Stepan Polyesters for Polyurethane Adhesives
Founded in 1932 in Chicago, IL, USA, Stepan Company is a publicly traded manufacturer of specialty and intermediate chemicals. These products include commercial and industrial surfactants, nutritional oils, polyester polyols for rigid and flexible foam, coatings, adhesives, sealants, and polyurethane elastomers. Stepan’s commitment to the global polyester polyol market has been complemented with recent acquisitions of manufacturing facilities in Europe and the United States bringing our global footprint for polyester polyols production to five sites.

STEPANPOL® aliphatic polyester polyols offer greater light stability and non-yellowing properties while providing durability, solvent resistance, and tear strength.

STEPANPOL® aromatic polyester polyols use several aromatic acids. Phthalic anhydride is also utilized to take advantage of ortho-ester linkages for enhanced hydrolytic stability. All of these polyesters offer diverse substrate adhesion while improving abrasion resistance and overall hardness.

STEPANPOL polyester polyols for polyurethane adhesives
Stepan is dedicated to being a global leader in esterification and the product line reflects this—Stepan remains strictly a raw material supplier providing polyester polyols for the polyurethane adhesive industry and offering polyester technical support. Stepan is a global company and as the Company grows and expands, customers can expect to purchase the same STEPANPOL grades regionally.

Stepan offers a broad range of aliphatic and aromatic products including many prepolymer grade products. The “P” in the name of certain products, such as STEPANPOL PC-105P-30, stands for prepolymer grade, meaning that these are neutralized particularly for use in making prepolymer grade products. Stepan is committed to innovation in the polyurethane adhesive market with the continuous addition of new products and dedicated resources in each region.

Stepan specializes in polyesters for use in polyurethane reactive hot melts (PURHMs) as a technology and flexible packaging adhesives, providing a technical introduction and basic formulation guidance.
## TYPICAL CHEMICAL PROPERTIES*

<table>
<thead>
<tr>
<th>STEPANPOL® Products</th>
<th>Region</th>
<th>Performance Features</th>
<th>Backbone</th>
<th>Viscosity at 25°C (cP)</th>
<th>Average Molecular Weight</th>
<th>Hydroxyl Value (mgKOH/g)</th>
<th>Tg/Tm (°C)◊</th>
<th>Functionality</th>
<th>Regulatory‡ Compliance</th>
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<tbody>
<tr>
<td>BC-180</td>
<td>A E C</td>
<td>Contains bio-content material, imparts low viscosity, aromatic</td>
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<td>3300</td>
<td>700</td>
<td>180</td>
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<td>2.25</td>
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<tr>
<td>PC-1011-55</td>
<td>A E C</td>
<td>Solvent resistance, general purpose product</td>
<td>DEG-AA</td>
<td>1075 at 60°C</td>
<td>2040</td>
<td>55</td>
<td>-58 Tg</td>
<td>2</td>
<td>FD FI B</td>
</tr>
<tr>
<td>PC-1011P-110</td>
<td>A E</td>
<td>Solvent resistance, general purpose product</td>
<td>DEG-AA</td>
<td>775 at 40°C</td>
<td>1020</td>
<td>110</td>
<td>ND</td>
<td>2</td>
<td>FD FI B</td>
</tr>
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<td>PC-1011P-210</td>
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<td>Solvent resistance, general purpose product</td>
<td>DEG-AA</td>
<td>250 at 40°C</td>
<td>540</td>
<td>210</td>
<td>ND</td>
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<tr>
<td>PC-2011-225</td>
<td>A E</td>
<td>Solvent resistance, general purpose product</td>
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<td>500</td>
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<tr>
<td>PC-107P-55</td>
<td>A E</td>
<td>Flexibility, elongation, and toughness</td>
<td>NPG-AA</td>
<td>2300 at 60°C</td>
<td>2040</td>
<td>55</td>
<td>36 Tm</td>
<td>2</td>
<td>FD FI B</td>
</tr>
<tr>
<td>PC-107-110</td>
<td>A E</td>
<td>Flexibility, elongation, and toughness</td>
<td>NPG-AA</td>
<td>565 at 60°C</td>
<td>1020</td>
<td>110</td>
<td>ND</td>
<td>2</td>
<td>FD FI B</td>
</tr>
<tr>
<td>PC-207-125</td>
<td>A E</td>
<td>Flexibility, elongation, and toughness</td>
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<td>6700</td>
<td>900</td>
<td>125</td>
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<td>2</td>
<td>FD FI B</td>
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<td>PC-5010-270</td>
<td>A E</td>
<td>Good pigment wetting and low viscosity, aromatic</td>
<td>Proprietary</td>
<td>1750</td>
<td>500</td>
<td>270</td>
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<td>B</td>
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<tr>
<td>PC-5010P-60</td>
<td>A E</td>
<td>Balance of flexibility and toughness, aliphatic</td>
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<td>2300</td>
<td>60</td>
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<td>PC-5060-165</td>
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<td>Low viscosity aromatic for bonding latitude, aromatic</td>
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<td>750</td>
<td>165</td>
<td>-29 Tg</td>
<td>2.21</td>
<td>B L</td>
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<tr>
<td>PC-5070P-56</td>
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<td>PD-195</td>
<td>A E</td>
<td>Aromatic for bonding, extends open time</td>
<td>DEG-PA</td>
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<td>600</td>
<td>200</td>
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<td>2</td>
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<tr>
<td>PD-279</td>
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<td>Low viscosity aromatic for 2K bonding</td>
<td>Proprietary</td>
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<td>416</td>
<td>279</td>
<td>-37 Tg</td>
<td>2.1</td>
<td>FI B X</td>
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<tr>
<td>PD-320</td>
<td>A E</td>
<td>Low viscosity aromatic for 1 and 2K applications</td>
<td>DEG-PA</td>
<td>2800</td>
<td>350</td>
<td>320</td>
<td>ND</td>
<td>2</td>
<td>FD FI B X</td>
</tr>
<tr>
<td>PDP-70</td>
<td>A E C</td>
<td>*Imparts low viscosity, flexibility, aromatic, and ester/ether compatibility</td>
<td>Proprietary</td>
<td>1900</td>
<td>1600</td>
<td>70</td>
<td>ND</td>
<td>2</td>
<td>FI B</td>
</tr>
</tbody>
</table>

