**About Mitsui Chemicals, Inc.**

Mitsui Chemicals, Inc. (MCI) contributes to society by providing high quality products and services to customers through innovations and creation of materials while maintaining harmony with the global environment. MCI has over 30 years of experience in the development and production of innovative optical lens materials for the global market. The optical monomer brand name of MR™ is now globally recognized as a premium high index lens material. In 2008, SDC Technologies, Inc., a California based premium coating material company, became a MCI group company. In 2011, MCI acquired Acomon AG, a leading optical lens material manufacturer well known for its RAV Series of RI 1.50 lens material. Thus MCI is able to provide a full range of lens material and coating solutions to global lens manufacturers. In 2013, KOC solution, a Korean manufacturer and distributor of plastic optical lenses monomers, became a MCI group company. This enables improvement of MCI’s product portfolio by its middle index to high index monomers.

**R&D Strength**

MCI is globally known as a leading manufacturer of urethane products and in 1987 became the first company in the world to apply thio urethane chemical technology to ophthalmic lenses. MCI’s global R&D network with a broad range of technology contributes to excellence in designing the most advanced molecules for ophthalmic lens materials.

**MR™ Series History**

~ Pioneer in high index lens material development ~

- **Early 1980s** Started development of high index lens materials.
  - **1987** Commercial release of MR-6™, the world’s first thio urethane high index ophthalmic lens material (RI 1.60)
  - **1991** Commercial release of MR-7™, the world’s first refractive index 1.67 ophthalmic lens material
  - **1998** Commercial release of MR-10™ (RI 1.67)
  - **1999** Commercial release of MR-8™ (RI 1.60)
  - **2000** Commercial release of MR-174™ (RI 1.74)
  - **2008** Acquisition of SDC Technologies, Inc., a California based premium coating material company
  - **2009** Acquisition of Film Specialties, Inc., an anti-fog coating specialty company of SDC Technologies, Inc.
  - **2011** Acquisition of Acomon AG, a Swiss based lens material company
  - **2013** Mitsui Chemicals becomes majority shareholder of KOC Solution, a Korea based lens material company

**Production, Quality Control and CSR**

MR™ Series is produced and delivered according to strictly controlled operation protocols for the sustainable supply of high quality materials to lens manufacturers. The MR™ Series production plant is certified under ISO9001 and strict precaution is taken not only in monomer production, but also in packaging, storage and logistics. As a chemicals company, human and environmental safety is a top priority. The MR™ Series plant is certified under ISO14001 and all operations are conducted with great consideration to minimize impact on the environment.

**Global Network**

MR™ Series sales, marketing and technical service are conducted by MCI global headquarters in Japan and 7 regional headquarters around the globe. Therefore, quick customer service in multiple languages is available for the highest customer satisfaction. Additionally, SDC Technologies, Inc. and Acomon AG also have global networks to support their customers in each region. Customer satisfaction is always the MCI group’s first priority.
MR™ Series ~ Trademark of Safe, Clear and Lightweight Lenses ~

Excellent optical materials with high refractive index, high Abbe number, low specific gravity and high impact resistance are provided by polymerizing monomers of MR™ Series. MR™ Series is especially suitable for ophthalmic lenses and is known as the first thioethane based high index lens material. MR™ Series offers a variety of products to provide the best solution for optical lens users.

Note: MR™ Series is a brand name of the raw material for optical lenses. MR™ Series based lenses are available from most leading lens manufacturers.

R.I. 1.60 : MR-8™

The best balanced high index lens material with the largest share of the R.I. 1.60 lens material market. MR-8™ is suited to any strength ophthalmic lens and is a new standard in ophthalmic lens material.

R.I. 1.67 : MR-7™ & MR-10™

Global standard R.I. 1.67 lens material. Great materials for thinner lenses with strong impact resistance.

- **Material Characteristics**
  - MR-7™: Better color tintability
  - MR-10™: Higher high heat distortion temperature

R.I. 1.74 : MR-174™

Ultra high index lens material for ultra thin lenses. Strong prescription lens wearers are now free from thick and heavy lenses.

### Comparison of physical properties of lenses made with MR™ Series vs. other optical materials

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<thead>
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<tbody>
<tr>
<td>Refractive Index (ne)</td>
<td>1.60</td>
<td>1.67</td>
<td>1.67</td>
<td>1.74</td>
<td>1.59</td>
<td>1.60</td>
<td>1.55</td>
<td>1.50</td>
<td>1.52</td>
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<tr>
<td>Abbe Number (ve)</td>
<td>41</td>
<td>31</td>
<td>31</td>
<td>32</td>
<td>26-30</td>
<td>32</td>
<td>34-36</td>
<td>58</td>
<td>59</td>
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<tr>
<td>Heat Distortion Temperature (°C)</td>
<td>118</td>
<td>85</td>
<td>100</td>
<td>78</td>
<td>142-148</td>
<td>80-89</td>
<td>-</td>
<td>84</td>
<td>&gt;450</td>
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<tr>
<td>Tintability</td>
<td>Good</td>
<td>Excellent</td>
<td>Good</td>
<td>OK</td>
<td>None</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>None</td>
</tr>
<tr>
<td>Impact Resistance</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>OK</td>
<td>Good</td>
<td>OK</td>
<td>OK</td>
<td>OK</td>
<td>Poor</td>
</tr>
<tr>
<td>Static Load Resistance</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>OK</td>
<td>Good</td>
<td>Poor</td>
<td>Poor</td>
<td>Good</td>
<td>Good</td>
</tr>
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</table>

