important that high concentrations of residual salt and detergent are removed from the immune complex prior to elution as both may interfere with a subsequent SDS-PAGE analysis.
- Apply 20 µL of pre-heated 95 °C hot Elution Buffer to the column and incubate for 5 minutes at room temperature.
- Apply 50 µL of pre-heated 95 °C hot Elution Buffer to the column and collect eluate as the immunoprecipitate which can now be analyzed by SDS-PAGE.

3. Tips for special applications

3.1 Lysis buffers for different protein sources

- Bacterial cell lysis : the supplied Lysis Buffer can be used to prepare a bacterial cell lysate by sonication.
- Yeast cell lysis : the supplied Lysis Buffer can be used to prepare a yeast cell lysate using glass bead disruption of the cell wall.
- In case of co-immunoprecipitations with very weak protein-protein interactions we recommend using a low salt lysis buffer: 1% Igepal CA-630 (formerly NP-40), 50 mM Tris HCl (pH 8.0).
- If strong background ionic interactions are expected, we recommend using a high salt lysis buffer : 500 mM NaCl, 1% Igepal CA-630 (formerly NP-40), 50 mM Tris HCl (pH 8.0); refer also to section 3.4.

3.2 Native protein elution

After the wash with Wash Buffer 2 (section 2.4, step 7), a non-denaturing elution of the column bound antigen is also possible: either by using a pH shift or by eluting the antigen – Anti-Tag MicroBead – complex.

Elution by pH shift using triethylamine, pH 11.8

Proceed after 2.4, step 7:

Rinse column with 1×100 µL Wash Buffer 2

- Apply 20 µL of 0.1 M triethylamine, pH 11.8, 0.1% Triton X-100 to the column and incubate for 5 minutes at room temperature.

- Apply 50 µL of 0.1 M triethylamine, pH 11.8, 0.1% Triton X-100 and collect eluate in a tube containing 3 µL of 1 M MES, pH 3 for neutralisation.
- Repeat last step twice, collecting the eluates in separate fractions and analyse the eluates by SDS-PAGE and/or Western Blot or use in downstream assays.

Elution of antigen-Anti-Tag MicroBead-complex

Proceed after 2.4, step 7:

Rinse column with 1×100 µL Wash Buffer 2

- Remove the µ Column from the µMACS Separator.
- Apply 50 µL of a suitable buffer to the µ Column and collect the brown eluate.
- Repeat last step once. The eluates can now be used in downstream assays.

3.3 Enzymatic reactions on the column

Enzymatic reactions with the immunoprecipitated epitope-tagged protein complex can be carried out while the protein remains bound to the µ Column. Performing the reaction on the µ Column offers the advantage of very convenient handling, especially when working with radioactively labeled proteins or substrates. It also allows a serial enzymatic reaction to be performed on the same µ Column.

A few guidelines are listed below on how to perform the enzymatic reaction on the µ Column, however, every enzymatic reaction must be performed with different optimised conditions.

▲ The lysis of the cells and the magnetic labeling should be performed as described in 2.3, Lysis of cells and 2.4, Magnetic labeling and separation for subsequent analysis by SDS-PAGE. However, neither lysis nor wash buffer should contain SDS since it may impair the biological activity of the immunoprecipitated complex. The magnetic separation conditions, e.g., type of wash buffer and number of wash steps, should be chosen so that non-specific proteins are efficiently removed. Prior to the enzymatic reaction, the μ Column should be rinsed with $1 \times 100 \mu\text{L}$ of reaction buffer used for the enzymatic reaction.

▲ The void volume of the μ Column is $25 \mu\text{L}$. Thus, buffers and solutions used for incubation with the immobilized immunoprecipitate should always be applied in $25 \mu\text{L}$ aliquots. If it is necessary to incubate immobilized immunoprecipitate with a volume $>25 \mu\text{L}$, sequentially incubate in steps of $25 \mu\text{L}$ aliquots until the total volume has been applied.

▲ For incubation at 37°C and 42°C the thermoMACS should be used. For different incubation temperatures the column and μMACS Separator should be placed in an incubator set at the appropriate temperature.

▲ After the enzymatic reaction has been performed, the immunoprecipitated protein (complexes) can be eluted for SDS-PAGE analysis. Therefore, remove residual salt by rinsing the μ Column with $2 \times 100 \mu\text{L}$ Wash Buffer 2. Then, apply $20 \mu\text{L}$ hot (95°C) Elution Buffer to the column and incubate for 5 minutes at room temperature. Apply $50 \mu\text{L}$ hot (95°C) Elution Buffer and collect eluate as the immunoprecipitated target protein. The target protein (complexes) can now be analyzed by SDS-PAGE.