A=Americas  E=Europe  C=Asia  

*Property values are typical and based on product concentration and/or mathematical and statistical calculations.

◊ ND is noted for Tg/Tm (°C) when no thermal transition was detected.

‡ F= FDA compliance for 175.300 (D) or 175.105 (I), B= European compliance for EU 10/2011, X= Chinese compliance for GB 9685, L= Insufficient information to determine FDA status.
### TYPICAL CHEMICAL PROPERTIES*

<table>
<thead>
<tr>
<th>STEPANPOL® Products</th>
<th>Region</th>
<th>Performance Features</th>
<th>Backbone</th>
<th>Viscosity at 60°C (cP)</th>
<th>Average Molecular Weight</th>
<th>Hydroxyl Value (mgKOH/g)</th>
<th>Tg/Tm (°C)</th>
<th>Viscosity 25°C (cP) 10% Prepolymer**</th>
<th>Viscosity 25°C (cP) 15% Prepolymer**</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEPANPOL PC-1011-55</td>
<td>A E C</td>
<td>Solvent resistance, general purpose product</td>
<td>DEG-AA</td>
<td>1075</td>
<td>2040</td>
<td>55</td>
<td>-58 Tg</td>
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<td>13700</td>
</tr>
<tr>
<td>STEPANPOL PC-1011P-110</td>
<td>A E</td>
<td>Solvent resistance, general purpose product</td>
<td>DEG-AA</td>
<td>775 at 40°C</td>
<td>1020</td>
<td>110</td>
<td>ND</td>
<td>38300</td>
<td>5540</td>
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<tr>
<td>STEPANPOL PC-1017P-55</td>
<td>A E</td>
<td>Tensile and tear strength, solvent and oxidation resistance</td>
<td>EG/PG-AA</td>
<td>1200</td>
<td>2040</td>
<td>55</td>
<td>69 Tm</td>
<td>26400</td>
<td>7280</td>
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<tr>
<td>STEPANPOL PC-201P-110</td>
<td>A E</td>
<td>Good adhesion to a variety of substrates</td>
<td>EG-AA</td>
<td>400</td>
<td>1020</td>
<td>110</td>
<td>42 Tm</td>
<td>43900</td>
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<tr>
<td>STEPANPOL PC-102P-110</td>
<td>A E</td>
<td>Tensile and tear strength, solvent resistance, flexibility</td>
<td>BDO-AA</td>
<td>320</td>
<td>1020</td>
<td>110</td>
<td>43 Tm</td>
<td>52000</td>
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<tr>
<td>STEPANPOL PC-202P-110</td>
<td>A E</td>
<td>Tensile and tear strength, solvent resistance, flexibility</td>
<td>BDO-AA</td>
<td>320</td>
<td>1020</td>
<td>110</td>
<td>43 Tm</td>
<td>52000</td>
<td>6210</td>
</tr>
<tr>
<td>STEPANPOL PC-1040P-55</td>
<td>A E C</td>
<td>Balance of tensile and tear strength and flexibility</td>
<td>EG/BDO-AA</td>
<td>1300</td>
<td>2040</td>
<td>55</td>
<td>17 Tm</td>
<td>29500</td>
<td>6050</td>
</tr>
<tr>
<td>STEPANPOL PC-1040P-110</td>
<td>A E</td>
<td>Balance of tensile and tear strength and flexibility</td>
<td>EG/BDO-AA</td>
<td>700</td>
<td>1020</td>
<td>110</td>
<td>11 Tm</td>
<td>49200</td>
<td>10950</td>
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<tr>
<td>STEPANPOL PC-105P-110</td>
<td>A E</td>
<td>Improve flexibility, tear strength, and cold crack resistance</td>
<td>HDO-AA</td>
<td>295</td>
<td>1020</td>
<td>110</td>
<td>46 Tm</td>
