Solventless Silicone Pressure Sensitive Adhesive Technology

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Contents

Overview of Silicone PSAs
- Silicone PSA Components
- Silicone PSA Modification/Cure Chemistry

Solventless Technology
- Challenges
- Performance
Why Silicone Pressure Sensitive Adhesives?

- Si-O flexibility, longer chain length, and bond angles leads to:
  - Sticks to low energy surfaces
  - Ability to reposition
  - Gas permeable
  - Minimal Property change over a wide temperature range

- Si-O stability leads to:
  - High temperature performance stability
  - UV stability

Siloxane Polymer

<table>
<thead>
<tr>
<th>Me</th>
<th>R</th>
<th>Me</th>
<th>R</th>
<th>Me</th>
<th>Me</th>
<th>Me</th>
</tr>
</thead>
<tbody>
<tr>
<td>OH</td>
<td>Si</td>
<td>O</td>
<td>Si</td>
<td>O</td>
<td>Si</td>
<td>O</td>
</tr>
<tr>
<td>Me</td>
<td>R</td>
<td>Me</td>
<td>Me</td>
<td>Me</td>
<td>Me</td>
<td></td>
</tr>
</tbody>
</table>

R = (methyl, phenyl, alkyl, OH, vinyl, etc...)
Why Silicones Instead of Organic PSAs?

**Advantages Typical of Silicones**
- Wide temperature range capabilities
- Moisture/UV resistance
- Adhesion to low energy surfaces
- Conformability
- Clean removability
- Electrical insulation properties
- Sound-damping characteristics

**Disadvantages Typical of Silicones**
- Poor solvent resistance
- Low adhesive strength
- Low tack
Where Are Silicone PSAs Used?

- Electronics
- Packaging
- Protective Tapes/Films
- Pressure Sensitive Converting
- General Industrial Processing
- Automotive
- Aerospace
- Medical & Healthcare
Electronic Masking Tapes

Applications
- Circuit Board Masking for Metal Plating
- Etching & Soldering Bath Operations

Backings
- Polyester
- Polyimide
- PTFE

Performance Needs
- Conformability
- Chemical & High Temperature Resistance
- Clean Removability
- Low Migration
Protective Tapes/Films

Applications
- Electronics/Electrical Protective Tape; Carrier Tape; LCD; Polarizing; Prism Film; Diffuser Metal Protective Film

Backing
- Polyester; Polyimide; PE

Performance Needs
- High Temperature Resistance; Low Adhesion; Stable Adhesion; Low Migration; Clean Removability; Excellent Wettability

Market Need
- Anti-Static; Anti-Fingerprint; Anti-Scratch
Splicing Tapes

Applications
- Splicing and Bonding of Lower Surface Energy Substrate/Film/Board etc... in High Temperature, Chemical, Solvent Etching Process, During High Speed Continuous Process

Backings
- PET

Performance Needs
- High Adhesion to Low Energy Surfaces
- Quick Stick/High Tack for Flying Splices
Thermal Spray Tapes

**Applications**
- Plasma; Flame Spray Tapes

**Backings**
- Glass Cloth; Coated Glass Cloth; Foil; PTFE; Silicone Coated Glass Cloth

**Performance Needs**
- Chemical and High Temperature Resistance; Clean Removability
General Industrial Assembly

**Applications**
- Bonding to Various Substrates (usually low surface energy plastics); High or Low Temperature Extremes (-25°C to 270°C)

**Backings**
- PET; Kapton

**Performance Needs**
- Adhesion to Difficult Substrates (Teflon, HDPE, LDPE); Adhesion to High and Low Temperatures

Teflon(TM) and Kapton(R) are marks of Chemours and DuPont
## Silicone-PSA Advantage

<table>
<thead>
<tr>
<th></th>
<th>Silicone PSA</th>
<th>Organic PSA</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong> (Cure/Material)</td>
<td>Addition</td>
<td>BPO</td>
</tr>
<tr>
<td>Heat Resistance</td>
<td>200° C</td>
<td>250° C</td>
</tr>
<tr>
<td>Lower Temp. Resistance</td>
<td>-50° C</td>
<td>-50° C</td>
</tr>
<tr>
<td>Weather Resistance</td>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Adhesion to PTFE</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>Adhesion to Si Rubber</td>
<td>Middle to High</td>
<td>High</td>
</tr>
</tbody>
</table>
Silicone PSA Components

Resins
Polymers
Solvents
Cross-linkers (for Pt system)
Catalyst
Silicone PSA Compositions

MQ Silicate Tackifier Resin
Silicone PSA Compositions - Resin

Silicate Tackifier Resin

![Chemical structure](image-url)
Silicone Polymer

R1 = (OH, vinyl, alkyl, phenyl, etc.)
R2 = (methyl, phenyl, alkyl, vinyl, etc.)
Resin/Polymer ratio effect on PSA properties

![Graph showing the effect of increasing R/P ratio on PSA properties. The graph indicates that increasing R/P ratio affects Tack, Hold/Shear, and Peel Adhesion differently.](Image)
Silicone PSA Compositions – Other Components

Solvent
● Toluene or Xylene

Catalyst
● BPO or Pt
Cure Mechanism of BPO Cure PSA
(BPO: benzoyl peroxide)

(1) \[
\text{BPO} \xrightarrow{\Delta} 2 \text{Ph-C=O}
\]

(2) \[
\text{Ph-C=O} + \equiv \text{Si}-\text{C} - \text{H} \rightarrow \text{Ph-C=O} - \text{H} + \equiv \text{Si} - \text{C}\cdot
\]

