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Raw Materials for Flexible Packaging:
Fulfilling Your Specific Needs

Baycoll® Bayhydur® Desmodur® Desmophen® Dispercoll®
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As the world’s leading manufacturer of aliphatic and aromatic polyisocyanates, Covestro offers an extensive range of innovative products and solutions for the coatings and adhesives industries. As your customers become more demanding in their expectations for the quality, durability, workability and sustainability of your products, we can help you to turn these challenges into a competitive advantage. That is what drives us to push the boundaries of what is possible.

The key to creating added value for you, our customers, as well as for society and the environment is innovation. At Covestro we innovate not only to address the key global challenges of population growth, urbanization, climate change, digitalisation and increasing mobility; we innovate to have a sustainable business that enables us to live up to our business purpose of “making the world a brighter place”. In the final analysis, this comes down to developing sustainable solutions that take the entire life cycle of a product into account. We are increasing our on-site efficiency, e.g., by recycling salt and water in our production plants. We are expanding our resource base, e.g., by turning CO₂ into a raw material in the manufacturing of plastics. And we are developing materials that are more energy-efficient and save natural resources.

In our Coatings, Adhesives, Specialties (CAS) segment we systematically develop and supply aliphatic and aromatic isocyanates and their derivatives as well as polyurethane dispersions. Our raw materials are used for coatings, adhesives, sealants and specialty products, such as elastomers, high-quality films, 3D printing products, cosmetics, textiles and medical products. The main application areas are in the automotive, transportation, infrastructure, construction, wood processing and furniture industries. In this segment our innovative efforts are focusing on enhancing efficiency, improving quality, boosting sustainability and environmental aspects such as reducing solvent content.

We are proud of over 80 years of groundbreaking innovations. But we are not defined by our past. Even with decades of experience behind us, Covestro remains a young enterprise. In a corporate world that can often be dull and uninspiring, we want to act in a curious, courageous, and colorful way: trying out new things, questioning established ways, and pushing boundaries – for your benefit.
Flexible packaging is growing as a result of several lifestyle and other social trends. One of them is the trend towards more convenience. People like to buy products that are easy-to-open and reclosable for use on the go. This situation-based convenience trend underlines the growing importance of functional integration and new solutions such as reclosing, lightweight, and easy-opening packaging.

Other lifestyle changes impacting on the industry include the increasing number of single households in developed countries, which is boosting the demand for more and smaller packaging sizes; the fast-growing market for pre-cooked meals in several regions of the world; and the need for flexible packaging to prolong shelf life and thus tackle the serious issue of food waste.

Demand for greater sustainability
The growth in flexible packaging is partly due to the fact that it is lighter than other packaging solutions like glass or metal, which makes it the more sustainable choice. This saves energy during transportation, which also makes it more cost-efficient. At the same time, the flexible packaging industry is constantly looking for solutions to make its packaging even more sustainable, i.e. through bio-based raw materials, even thinner materials, or recyclable solutions.

Stricter food safety regulations and standards
Packaged food regulations and internal guidelines of processing enterprises are becoming stricter, with new regulations and standards frequently issued. As a result, every member of the value chain from the raw material provider to the brand owner has to assess and ensure the safety of their products. The question of which raw materials are used for which individual packed product has to be considered throughout the value chain. And that is why the industry is looking for economical products that simultaneously deliver a high degree of safety and avoid risk.

Maximizing efficiency
In a competitive environment it is crucial for converters to operate at the highest possible level of efficiency. That means high lamination speeds as well as the shortest possible production-to-customer times. Since ever-faster changes in packaging design are leading to smaller order sizes, converters need to adapt their production to this changing environment with a high degree of flexibility, while at the same time maintaining a high level of efficiency.

Covestro is working on new product developments that will enable the flexible packaging industry to respond to these trends.

Where the market for flexible packaging is heading
Our ambition – Providing you the best-in-class solutions

Quality & supply security
Our products are of outstanding quality and we offer supply security – worldwide.