### Premium Lens Applications of the MR™ Series

- **SingleVision/Progressive Ophthalmic Lenses**
  - MR™ Series has superb processability to realize desired lens design.

- **Wide Color Range Sunglasses**
  - MR™ Series has good color tintability making it suitable for high fashion sunglasses which have special color needs.

- **TRANSITIONS® Photochromic Lens System**
  - MR™ Series has good compatibility with TRANSITIONS® photochromic lens systems.

- **Polarized Lens**
  - MR™ Series is widely used for both ophthalmic & plano polarized sunglasses.

- **Sophisticated Design**
  - MR™ Series has good mechanical strength and stress free properties making it suitable for various unique lens designs such as “Timeless frame” or “High curve lens”.

**CAUTION:** Selecting any of these properties may reduce the impact resistance of the lens, please consult with your lens manufacturer before selecting any of these properties.
**Optical Quality**

- Thinner and lighter lenses can be achieved with 3 different refractive index MR™ Series. (R.I. 1.60, 1.67, 1.74)
- Both high refractive index and high Abbe number provide optical performance similar to glass lenses.
- Glass mold-casted MR™ Series shows minimal stress-strain.

**High Refractive Index**

- MR™ Series offers 3 different refractive index products (R.I. 1.60, 1.67, 1.74).
- With higher refractive index materials, it is possible to achieve thinner lenses with the same strength.

**Comparison of thickness of MR™ Series and R.L. 1.50 lenses (-6.00D)**

- MR-8™ lens (R.I. 1.60) Low-Index lens (R.I. 1.50)
- MR-174™ lens (R.I. 1.74) Low-Index lens (R.I. 1.50)

- MR™ Series realizes thinner and lighter lenses.

**Strain Free**

- MR™ Series resin is uniformly polymerized in a glass mold. Compared to injection molded polycarbonate lenses, MR™ Series lenses show minimal stress strain and offer stress free clear vision.

**Stress Strain Observation**

- Crossed Nicol method using polarizing film and a white light source.

- No stress-strain
- Severe stress-strain

- MR™ Series offers stress free clear vision.

**High Abbe Number**

- Both high refractive index and high Abbe number provide optical performance similar to glass lenses.
- High Abbe number material such as MR-8™ minimizes the prism effect (chromatic aberration) of lenses and provides comfortable use for all wearers.

**High Abbe Number Material**

- MR-8™ lens : 41

**Low Abbe Number Material**

- Polycarbonate lens: 27-30
- Acrylic lens: 52
- Middle-Index lens: 34-36

All tests were conducted under specified test methods at Miyuo Chemicals, Inc. and are not guaranteed as specifications.
**Mechanical Features**

**Mechanical Strength**
- High impact and static load resistance helps promote wearer eye safety.
- Suitable for fashionable “Rimless frame” and “High curve lens”.
- Good processability for precisely designed progressive lenses. (an advantage of thiourethane materials)

**Impact Resistance**

**FDA Drop Ball Test**
- 5/8-inch steel ball weighing approximately 0.56 oz.
- Tested for drop ball test to simulate dynamic impact.
- MR-8™ lens shows good impact resistance.
- Middle-Index & Acrylic lenses were broken.
- ADC lens had cracks.

**Static Load Resistance**

**Static Loading Test**
- Quasi-static loading type test for minimum robustness.
- MR-8™ lens shows good static load resistance.

**Tensile Strength Resistance**
- MR-8™ lens shows good tensile strength.
- MR-8™ is widely recognized as the best material for rimless frames.

**Tensile Test**
- Lens deformation:
  - MR-8™ lens showed no deformation of drilled hole (size: 1mm)
  - Polycarbonate lens showed deformation.
- Tensile test results:
  - MR-8™ lens broke at 72kg tensile force.
  - Polycarbonate lens broke at lower force.

**Butterfly Test**

**“Butterfly Test” for Rimless Frames**
- Endurance test under cyclic load for spectacle frames.
- MR-8™ lens broke at over 30,000 strokes.
- Acrylic lens broke at 10,000 times.
- Middle-Index lens broke at 10,000 times.

**JIS B7283**
- Specifications:
  - B7283:2012
  - Broke at 30,400 strokes

**Japanese Lens Manufacture**
- Tested by a Japanese lens manufacture.
**Product Features**

**Durability**
- Good weatherability provides minimal change in lens color after years of usage.
- Good compatibility with coating materials.