(3) \[
\equiv \text{Si} - \text{C} - \text{H} + \equiv \text{Si} - \text{C} - \text{H} \rightarrow \equiv \text{Si} - \text{C} - \text{C} - \text{Si} - \text{equiv}
\]

- Drive Off Solvent at 70°C 1st Step – 1-2 minutes
  - Residual Solvent can react with BPO, causing bubble formation

- Cure 180-204°C 2nd Step 1-2 minutes
Cure Mechanism of Addition Cure PSA

- Cure in 1 step
- 100-150°C for 1-2 minutes
- Solvent will not react with process and comes off independently
## Cure System Comparison

<table>
<thead>
<tr>
<th>Peroxide Cure</th>
<th>Addition Cure</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Must be cured at high temp</td>
<td>• Can be cured at low temp</td>
</tr>
<tr>
<td>• Very good high temp props</td>
<td>• Good high temp props</td>
</tr>
<tr>
<td>• Good tack and adhesion</td>
<td>• Superior tack/adhesion</td>
</tr>
<tr>
<td>• Often requires priming</td>
<td>• May not require priming</td>
</tr>
<tr>
<td>• Properties formulation and condition dependent</td>
<td>• Properties only formulation dependent</td>
</tr>
<tr>
<td>• Not easily poisoned</td>
<td>• Easily poisoned</td>
</tr>
</tbody>
</table>
Si Tape Manufacturing Process – Peroxide Cure

| Zone 1 – 80°C | Zone 2 – 180 to 204°C |

Fluorosilicone Liner
PET Film
Silicone PSA
Si Tape Manufacturing Process – Platinum Cure

Zone 1 – 125 to 150°C

Fluorosilicone Liner

Silicone PSA

PET Film
Si Tape Transfer Coat Manufacturing Process

Peroxide Cure

Fluorosilicone Liner

<table>
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<tr>
<th>Zone 1 – 80°C</th>
<th>Zone 2 – 180 to 204°C</th>
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Platinum Cure

Fluorosilicone Liner

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<th>Zone 1 – 125 to 150°C</th>
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Silicone PSA Modification – Customer Influenced Factors

Solvent Choice
Adhesive Coat Weight
BPO Level (0-3%)
BPO Choice (Benzoyl Peroxide or 2,4-Dichlorobenzoyl peroxide)
Cure Cycle – Peroxide: Dependent on Peroxide Level & Time
Cure Cycle – Pt Addition: Dependent on time, temperature, and catalyst level
Crosslink level – Peroxide – Dependent on BPO level
Filler Additives
Resin Additives for Adhesion Modification
Processing Conditions
Silicone PSA Modification – Customer Influenced Factors

- Proportion of resin and polymer used in the formulation
- Resin and polymer molecular weight
- Type of functionality on the resin and polymer
- Level of functionality on the resin and polymer
- Bodied versus Cold Blend PSA
- Process conditions (e.g. Reaction time / Temperature)
- Additives (Pigments, fillers, etc.)
Challenges for Solventless Silicone PSA

MQ resins are solids in neat form
  • Provide elastic properties to PDMS systems

Silicone polymers used in PSAs
  • High viscosity liquids or ultra-high viscosity gums
Formulation Approach to Solventless Silicone PSA

Platinum cure
• Avoids peroxide insolubility in the system
• Lower temperature cure versus peroxide systems

Mw of MQ resin for shear/temperature performance
• Earlier generation of solventless silicone PSAs used low Mw for viscosity control
• Too low Mw MQ product suffered from poor high temperature shear performance

Polymer components
• Specific molecular weights chosen to balance performance, efficiency, and viscosity control
• “Crosslinker-In” to provide workable viscosity
Coating and Cure of Solventless Silicone PSA

Similar to solvent silicone PSAs
- Customer adds platinum catalyst
- Mix with adequate agitation
- Coat onto moving web via knife over roll, multi roll with metering, etc.
- Dry and cure in a single zone
  - 3 minutes at 150 °C

Additional advantages of solventless silicone technology
- Lower silicone dusting components versus other silicone PSAs
- Stable direct cast release from fluorosilicone release liner
- Able to coat thicker constructions
Tan Delta Profile of Selected Silicone PSAs
Storage Modulus (G’) Profile of Selected Silicone PSAs

![Graph showing the storage modulus (G’) profile of selected silicone PSAs. The x-axis represents temperature in °C, ranging from -35.0 to 300.0, and the y-axis represents G’ in dyn/cm², ranging from 10^5 to 10^9. The graph compares different PSAs, including S-Pt-SiPSA, SL-Pt-SiPSA, and S-BPO-SiPSA.](image-url)
Adhesion, Tack, and High Temperature Hold

Solvent dimethyl (platinum cured)

Solventless dimethyl (platinum cured)

Solvent dimethyl (BPO cured)

Solvent high temp dimethyl (BPO cured)

Solvent Protective Film PSA (platinum cured)

High Temp Hold Data

Black = N/A

Orange 400F

Green 450F

Blue 500F

Red - 550F
Summary
Silicone PSAs applications
• Performance at extreme temperatures
• Adhesion to low energy substrates
• UV/Weather resistance

Need for solventless silicone PSA
• Handling of solvents

Challenges for solventless silicone PSA
• Viscosity control

Performance of solventless vs solvent silicone PSA
• Comparable to solvent based systems for adhesion and temperature performance
Thank You

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