Background Information

Recently, it was shown that the MICAL protein can interact with F-actin to promote oxidation at Met44 and Met47 [1] (see Figure 1). Subsequent studies discovered that MICAL-mediated methionine sulfoxide (MetO) of actin is reversed by the SelR/MsrB family of methionine sulfoxide reductase (Msr) enzymes [2,3]. The Msr family are well conserved proteins that function to reduce oxidized methionine to L-methionine [4]. Two groups independently identified SelR (MsrB) as the enzyme responsible for reduction of the Met 44 and Met47 amino acids of actin; importantly, this reduction of Met44 and Met47 was sufficient to restore normal actin polymerization [2,3]. These studies determined that the CxxS catalytic cysteine motif was essential for MsrB effects, as mutating the cysteine residue abolished MsrB's ability to restore actin polymerization [2]. These studies also determined that SelR/MsrB selectively reduced MICAL-oxidized actin, while another methionine sulfoxide reductase member, MsrA, did not [2,3]. Since SelR/MsrB specifically reduces R-isomer (MetO) and MsrA specifically reduces S-isomer MetO the groups concluded that MICAL stereo-specifically oxidized actin with MetO R-isomer. Collectively, these data describe a reversible, specific redox system that controls actin dynamics and cytoskeletal organization through regulation of a specific MetO of actin.

Material

Human MSRB2 protein (MB201) [accession # Q9Y3D2 (MSRB2_HUMAN)] has been produced and purified from a bacterial expression system. The recombinant protein is N-terminally 6x Histidine tagged and is comprised of amino acids 42-182 [5]. MB201 has an approximate molecular weight of 17 kDa. MB201 is supplied as a white lyophilized powder.

Storage and Reconstitution

Shipped at ambient temperature. The lyophilized protein can be stored desiccated at 4°C for 6 months. For reconstitution, the product tube should be briefly centrifuged to collect the powder to the bottom of the tube. Each tube of MB201 contains 50 µg of protein. When reconstituted with 50 µl of water, the final buffer composition is 10 mM Tris pH 8.0, 50 mM NaCl, 2.5% sucrose, and 0.5% dextran. We recommend that you make 10 µl aliquots, flash freeze, and store at –70°C. When stored and reconstituted as described, MB201 is stable for 6 months at –70°C.

Purity

Protein purity is determined by scanning densitometry of Coomassie Blue stained protein on a 4-20% gradient tris-glycine gel. MsrB2 protein was determined to be ≥90% pure (Figure 2).

Activity

Effective MsrB2 (MB201) + DTT reduction of MICAL-oxidized actin will enhance subtilisin A cleavage of MICAL-oxidized actin (Cat. # MXA95) at M47/G48 by > 90%. See the next page for details. Whereas DTT alone will not affect subtilisin cleavage.

Figure 1. Actin Met 44 and Met 47 physiological redox system. A schematic diagram of the enzymes that control the physiological and reversible oxidation and reduction of methionines 44 and 47 of actin. Specifically, the MICAL family of proteins regulate oxidation of actin at Met 44 and Met 47. Conversely, the SelR/MsrB family of methionine sulfoxide reductase family specifically reduces actin at Met 44 and Met 47.

Figure 2. MsrB2 Protein Purity Determination. A 10 µg sample of MsrB2 protein was separated by electrophoresis in a 4-20% gradient tris-glycine gel and stained with Coomassie Blue. Protein quantitation was performed using the Precision Red Protein Assay Reagent (Cat. # ADV02). Mark12 standard molecular weight markers are from Invitrogen.

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**Evaluating MsrB2 Activity: Subtilisin A Limited Proteolysis Application**

**Rationale:**
MsrB2 (MB201) is a protein that can reduce actin at amino acids M44 and M47 (β-actin nomenclature) \(^{2,3}\). The MsrB2 becomes oxidized during the reduction of actin and can be regenerated through reduction by DTT in vitro. It has been reported that M44 oxidation by MICAL is concomitant with M47 oxidation \(^{4,5}\). Subtilisin A is a protease that has been shown to specifically cleave actin between M47 and G48 \(^{6,7}\). When actin is oxidized at M47 by MICAL the efficiency of subtilisin A cleavage is significantly reduced; conversely, when actin is reduced at M47 by MsrB2 (+DTT) the efficiency of subtilisin A cleavage should be significantly enhanced \(^8\). Therefore, subtilisin A can be used in limited proteolysis assays to determine MsrB2 activity, and efficiency of M47 and M44 reduction by evaluating cleaved vs uncleaved actin.

**Expected Results:**
Effective MsrB2 (MB201) + DTT reduction of MICAL-oxidized actin will enhance subtilisin A cleavage of MICAL-oxidized actin (Cat. # MXA95) at M47/G48 by > 90% under the conditions described. Whereas DTT alone will not affect subtilisin cleavage.