Covestro, the world’s leading manufacturer of aliphatic and aromatic poly-isocyanates, offers an extensive range of raw materials and services for the coatings and adhesives industry. This allows the very latest technology to be used extremely effectively for a variety of applications. Our global setup enables you to increase your competitive advantage.

What we offer:
• A global network of research & development centers where our staff are dedicated to offering solutions for the coating and adhesive industry.
• A unique setup and worldwide network of state-of-the-art production sites ensuring short lead times and supply chain flexibility.
• Outstanding product quality through fulfilling the requirements of state-of-the-art quality, environmental and safety (HSEQ) as well as energy management standards; we are proud of having enjoyed ISO 9001, ISO 14001, ISO 18001 and ISO 50001 certifications for many years.

Covestro is your reliable partner for polyurethane chemistry.

Solutions to enhance your process efficiency
Nowadays, the quality demands made on industrial processes are very high. This is equally true of the cost-cutting requirements. However, both goals can be achieved by increasing process efficiency. At Covestro we have a wide range of solutions designed to enhance your process efficiency. Why not take advantage of our know-how? These solutions will benefit your bottom line.

Sustainability
Sustainability is at the heart of the Covestro strategy. We inspire innovation and drive growth through profitable products and technologies that benefit society and reduce the impact on the environment.

Renewable feedstocks, as one example, offer opportunities for developing more sustainable building blocks for flexible packaging – with significant potential for reducing the carbon footprint of end products while also reducing our overall dependence on fossil-based resources. To make more sustainable solutions not just possible but also economically feasible, the performance of polyurethane adhesives, as the main technology for flexible packaging, needs to satisfy high industry standards. To this end, we are evaluating the use of renewable raw materials to enlarge our product portfolio with new bio-based and mid- to long-term cost-competitive products. In all these efforts we are committed to focusing on products that do not compromise performance while at the same time are improving their contribution to sustainability.

Our coatings, adhesives and specialty products and solutions contribute to sustainability through:
• Saving energy – fast and smart
Polyurethane systems represent a benchmark in productivity and process efficiency in many industries. We strive to further push the limits of efficiency by developing game-changing new solutions.
• Reducing waste
We offer solutions such as innovative 1K technologies that enable our value chain partners to use materials more efficiently and reduce waste.
• Cutting emissions
Bayhydur® and Desmodur® grades are key enablers for low-emission solutions in the coatings and adhesives industries.
• Responsible management of natural resources
Highly durable PU-based coatings and adhesives significantly extend the lifetime of products applied to and thus help to prolong resource use.
• Closing the loop (circularity)
Through economically viable products made from bio-based raw materials—with no deterioration in performance—we help our customers and value chain partners to reduce their carbon footprint and offer solutions that incorporate renewable building blocks.

What we do
As a world-leading polymer and material science company, we inspire innovation and drive growth through profitable products and technologies that benefit society and reduce the impact on the environment.

Who does all this?
It’s our people! And the way we work together as one global team following a set of six elementary principles – value creation, sustainability, innovation, focus on people, safety and fair play. This is our formula for success.
The right answer to your needs – our technology

Polyurethane adhesives – the main technology for flexible packaging laminates

Polyurethane (PU) adhesive polymers can be produced from a wide range of raw materials. The enormous adaptability of PU polymers allows adhesive manufacturers to provide tailor-made adhesive polymers for flexible packaging applications. PU adhesives are therefore the number one choice for producing film/film or film/foil laminates. PU adhesives are in use for all classes of laminates from general-purpose laminates for dry food up to high-performance laminates for steam sterilization processes at temperatures of up to 134°C and/or aggressive products. At Covestro we offer a broad range of raw materials for PU adhesives used for flexible packaging applications. Our product range comprises aromatic and aliphatic diisocyanates, pre-polymers, aliphatic and aromatic crosslinkers, dispersions, as well as difunctional or polyfunctional polyester and polyester polyols. The raw materials we provide are manufactured in compliance with good manufacturing practice and fulfill the requirements of regulation (EC) 1935/2004.