3.4 Tips & hints

The function of different buffer components:

Detergents – these are partially hydrophobic and partially hydrophilic and can solubilize membranes and membrane proteins. They work to increase protein solubility and decrease aggregation. Non-ionic detergents tend to be more gentle in their actions than ionic detergents and are more suitable for protein-protein interaction studies.

Salts – increasing the salt concentration in the buffer will decrease ionic interactions between proteins in a cell lysate.

▲ Note: To create a high salt lysis buffer, add 0.2 g NaCl per 10 mL Lysis Buffer.

▲ Note: To create a high salt wash buffer, add 0.2 g NaCl per 10 mL Wash Buffer.

pH – increasing or decreasing the pH of the buffer will change the net charge of the proteins depending on their pI and therefore influence the extent of non-specific ionic interactions.

DTT – this reducing agent is often used to prevent loss of enzyme function via oxidation during protein isolation.

EDTA – this chelation agent binds divalent cations and can be used to prevent the action of certain enzymes that require ions such as Mg^{2+} or Ca^{2+} . It can also prevent protein-protein interactions that are dependent on the presence of cations. The Anti-Tag MicroBead Storage Buffer contains 5 mM EDTA.

4. Troubleshooting

Phosphatase inhibitors – when active kinases or phosphorylated proteins are to be isolated, we recommend the addition of 1 mM activated sodium orthovanadate (not compatible with DTT) and 1–10 mM NaF to inhibit phosphatase activity.

We recommend using a fresh tip every time that hot Elution Buffer is pipetted to ensure reproducible elution volumes are obtained.

4. Troubleshooting

Slow column – if the column begins to run slowly it could be due either to cell debris present in the lysate occluding the column or to air bubble formation within the column. Cell debris should be efficiently removed by high-speed centrifugation ($>10,000 \text{ g}$) before addition of the Anti-Tag MicroBeads. To prevent air bubble formation, use room-temperature buffers for the wash steps or (where possible) degas the buffers before use.

No protein recovery – can be caused by insufficient lysis. The lysis buffer should be altered to optimise the recovery of the tagged target protein (refer to 2.1 and 3.4). Too stringent lysis or wash buffers may also impair the binding of antibody to the epitope tag, in this case a lower salt concentration may help.

Protein background – if many background protein bands are present following SDS-PAGE analysis of the eluates, a more stringent lysis and/or wash buffer (with higher salt concentrations) should be used (refer to 3.4).

5. Appendix

Background smear – if a smear is seen following SDS-PAGE analysis of the eluates, suitable protease inhibitors should be added to the lysis and wash buffers (refer to 5. Appendix, A).

5. Appendix

5.1 Protease inhibitors

Inhibitor	Final concentration	Stock solution preparation
α 1-Antitrypsin (S)	10 μM	6 mg/mL (1000 \times) in ddH ₂ O, pH 7
Aprotinin (S)	0.3 μM	1 mg/mL (500 \times) in ddH ₂ O, pH 7
Benzamidin (S)	2 mM	3 mg/mL (10 \times) in ddH ₂ O, pH 7
EDTA-Na ₂ (M)	1 mM	0.5 M (500 \times) in ddH ₂ O, pH 8
E-64 (C)	10 μM	0.36 mg/mL (100 \times) in 1:1 mixture ddH ₂ O, pH 7: EtOH
Leupeptin (S, C)	10 μM	5 mg/mL (1000 \times) in ddH ₂ O, pH 7
PMSF (S)	1 mM	17 mg/mL (100 \times) in Ethanol, Isopropanol or Methanol. Inactivated by DTT

Cocktails recommended, for example, PMSF, Leupeptin, Aprotinin:

- S Serine proteases
- M Metalloproteases
- C Cysteine proteases

5.2 Preparation of nuclear extracts from cells

Nuclear extraction buffers (NE):

- **Buffer NE-1:** 10 mM HEPES-KOH pH 7.9, 2.5 mM MgCl₂, 10 mM KCl, 0.5 mM DTT, Protease inhibitors (e.g. 1 mM PMSE, 10 μM Leupeptin (add protease inhibitors fresh before use)). (Optional) Phosphatase inhibitors (e.g. 10 mM NaF, 1 mM Na₃VO₄).
- **Buffer NE-2:** 20 mM HEPES-KOH pH 7.9, 2.5 mM MgCl₂, 0.42 M NaCl, 25% (v/v) Glycerol, 0.2 mM EDTA, 0.5 mM DTT, Protease inhibitors. (Optional) Phosphatase inhibitors.
- **Buffer NE-3:** 20 mM HEPES-KOH pH 7.9, 2.5 mM MgCl₂, 100 mM KCl, 20% (v/v) Glycerol, 0.2 mM EDTA, 0.5 mM DTT, Protease inhibitors. (Optional) Phosphatase inhibitors.