**Reagents Needed:**
- MsrB2 (Cat. # MB201): When used as described below, 50 μg will reduce 10 ml of actin at 0.5 mg/ml
- MICAL-oxidized rabbit skeletal muscle actin (Cat. # MXA95)
- G-buffer (Cat. # BSA01)
- ATP (Cat. # BSA04)
- DTT 1 M stock
- Precision red advanced protein assay (Cat. # ADV01)
- Phenylmethylsulfonyl fluoride (PMSF)
- Subtilisin A (Cat. # P5380; Sigma)

**Method:**

### Day 1
1. Resuspend MICAL-oxidized rabbit skeletal muscle actin (Cat. # MXA95) to 0.2 mg/ml with G-buffer (5 mM Tris pH 8.0, 0.2 mM CaCl₂, 0.2 mM ATP, 0.5 mM DTT)
2. Incubate the oxidized actin on ice for 1 h
3. Centrifuge the oxidized actin in a microcentrifuge at 14,000 rpm for 30 min at 4°C
4. Transfer the supernatant to a new tube on ice
5. Determine the protein concentration. We recommend using precision red advanced protein assay (Cat. # ADV01)
6. Dilute oxidized actin to 0.1 mg/ml with G-buffer
7. Resuspend one tube of MB201 with 50 μl of water. The approximate concentration will be 1 μg/μl (58.82 μM). This is your stock tube
8. Prepare DTT to 1 M stock
9. Prepare the following 4 samples in 1.5 ml centrifuge tubes as shown in Table 1
10. Incubate samples overnight at room temperature. This will allow MsrB2 to reduce the oxidized actin

<table>
<thead>
<tr>
<th>Sample</th>
<th>Name</th>
<th>MXA95 11.9 μM</th>
<th>DTT 1 M stock</th>
<th>MB201 1 M stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MXA95</td>
<td>200 μl</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>MXA95 + DTT</td>
<td>200 μl</td>
<td>10 mM Final</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>MXA95 + MB201</td>
<td>200 μl</td>
<td>0</td>
<td>0.3 μM Final</td>
</tr>
<tr>
<td>4</td>
<td>MXA95 + DTT + MB201</td>
<td>200 μl</td>
<td>10 mM Final</td>
<td>0.3 μM Final</td>
</tr>
</tbody>
</table>

### Day 2
1. Aliquot 20 μl (2 μg actin) of each sample into individual 1.5 ml tubes. 2 aliquots per sample are needed for untreated versus subtilisin treated conditions. You should have the following 8 conditions as shown in Table 2
2. Before beginning subtilisin treatment boil a beaker of water. The water should be boiling when the subtilisin reaction is complete to inactivate the protease
3. Make a stock of subtilisin: 1 mg of subtilisin can be dissolved in 32 ml of 2 mM Tris pH 8.0/0.2 mM CaCl₂ to make a 31.25 μg/ml stock. Aliquot and store at -70°C
4. Dilute a tube of subtilisin stock to 2 μg/ml with G-buffer. (Subtilisin analysis: 1:200 w/v subtilisin to actin = 10 ng subtilisin / 2ug actin)
5. Add 5 μl (10 ng) of subtilisin to treated condition for all 4 samples
6. During treatment make PMSF (10 mM: 1.74 mg PMSF per ml of isopropanol)
7. After 15 min of subtilisin treatment, stop the reactions by adding 1 μl of PMSF to each sample (1-8)
8. Add 5 μl of 5x reducing sample buffer to each sample (1-8)
9. Immediately place samples into boiling water. Leave samples for 5 min
10. Briefly spin samples at 10,000 rpm to collect samples at the bottom of the tubes
11. Load a 4-20% tris-glycine gel and run at 170 V until the dye front reaches the end of the gel
12. Visualize with Coomassie staining. See Figure 3

**Table 1: Composition of Experimental Samples for MsrB2 Reduction**

<table>
<thead>
<tr>
<th>Sample</th>
<th>Name</th>
<th>MXA95 11.9 μM</th>
<th>DTT 1 M stock</th>
<th>MB201 1 M stock</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MXA95</td>
<td>200 μl</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>MXA95 + DTT</td>
<td>200 μl</td>
<td>10 mM Final</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>MXA95 + MB201</td>
<td>200 μl</td>
<td>0</td>
<td>0.3 μM Final</td>
</tr>
<tr>
<td>4</td>
<td>MXA95 + DTT + MB201</td>
<td>200 μl</td>
<td>10 mM Final</td>
<td>0.3 μM Final</td>
</tr>
</tbody>
</table>