The requirements for adhesives differ from market segment to market segment. Laminated film/film or film/foil composites are generally divided into three quality clusters: general-purpose, medium-performance, and high-performance laminates. The filling, the filling process, and the final use of the product determine the type of raw material to be used.

Choose our raw materials suitable for your one- or two-component solvent-based, solvent-free or water-based polyurethane formulation

Solvent-based polyurethane
- Possibility to apply thick adhesive layer
- Very high line speeds
- Mature technology
- Reaching highest performance levels

Solvent-free polyurethane
- Very high line speeds
- Typically used for general performance applications
- No need of hot room storage necessary
- Minimized lead times
- Lowest VOC level

Water-based polyurethane
- Initial bonding for direct slitting
- No need of hot room storage necessary
- Minimized lead times
- Lowest VOC level

Safe adhesives for safe food packaging

Laminated films and foils for flexible packaging need to meet demanding and very specific requirements. This is particularly true when they are being used for food or in medical applications. A polymer used in food packaging applications – in either direct or indirect food contact – has to comply with various regulations depending on the region the flexible packaging laminate is used in, for example:
- Regulation (EU) No. 10/2011
- BfR recommendation XXVIII (cross linked polyurethanes as adhesive layers for food packaging materials)
- FDA regulations in 21 CFR 175.105 (adhesives) and 21 CFR 177.1390 (laminate structures for use at temperatures of 250°F and above)
- Chinese hygienic standard GB 9685-2008

Upon request, we can provide you with a food contact use statement for suitable adhesive raw materials. Nevertheless, every adhesive manufacturer needs to make their own assessment of compliance for each particular adhesive formulation and provide a declaration of compliance to downstream users, i.e. converters and food manufacturers.
A broad portfolio to suit your needs

Building blocks for pre-polymer formation

Diisocyanates

Diisocyanates, and in particular the MDI-grades, are used in combination with polyether or polyester polyols for manufacturing NCO-terminated pre-polymers.

Desmodur® T, Desmodur® I and Desmodur® H are usually used to extend the molecular weight of polyether or polyester diols in order to adjust the processing window and adhesion properties of the adhesive polymer.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>TYPE</th>
<th>NCO CONTENT [%]</th>
<th>VISCOSITY [mPa·s]</th>
<th>PROPERTIES/APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desmodur® 44M, liquid</td>
<td>4,4’ MDI</td>
<td>33.6</td>
<td>4 at 40°C</td>
<td>Pre-polymer formation</td>
</tr>
<tr>
<td>Desmodur® LS 2424</td>
<td>MDI with high 2,4’-MDI isomer</td>
<td>33.6</td>
<td>12 at 25°C</td>
<td>Chain extender; pre-polymers with reduced viscosity and reduced monomer content.</td>
</tr>
<tr>
<td>Desmodur® 2460 M</td>
<td>MDI with high 2,4’-MDI isomer; color-stabilized</td>
<td>33.6</td>
<td>12 at 25°C</td>
<td>Chain extender; pre-polymers with reduced viscosity and reduced monomer content.</td>
</tr>
<tr>
<td>Desmodur® T 100</td>
<td>TDI with &gt; 99.0% 2,4-TDI</td>
<td>48</td>
<td>3 at 25°C</td>
<td>Chain extender.</td>
</tr>
<tr>
<td>Desmodur® T 80</td>
<td>TDI with 80.5% 2,4-TDI</td>
<td>48</td>
<td>3 at 25°C</td>
<td>Chain extender.</td>
</tr>
<tr>
<td>Desmodur® I</td>
<td>IPDI</td>
<td>37.5</td>
<td>10 at 25°C</td>
<td>Chain extender.</td>
</tr>
<tr>
<td>Desmodur® H</td>
<td>HDI</td>
<td>49.7</td>
<td>3 at 25°C</td>
<td>Chain extender.</td>
</tr>
</tbody>
</table>