Preparation of nuclear extracts from activated cells

1. Stimulate approximately 1×10⁸ cells to obtain activated transcription factors.
2. Harvest the cells by centrifugation for 10 minutes at 300×g.
3. Wash the cells in PBS (ice cold) and centrifuge again.
4. Place the cell pellet on ice and carry out all further steps on ice.
5. Estimate the volume of the cell pellet and resuspend in 5 volumes of **Buffer NE-1** by pipetting and incubate for 10 minutes to allow swelling.

6. Centrifuge for 10 minutes at 300×g, 4 °C.
7. Resuspend the cell pellet in 2–3× cell pellet volume of **Buffer NE-1** (ice cold).
8. Lyse the cells by douncing in a glass homogenizer and by shearing with a 23G needle.
9. Spin down the nuclei for 10 minutes at 250×g, 4 °C. Discard the supernatant.
10. Resuspend the pellet in **Buffer NE-2** (ice cold) (1 mL per 0.5–1×10⁸ cells).
 - ▲ **Note:** The addition of 1 M NDSBs (non detergent sulfofetaines, e.g. NDSB-201) to **Buffer NE-2** may enhance the recovery of nuclear proteins.
11. Resuspend the pellet by sonication. The pellet must be **completely** solubilized to achieve lysis of the nuclei!
12. Incubate for 30 minutes on ice, rock gently.
13. Centrifuge for 30 minutes at ≥25,000×g, 4 °C. The supernatant contains the nuclear proteins.
14. Dialyze the supernatant against 50× supernatant volume of **Buffer NE-3** for 5 hours.

6. References

1. Sambrook, J. and Russell, D. W. (2001) *Molecular Cloning : a laboratory manual* 3rd Edition, Cold Spring Harbor Laboratory, New York, USA 17.84–17.90.
2. Yuzuru, S. *et al.* (1991) Epitope tagging. *Meth. Enzymol.* 254: 497–502.
3. Harlow, E. and Lane, D. (1988) "Immunoprecipitation" In *Antibodies: A Laboratory Manual*, Cold Spring Harbor Laboratory, New York, USA.
4. Evan, G. I. *et al.* (1985) Isolation of monoclonal antibodies specific for human c-myc proto-oncogene product. *Mol. Cell Biol.* 5 : 3610–3616
5. Wilson, I. A. *et al.* (1984) The structure of an antigenic determinant in a protein. *Cell.* 37: 767–778.
6. Field, J. *et al.* (1988) Purification of a RAS-responsive adenylyl cyclase complex from *Saccharomyces cerevisiae* by use of an epitope addition method. *Mol. Cell Biol.* 8: 2159–2165.
7. Zentgraf, H. *et al.* (1995) Detection of histidine-tagged fusion proteins by using a high-specific mouse monoclonal anti-histidine tag antibody. *Nucleic Acids Res.* 23: 3347–3348.
8. Cormack, B. P. *et al.* (1996) FACS-optimized mutants of the green fluorescent protein (GFP). *Gene* 173: 33–38.
9. Smith, D. B. and Johnson, K. S. (1988) Single-step purification of polypeptides expressed in *Escherichia coli* as fusions with glutathione-S-transferase. *Gene* 67: 31–40.
10. Hopp, T. P. *et al.* (1988) A short polypeptide marker sequence useful for recombinant protein identification and purification. *Nature Biotechnology* 6:1204–1210.

All protocols and data sheets are available at www.miltenyibiotec.com.

Warnings

Reagents contain sodium azide. Under acidic conditions sodium azide yields hydrazoic acid, which is extremely toxic. Azide compounds should be diluted with running water before discarding. These precautions are recommended to avoid deposits in plumbing where explosive conditions may develop.

Warranty

The products sold hereunder are warranted only to be free from defects in workmanship and material at the time of delivery to the customer. Miltenyi Biotec GmbH makes no warranty or representation, either expressed or implied, with respect to the fitness of a product for a particular purpose. There are no warranties, expressed or implied, which extend beyond the technical specifications of the products. Miltenyi Biotec GmbH's liability is limited to either replacement of the products or refund of the purchase price. Miltenyi Biotec GmbH is not liable for any property damage, personal injury or economic loss caused by the product.

MACS is a registered trademark and μMACS and thermoMACS are trademarks of Miltenyi Biotec GmbH.

All other trademarks mentioned in this document are the property of their respective owners and are used for identification purposes only.

Unless otherwise specifically indicated, Miltenyi Biotec products and services are for research use only and not for diagnostic or therapeutic use.

Copyright © 2013 Miltenyi Biotec GmbH. All rights reserved.