POLYVINYL BUTYRAL
OF SUPERIOR QUALITY
Kuraray is the leading supplier of polyvinyl alcohol (Mowiol® and Kuraray Poval®), its films and fibres (KURALON), polyvinyl butyral (Mowital® and Pioleform®) and its films (TROSIFOL®) for the global market. Kuraray also manufactures a variety of special polymers like ethylene vinyl alcohol copolymers (Exceval™ & EVAL™) and thermoplastic elastomers (SEPTON™ & HYBRAR™). In addition, based on the polymer technologies, the company also supplies dental products, fibres, textiles and synthetic leathers.

Employing more than 7,000 people, the Kuraray Group achieves annual sales of about four billion dollars. Kuraray Europe GmbH is a 100 percent subsidiary of the Japanese Kuraray Co. Ltd. in Tokyo based in Hattersheim am Main and employs almost 650 people. At its production site in the industrial park in Frankfurt-Höchst (Germany) it produces about 94,000 tons of polyvinyl alcohol and 40,000 tons of polyvinyl butyral per year.
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Production of polyvinyl butyral
WHAT ARE POLYVINYL BUTYRAL POLYMERS?
Under the brand names Mowital and Pioloform, Kuraray Europe GmbH produces polyvinyl butyral resins whose properties are characterised by the presence of butyral units, hydroxyl, and acetyl groups. With its excellent adhesive and film-forming properties, its strong binding power and its outstanding optical transparency, polyvinyl butyrals are unquestionably a versatile thermoplastic material. Today, the main areas of application of polyvinyl butyral include inter-layers for safety glass, paints, lacquers, and varnishes (e.g. primers for metals and anti-corrosion paints), printing inks, temporary binders, and adhesives.

PRODUCTION OF POLYVINYL BUTYRALS
The principal manufacturing processes for the production of polyvinyl butyral were developed between 1929 and 1939. Polyvinyl butyrals have been produced for more than 50 years at the Frankfurt-Höchst Industrial Park. This is a product tradition which Kuraray continues by constantly optimising existing applications and developing new innovative uses. The company currently produces around 40,000 metric tons of polyvinyl butyrals annually at the Frankfurt-Höchst production site.

Polyvinyl acetates with various molecular weights serve as the starting materials for the production of polyvinyl butyrals. Polyvinylalcohols (PVA) are produced from polyvinyl acetates by means of transesterification. The reaction of the aqueous polyvinyl alcohol solutions with aldehydes in the presence of small amounts of mineral acid yields polyvinyl butyrals.

PIOLOFORM - MIXED POLYVINYL BUTYRAL
Pioloform is a special type of polyvinyl butyral that is generally produced in a three-step process. First, vinyl acetate is polymerized to polyvinyl acetate. Second, this is saponified to polyvinyl alcohol. Third, an aqueous solution of the polyvinyl alcohol reacts with two aldehydes, in the presence of acidic catalysts, for polyvinyl butyral.

The polyvinyl butyral precipitate is filtered off the aqueous liquor, washed, and dried. Since not all hydroxyl groups (OH) of the polyvinyl alcohol react with aldehyde, however, Pioloform invariably contains a certain percentage of the hydroxyl groups. Moreover, a small percentage of the acetyl groups always remains in the Pioloform polymer chain from the upstream transesterification during which polyvinyl acetate is converted to polyvinyl alcohol.

For statistical reasons, the theoretical upper limit of the acetalisation reaction of polyvinyl alcohols is about 82 mol %. Consequently, polyvinyl butyrals always contain at least 7 % by weight residual vinyl alcohol units (hydroxyl groups).