Polyether and polyester diols

Polyester and polyester polyols can be used to produce both NCO- and OH-terminated pre-polymers for solvent-based or solvent-free one-component or two-component adhesives. Polyester polyols generally provide better adhesion to many substrates. Polyether polyols are used to reduce the processing viscosity and adjust the reactivity of the 2K polyurethane adhesives. Covestro offers a broad portfolio of polyester and polyether polyls that are suitable as building blocks for adhesives. The following table shows some selected examples. Please see also our brochure “Resins – Polyls and Aspartics for Reaction with Polysocyanates” for additional products.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>TYPE</th>
<th>OH NUMBER [mg KOH/g]</th>
<th>VISCOSITY [mPa·s]</th>
<th>PROPERTIES/APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baycoll® AD 2047</td>
<td>Polyester diol</td>
<td>Approx. 56</td>
<td>Approx. 7,000</td>
<td>Hydrolysis resistance, slip agent compatibility.</td>
</tr>
<tr>
<td>Baycoll® AD 2055</td>
<td>Polyester diol</td>
<td>Approx. 56</td>
<td>Approx. 630 at 75°C</td>
<td>Hydrolysis resistance, slip agent compatibility.</td>
</tr>
<tr>
<td>Baycoll® CD 2084</td>
<td>Polyester diol</td>
<td>Approx. 84</td>
<td>Approx. 120 at 75°C</td>
<td>Compatibility, bifunctional.</td>
</tr>
<tr>
<td>Desmophen® 2060 BD</td>
<td>Polyester diol</td>
<td>Approx. 56</td>
<td>Approx. 310 at 25°C</td>
<td>Low viscosity, compatibility.</td>
</tr>
<tr>
<td>Desmophen® 1110 BD</td>
<td>Polyester diol</td>
<td>Approx. 112</td>
<td>Approx. 140 at 25°C</td>
<td>Low viscosity, compatibility.</td>
</tr>
<tr>
<td>Desmophen® 1400 BT</td>
<td>Polyester triol</td>
<td>Approx. 400</td>
<td>Approx. 370 at 25°C</td>
<td>Long pot life, short reaction time, compatibility, increase functionality.</td>
</tr>
</tbody>
</table>
Isocyanate crosslinkers
Crosslinkers are used to crosslink solvent-based OH-terminated pre-polymers manufactured from polyether and/or polyester diols. The dosage of isocyanate crosslinker is usually in the range of isocyanate index 1.2–1.4. All isocyanate crosslinkers except Desmodur® ultra N 3300 are dissolved in ethyl acetate.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>NCO CONTENT</th>
<th>TYPE</th>
<th>VISCOSITY AT 23°C [mPa·s]</th>
<th>PROPERTIES/ APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desmodur® L 75</td>
<td>13</td>
<td>Adduct of TDI/ TMP</td>
<td>1,600</td>
<td>Standard crosslinker for solvent-based adhesives.</td>
</tr>
<tr>
<td>Desmodur® ultra L 75</td>
<td>13.3</td>
<td>Adduct of TDI/ TMP</td>
<td>1,600</td>
<td>Crosslinker for solvent-based adhesives; low monomeric TDI content (&lt; 0.1%).</td>
</tr>
<tr>
<td>Desmodur® HL EA</td>
<td>10.5</td>
<td>TDI isocyanurate</td>
<td>1,100</td>
<td>Highly functional crosslinker with partly aliphatic NCO groups for solvent-based adhesives.</td>
</tr>
<tr>
<td>Desmodur® ultra N 3300</td>
<td>21.8</td>
<td>HDI isocyanurate</td>
<td>3,000</td>
<td>Highly functional crosslinker with aliphatic NCO groups for solvent-based adhesives. Low monomeric HDI content (&lt; 0.1%).</td>
</tr>
<tr>
<td>Desmodur® ultra N 3600</td>
<td>23.0</td>
<td>HDI trimer</td>
<td>1,200</td>
<td>HDI isocyanurate. Low monomeric HDI content (&lt; 0.1%).</td>
</tr>
</tbody>
</table>
NCO-terminated pre-polymers and polyfunctional isocyanates