<td>Solid</td>
<td>955</td>
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<tr>
<td>STEPANPOL PC-107-110</td>
<td>A E</td>
<td>Improve durability, UV stable</td>
<td>NPG-AA</td>
<td>565</td>
<td>1020</td>
<td>110</td>
<td>ND</td>
<td>15700</td>
<td>875</td>
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<tr>
<td>STEPANPOL PDP-70</td>
<td>A E C</td>
<td>Imparts low viscosity, flexibility, aromatic, and ester/ether compatibility</td>
<td>Proprietary</td>
<td>1900 at 25°C</td>
<td>1600</td>
<td>70</td>
<td>ND</td>
<td>61600</td>
<td>7250</td>
</tr>
</tbody>
</table>

**Property values are typical and based on product concentration and/or mathematical and statistical calculations.**

A=Americas  E=Europe  C=Asia  **Prepolymers were made by reaction of polyol component with 4, 4'-diphenylmethane diisocyanate (MDI) to targeted % NCO by weight.

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### Polyester Polyols for Polyurethane Reactive Hot Melts (PURHMs)

<table>
<thead>
<tr>
<th>STEPANPOL® Products</th>
<th>Region</th>
<th>Performance Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEPANPOL PC-105-10</td>
<td>A E</td>
<td>Broad adhesion profile, extends open time, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-205P-17</td>
<td>A E</td>
<td>Good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-205P-20</td>
<td>A E</td>
<td>Good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-105P-22</td>
<td>A E</td>
<td>Good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-105P-30</td>
<td>A E</td>
<td>Workhorse, good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-205P-30</td>
<td>A E C</td>
<td>Workhorse, good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-105P-42</td>
<td>A E</td>
<td>Good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-205P-56</td>
<td>A E</td>
<td>Good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-2072P-30</td>
<td>A E</td>
<td>Excellent bonding profile, amorphous, aromatic, flexibility</td>
</tr>
<tr>
<td>STEPANPOL PC-5000P-30</td>
<td>A E C</td>
<td>Good bonding profile, crystalline</td>
</tr>
<tr>
<td>STEPANPOL PC-5120P-35</td>
<td>A E</td>
<td>Broad adhesion profile, flexibility, aromatic, extends open time while maintaining green strength</td>
</tr>
<tr>
<td>STEPANPOL PC-5120P-20</td>
<td>E</td>
<td>Good bonding profile, increase flexibility, amorphous, aromatic</td>
</tr>
<tr>
<td>STEPANPOL PH-56</td>
<td>A E C</td>
<td>Broad adhesion profile, extends set time, prepolymer grade</td>
</tr>
<tr>
<td>STEPANPOL PD-56</td>
<td>A E C</td>
<td>Broad adhesion profile, shortens set time, prepolymer grade</td>
</tr>
<tr>
<td>STEPANPOL PDP-70</td>
<td>A E C</td>
<td>Imparts low viscosity, flexibility, aromatic, and ester/ether compatibility</td>
</tr>
<tr>
<td>STEPANPOL PHN-56</td>
<td>A E C</td>
<td>Improves green strength, prepolymer grade</td>
</tr>
<tr>
<td>STEPANPOL PN-110</td>
<td>A E C</td>
<td>Improves green strength, prepolymer grade</td>
</tr>
</tbody>
</table>