**Figure 3. Subtilisin Assay on MsrB2 Treated Oxidized Actin.** MICAL-oxidized actin (Cat. # MXA95) was diluted to 0.1 mg/ml (2.3 μM) and left untreated, or treated with DTT (10 mM), MB201 (0.3 μM), or a combination of both (see method). 2 μg of each sample was then left untreated, or treated with subtilisin (1:200 w/v) for 15 min. Samples were then separated by SDS-PAGE and visualized with Coomassie staining.
**Using MsrB2 as a research tool: Oxidized and Reduced Actin Polymerization Application**

**Rationale:**
MsrB2 (MB201) is a protein that can reduce actin at amino acids M44 and M47 ([α-actin nomenclature](#)[2,3]). When actin is oxidized at M44 its ability to polymerize is significantly diminished [1]; conversely when oxidized actin is reduced at M44 its ability to polymerize is restored [2,3]. Actin polymerization assays can be used to measure the polymerization capabilities of MICAL-oxidized actin vs MsrB2-reduced actin.

**Expected Results:**
Effective MsrB2 (MB201) + DTT reduction of MICAL-oxidized pyrene-labeled actin (Cat. # MXAP95) will restore fluorescence signal at 1 hour to a level comparable to Effective MsrB2 (MB201) + DTT reduction of MICAL.

**Reagents Needed:**
1. MsrB2 (Cat. # MB201): When used as described below, 50 µg is sufficient for 4900 µl of 2x pol buffer + DTT + MB201 0.3 µM assay buffer (Table 6), enough for 39 runs.
2. Pyrene-labeled rabbit skeletal muscle actin (Cat. # AP05).
3. MICAL-oxidized pyrene-labeled rabbit skeletal muscle actin (Cat. # MXAP95).
4. G-buffer (Cat. # BSA01) (5 mM Tris pH 8.0, 0.2 mM CaCl2).
5. Precision red advanced protein assay (Cat. # ADV02).
6. DTT 1 M stock.
7. 2x polymerization buffer (5 mM Tris pH 7.5, 4 mM MgCl₂, 100 mM KCl, 2 mM EGTA, 0.2 mM ATP, 0.5 mM DTT).

**Equipment Needed:**
1. Fluorescence spectrophotometer with an excitation wavelength of 360 +/- 20 nm and an emission wavelength of 405 +/- 10 nm or 420 +/- 20 nm. Cytoskeleton recommends the SPECTRAFluor Plus from TECAN Austria GmbH or Gemini from Molecular Devices Inc.
2. Black polystyrene 96 well assay plate (Costar, Cat. # 3915).
3. Pipet 100 µl of 0.2 mM ATP, 0.5 mM DTT.
4. 2x polymerization buffer (58.82 µM).

**Method:**
1. Dilute both pyrene-labeled rabbit skeletal muscle actin (Cat. #AP05) and MICAL-oxidized pyrene-labeled rabbit skeletal muscle actin (Cat. #MXAP95) to 0.45 mg/ml with G-buffer (Cat. # BSA01) supplemented with 0.2 mM ATP and 1 mM DTT.
2. Leave on ice for 1 h to depolymerize actin oligomers.
3. Centrifuge at 14,000 rpm at 4°C for 30 min to remove nucleating centers.
4. Determine the protein concentration.
5. Dilute AP05 and MXAP95 to 0.1 mg/ml with G-buffer.
6. Resuspend one tube of MB201 with 50 µl of water.
7. Prepare DTT 1 M stock.
8. Prepare the following Assay Polymerization buffers as shown in Table 6.
10. Pipet 100 µl of 0.1 mg/ml AP05 into eight wells (A3-10) of a black 96 well plate.
11. Pipet 100 µl of 0.1 mg/ml MXAP95 into eight wells (B3-10) of a black 96 well plate.
12. Place the 96 well plate into the fluorescent spectrophotometer and read the fluorescence every 3 s for 30 s.

**Table 6: Composition of Assay Polymerization Buffers**

<table>
<thead>
<tr>
<th>Buffer Type</th>
<th>Buffer</th>
<th>DTT</th>
<th>MB201 Stock</th>
<th>Add to Lanes (Step 12)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2x pol buffer</td>
<td>1 ml</td>
<td>0</td>
<td>0</td>
<td>A1-4, B1-4</td>
</tr>
<tr>
<td>2x pol buffer + DTT</td>
<td>500 µl</td>
<td>20 mM</td>
<td>0</td>
<td>A5-6, B5-6</td>
</tr>
<tr>
<td>2x pol buffer + DTT + MB201 0.3uM</td>
<td>500 µl</td>
<td>20 mM</td>
<td>0.6 µM</td>
<td>A7-8, B7-8</td>
</tr>
<tr>
<td>2x pol buffer + DTT + MB201 1.2uM</td>
<td>500 µl</td>
<td>20 mM</td>
<td>2.4 µM</td>
<td>A9-10, B9-10</td>
</tr>
</tbody>
</table>

**References:**

**Product Citations/Related Products**
For the latest citations and related products please visit www.cytoskeleton.com