NCO-terminated pre-polymers are reaction products of aromatic or aliphatic isocyanates and polyols, such as polyethers or polyesters. Thanks to the wide variability of the isocyanate content and functionality, the viscosity of the pre-polymers and the mechanical properties of the finished products can be precisely adjusted. NCO-terminated pre-polymers can be used as the isocyanate components of 2K solvent-free adhesive. The pre-polymers can be used individually or in combination with other pre-polymers, e.g., to adjust the processing viscosity or crosslinking density of the adhesive polymer.

### Pre-polymers

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>NCO CONTENT [%]</th>
<th>VISCOSITY AT 23°C [mPa·s]</th>
<th>PROPERTIES/ APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desmodur® E XP 2726</td>
<td>MDI pre-polymer 6.0</td>
<td>ca. 15% 4,500</td>
<td>Pre-polymers for solvent-free adhesives.</td>
</tr>
<tr>
<td>Desmodur® E 23</td>
<td>MDI pre-polymer 15.4</td>
<td>ca. 40% 1,800</td>
<td>Pre-polymers for solvent-free adhesives.</td>
</tr>
<tr>
<td>Desmodur® XP 2617</td>
<td>HDI pre-polymer 12.5</td>
<td>≤ 0.5% 4,250</td>
<td>Pre-polymers for solvent-free adhesives.</td>
</tr>
</tbody>
</table>

### Crosslinker

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>NCO CONTENT [%]</th>
<th>VISCOSITY AT 23°C [mPa·s]</th>
<th>PROPERTIES/ APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Desmodur® ultra N 3600</td>
<td>HDI trimer 23.0</td>
<td>≤ 0.25% 1,200</td>
<td>HDI isocyanurate. Low monomeric HDI content (&lt; 0.1%).</td>
</tr>
<tr>
<td>Desmodur® ultra N 3300</td>
<td>HDI trimer 21.8</td>
<td>≤ 0.15% 3,000</td>
<td>HDI isocyanurate. Low monomeric HDI content (&lt; 0.1%).</td>
</tr>
<tr>
<td>Desmodur® ultra L 75</td>
<td>Adduct of TDI/TMP 13</td>
<td>&lt; 0.1% 1,600</td>
<td>Standard crosslinker for solvent-based adhesives.</td>
</tr>
</tbody>
</table>
Our water-based dispersions enable adhesive solutions that are both highly efficient and more sustainable. Laminates made from water-based adhesives can be immediately processed and thus help to optimize and reduce costs in a converter’s production process.

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>TYPE</th>
<th>VISCOSITY AT 23°C [mPa·s]</th>
<th>NON-VOLATILE CONTENT [%]</th>
<th>PROPERTIES/APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dispercoll® U XP 2643</td>
<td>Polyester-based PU dispersion</td>
<td>39–41</td>
<td>&lt; 1,000</td>
<td>Dispercoll® polymer containing carboxyl groups in the polymer chain; can be crosslinked.</td>
</tr>
<tr>
<td>Dispercoll® U 2824 XP</td>
<td>Polyester-based PU dispersion</td>
<td>38–41</td>
<td>50–400</td>
<td>Dispercoll® polymer containing carboxyl groups in the polymer chain; can be crosslinked with isocyanate and polycarbodiimide.</td>
</tr>
<tr>
<td>Dispercoll® U 42</td>
<td>Polyester-based PU dispersion</td>
<td>48–52</td>
<td>150–800</td>
<td>Dispersion polymer can be crosslinked with isocyanate.</td>
</tr>
<tr>
<td>Dispercoll® U 2682</td>
<td>Polyester-based PU dispersion</td>
<td>49–51</td>
<td>&lt; 1,000</td>
<td>Dispersion polymer can be crosslinked with isocyanate for formulation of industrially compostable adhesives.</td>
</tr>
</tbody>
</table>

Isocyanate crosslinker for water-based adhesives + higher functionality. Low monomer content (< 0.1%).