**Property values are typical and based on product concentration and/or mathematical and statistical calculations.**

A=Americas  E=Europe  C=Asia  *ND is noted for Tg/Tm (°C) when no thermal transition was detected.
Thermoplastic to Thermoset - The Basics of PURHMs

Polyurethane Reactive Hot Melts, or PURHMs, are one component (1K) urethane reactive adhesives. These isocyanate-functional prepolymers are usually melted and applied around 120°C. Polyols in the PURHMs that are solid at room temperature refreeze upon cooling to develop initial bonds. Moisture curing then converts the adhesives from thermoplastic to thermoset polymers of even higher bond strength. As a technology, PURHMs provide variable open times to tailor assembly requirements with good green and ultimate bond strengths. Below is a representation of how these are made and work.

Polyol + Excess Isocyanate ➔ Prepolymer of ~2% excess Isocyanate

Prepolymer + heat to 120°C to melt and apply; acts as thermoplastic tacky adhesive

Cooling: thermoplastic product refreezes to form an initial fixture/bond

After cooling: Prepolymer + H2O ➔ Urethane crosslinked adhesive

<table>
<thead>
<tr>
<th>Backbone</th>
<th>Viscosity at 80 °C (cP)</th>
<th>Average Molecular Weight</th>
<th>Hydroxyl Value (mgKOH/g)</th>
<th>Tg/Tm °C</th>
<th>Melt Viscosity at 120 °C (cP)</th>
<th>Melt Viscosity at 130 °C (cP)</th>
<th>Polyl or blend</th>
<th>Open time, s†</th>
<th>Set time, s†</th>
<th>Tensile strength, psi***</th>
<th>Elongation at break, %***</th>
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<tbody>
<tr>
<td>HDO-AA</td>
<td>4500 at 60 °C</td>
<td>11,220</td>
<td>10</td>
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<td>45860</td>
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<td>HDO-AA</td>
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<td>HDO-AA</td>
<td>2650 at 60 °C</td>
<td>2670</td>
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<td>14720</td>
<td>12660</td>
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<td>10500</td>
<td>3740</td>
<td>30</td>
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<td>12280</td>
<td>9460</td>
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<td>35</td>
<td>21</td>
<td>3175</td>
<td>1146</td>
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<tr>
<td>Proprietary</td>
<td>26000</td>
<td>3200</td>
<td>35</td>
<td>-36 Tg</td>
<td>16000</td>
<td>13050</td>
<td>blend 25% in 205P-30</td>
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<td>15</td>
<td>3315</td>
<td>1215</td>
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<tr>
<td>Proprietary</td>
<td>6500 at 75 °C</td>
<td>5600</td>
<td>20</td>
<td>ND</td>
<td>7350</td>
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<td>blend 25% in 205P-30</td>
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<td>21</td>
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<td>HDO-PA</td>
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<td>2000</td>
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<td>-15 Tg</td>
<td>12650</td>
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<tr>
<td>Proprietary</td>
<td>1900 at 25 °C</td>
<td>1600</td>
<td>70</td>
<td>ND</td>
<td>6480</td>
<td>5310</td>
<td>blend 25% in 205P-30</td>
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<td>22</td>
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<td>2000</td>
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<td>blend 25% in 205P-30</td>
<td>90</td>
<td>72</td>
<td>1555</td>
<td>15</td>
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</tbody>
</table>

Crystalline aliphatic polyesters, typically hexanediol adipates or hexanediol dodecadioic acid polyols, are used as the workhorse polyols to put the “melt” in “hot-melts”. These provide great strength, chemical and solvent resistance, a broad adhesion profile, and sufficiently low viscosity at working temperatures. Aromatic polyesters are used to modify product adhesion and setting.

Typical Chemical Properties:

- Property values are typical and based on product concentration and/or mathematical and statistical calculations.
- ND is noted for Tg/Tm (°C) when no thermal transition was detected.
- Tests completed on the reaction products of the polyol blend with 4, 4'-diphenylmethane diisocyanate (MDI) to 2% NCO by weight.
- The same prepolymers were first cured at 25°C and 50% relative humidity for at least 72 hours before testing.

TYPICAL CHEMICAL PROPERTIES*
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