**Lens Color Change**

**Weatherability Test**
Accelerated test to observe lens color change after long-term usage

- **QUV Test:** 0.50W/m², 50°C, 100hrs

**Coating Compatibility**

**Heat Resistance Test**
Evaluation of cracks in coating after high temperature conditions

- **Test condition:** 90°C, 15 min.
  - No Cracks
  - Polycarbonate lens
  - ADC lens

- **Test condition:** 80°C, 15 min.
  - No Cracks
  - Middle-Index lens
  - Acrylic lens

Good heat resistance and coating compatibility of MR-8™ prevent coating cracks under severe conditions.

**Cross-cut Adhesion Test**

1) Cut a coating layer in a reticular pattern.
2) Apply tape over the pattern and then remove it.

- MR-8™ showed very good compatibility with coating materials. Lens wearers can enjoy unchanged high performance lens coating after long-term usage.

**MR-8™ lens**

- Middle-Index lens
- Acrylic lens
- Polycarbonate lens
- ADC lens

No Peeling

Peeling

All tests were conducted under specified test methods at Mitsubishi Chemical, Inc. and are not guaranteed as specifications.

**MR-8™ lens**

- Middle-Index lens
- Acrylic lens
- Polycarbonate lens
- ADC lens

No Peeling

Peeling

MR-8™ shows only minor color change after exposure to strong UV light. Wearers can enjoy clearer lenses after long-term usage.

- Middle-Index lens
- Acrylic lens
- Polycarbonate lens
- ADC lens

No Peeling

Peeling

MR-8™ lens
SDC Technologies, Inc. is a wholly owned MCI affiliate company and is the recognized world leader in the development and manufacture of abrasion-resistant and functional coatings for application to plastic, glass, and metals. SDC’s products add premium performance, optical clarity, appearance and durability to eyewear, sunglasses, safety lenses, automotive and aeronautical products, electronic devices and other custom applications.

**SDC High Index Coating Use on MR™ Series**

SDC Technologies Inc. range of high index coating products have been specifically formulated to work with the MR™ Series and provide the best coating and product performance for MR™ Series based lenses.

**SDC High Index Coating Features**
- Index matched
- Tintable & Non-tintable
- Excellent steel wool resistance
- AR compatible
- Optically clear
- Compatible index matched primers

**Market Applications**

**Optical**

As the market leader in premium abrasion-resistant coatings, SDC manufactures a variety of CrystalCoat® coatings and primers for vision corrective lenses and other optical applications. SDC manufactures tintable and non-tintable coatings in both thermal cure and UV cure formulas. Its CrystalCoat® abrasion-resistant coatings can be applied to all lens substrates. SDC also manufactures high-performance index matched coatings that have been specifically formulated to work with the MR™ Series and provide the best coating & product performance for MR™ Series based lenses.

**Sunglasses & Sports Eyewear**

CrystalCoat® products are recommended for sunglasses and sports eyewear to improve scratch resistance and product durability. CrystalCoat® products can be used on tinted or clear substrates such as MR™ Series, polycarbonate, polystyrene, ADC (CR-39®, RA7®), acrylic and Trivex®. Available globally, SDC products provide tintability, anti-fog, and premium abrasion resistance for sunglasses and sports eyewear applications.

**Safety**

SDC manufactures a broad range of CrystalCoat® products for safety applications. To address the current trend for anti-fog coating, SDC offers high-performance water sheeting, anti-fog coating and abrasion resistance specifically designed to meet the industry’s high standards and testing requirements. SDC also offers primer-free coatings with a rapid thermal cure.

**Anti-Fog**

Following the recent acquisition of FSI Coating Technologies, Inc. (FSIC), formerly Film Specialties, Inc., SDC now offers a whole new range of premium anti-fog coatings. Solutions that improve product durability include high performance “Water Washable” anti-fog coatings, standard and customized anti-fog coated film and sheet products, as well as complementary hard coating systems and primers. Anti-fog applications include medical, safety, military, and sports eyewear as well as industrial sheet and PET film for commercial freezer display doors.
1. Preparation of MR™ Series

Mix MR™ monomer (component) A & B with additives, then degas the MR™ monomer mixture.

2. Filling

Fill molds with the MR™ monomer mixture.

3. Polymerization

Place the filled molds into ovens, where they undergo a heat-cycle, turning the MR™ monomer mixture into an MR™ lens.

4. Grinding / Polishing

Grind and polish the surface of the MR™ lens to create a curvature for required strength.

5. Tinting

Tint the surface of the MR™ lens.

6. Coating

- Hard Coating
- Anti Reflection Coating

Coat the surface of the MR™ lens to protect from scratches, reflection etc.

7. Final Inspection

Inspect the coated lens.

Typical example of lens production process.

Lens production process varies among lens manufacturers.