<table>
<thead>
<tr>
<th>PRODUCT</th>
<th>VISCOSITY AT 23°C [mPa·s]</th>
<th>ACTIVE INGREDIENTS</th>
<th>PROPERTIES/APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bayhydur® ultra 304</td>
<td>Approx. 4,000</td>
<td>18.2% NCO</td>
<td>Isocyanate crosslinker for water-based adhesives. Low monomer content (&lt; 0.1%).</td>
</tr>
<tr>
<td>Bayhydur® ultra 3100</td>
<td>Approx. 2,800</td>
<td>17.4% NCO</td>
<td>Isocyanate crosslinker for water-based adhesives. Low monomer content (&lt; 0.1%).</td>
</tr>
<tr>
<td>Desmodur® XP 2802</td>
<td>Approx. 30</td>
<td>1 mmol/g –N=C=N– + 1 mmol/g –N=C=O–</td>
<td>Carbodiimide crosslinker for 1 component water-based adhesives containing carboxyl groups in the polymer chain; with long pot life (6 months) &amp; very fast curing. direct slitting after lamination.</td>
</tr>
</tbody>
</table>
Safeguard your market position with our latest innovations

We regularly innovate to serve our customers with raw materials for adhesives that deliver on industry trends. Modern PU adhesives for flexible packaging applications ideally combine the benefits of easy handling, good process ability, fast curing, safe use by consumers, and the lowest possible environmental impact.

Process efficiency
Maintaining high converting line speeds, even under tough packaging performance requirements, is key to maximizing profitability. As our Dispercoll® U types for water-based adhesives enable sufficient curing directly after application on laminate substrates, direct downstream processing (e.g. slitting) is possible. This enables direct and food-safe delivery of reeled laminates to brand owners. Furthermore, our Desmodur® XP 2802 crosslinker can be incorporated into water-based adhesives to produce a one-component system with the performance of a two-component system. Easy handling is ensured as mixing errors are prevented. Moreover, the long pot life of up to six months prevents adhesive waste.

Safe packaging
There is no compromising on safety. Our ultra line crosslinkers (e.g. Desmodur® ultra for solvent-based and solvent-free adhesives or Bayhydur® ultra for water-based adhesives) maximize safety for packed food. Thanks to their aliphatic structures there is no risk of polymeric aromatic amine formation. Additionally, workplace hygiene is maximized as monomeric content has been reduced to a minimum level (<0.1%).

Sustainability
Flexible packaging already contributes to sustainability by preserving nutrients, extending the shelf life of food, and thus preventing food waste. At same time, material usage is minimized.

Nevertheless, the impact on the environment of plastic waste that is not correctly disposed of makes the news almost every day. So through our research and in close cooperation with our customers we are striving to improve flexible packaging with regards to sustainability in several ways. For example, we are improving its environmental footprint through the increased utilization of bio-based feedstocks, such as our Desmodur® eco line products. Moreover, Dispercoll® U 2682 is used for the formation of industrially compostable water-based adhesives (according to DIN EN 13432 and ASTM D 6400-04). And we are already working on the next step forward: raw materials for biodegradable adhesives. Together with our partner network along the value chain, we are further assessing adhesive-related potentials to improve sustainability aspects of multi-layer laminates.
Fast-lane access to polyurethane innovations

At Covestro, innovation is in our DNA. Ever since Otto Bayer discovered polyurethanes in 1937, we have been driving polyurethane innovations in coatings and adhesives as well as in other application areas. As our partner, you enjoy fast-lane access to polyurethane innovations, and can help us in developing the next generation of polyurethanes to meet the industry’s upcoming challenges and needs. What can we offer you?

- Powerful know-how on both established and new polyisocyanates, as well as on new polyurethane hybrid technologies.
- The prospect of new application technologies to enable efficient processes.
- More sustainable, biomass- or CO₂-based materials that do not sacrifice high performance.

Join us to shape the future!