It is standard practice to use polyvinyl butyrals with vinyl alcohol contents of 9 to approx. 30 % by weight.
Polyvinyl butyrals (PVB) consist of carbon, hydrogen, and oxygen. Under free-air combustion conditions (I-value = 1), Mowital burns with virtually no residue to produce carbon dioxide and water (investigation performed in the VCI combustion apparatus). For this reason, Mowital is one of the waste products which poses no disposal problems. Mowital is non-toxic and therefore especially suitable for use in food packaging. The use of Mowital in this area is governed by:

- EU regulation No. 0010/2011 of 14 January 2011 on plastic materials and articles intended for contact with food (Plastic Implementation Measures, PIM Regulation),
- Council of Europe, Resolution RESAP (2004) 1, formerly AP (96) 5, on surface coatings intended for contact with foodstuffs (list of authorized monomers and starting substances in Appendix II, List 1),
THE PRODUCT RANGE
The constellation of properties displayed by the individual grades of Mowital and Pioloform, and thus the suitability of each grade for the particular application, is determined mainly by three factors:

- the degree of acetalisation
- the degree of polymerisation (the solution viscosity)
- the used aldehydes

As relative measures of polarity and molecular weight of the polymer, the above parameters are characteristic values of prime importance.

The degree of acetalisation of Mowital or Pioloform correlates directly with the residual concentration of polyvinyl alcohol: the lower the residual PVA concentration, the higher the degree of acetalisation. In the following schematic representation, the different grades of Mowital are arranged according to the above-mentioned parameters.

NOMENCLATURE OF MOWITAL/PIOLOFORM
The numbers 16, 20, 30, 45, 60, and 75 contained in the type designation for Mowital are relative measures indicating the increasing degree of polymerisation or molar mass and thus the rising solution viscosity. The alphabetical suffix points to the increasing degree of acetalisation ranging from the T grades over the H grades up to the HH grades.

Pioloform BL 16 represents a special grade of PVB consisting of mixed aldehydes. Mowital BX represents a new class of polyvinyl butyral which is characterized by a significant higher number of acetate groups.
Characteristic properties of polyvinyl butyrals
The different grades of Mowital and Pioloform are thermoplastic polyvinyl butyral resins supplied as fine-grained, free-flowing powders. The degrees of acetalisation and polymerisation largely determine important properties of these grades, such as their solubility, film properties and ability to combine and react with other binders. Mowital and Pioloform produce lightfast, tough-elastic films with a high inner strength.

The water resistance of the films rises as the number of butyral groups in the Mowital and Pioloform molecule increases. Accordingly, coatings based on the highly butyralised Mowital grades B 30 HH and B 60 HH display the greatest water resistance. Because the polarity of the molecule decreases as the degree of acetalisation rises, the HH grades (which have the lowest polarity) display the best solubility in non-polar solvents.

The glass transition temperature (Tg) of the Mowital and Pioloform grades declines as the number of butyral groups increases and the degree of polymerisation decreases. Values between 63 and 84 °C have been measured for the individual grades. (DSC; heating rate of 10 K/min).

The films formed by all the Mowital and Pioloform grades are heat-sealable. In addition, Mowital is non-toxic and therefore especially suitable for use in food packaging. The use of Mowital in this area is governed by:

- EU regulation No. 0010/2011 of 14 January 2011 on plastic materials and articles intended for contact with food (Plastic Implementation Measures, PIM Regulation),
- Council of Europe, Resolution RESAP (2004) 1, formerly AP (96) 5, on surface coatings intended for contact with foodstuffs (list of authorized monomers and starting substances in Appendix II, List 1),
Depending on the degree of acetalisation, or the residual PVA content, the individual Mowital and Pioloform grades display different physical and chemical properties. The molar mass, or the degree of polymerisation, is of great importance for the thermal and mechanical properties and the viscosity in solution. Of all the Mowital and Pioloform grades, Mowital B 16 H exhibits the lowest solution viscosity. With this resin, the greatest film thickness can be achieved during each spray-application step. The good water resistance of Mowital B 60 H is topped by Mowital B 60 HH. Mowital B 30 HH displays the best solubility in non-polar solvents and the best compatibility with aromatic components. Mowital B 30 H has proven its worth as an ‘all purpose’ grade with a broad application spectrum. For the Mowital grades shown in the graphic on page 14, the weight(ed) average molecular weight of the molar masses (Mw) was determined via gel permeation chromatography (GPC) in combination with a molar mass calibration curve. The molar masses determined for polymers always depend on the method of determination. Consequently, comparisons are permissible here only if the values were obtained using the same methods under identical conditions. However, precise knowledge of the molar mass is frequently of only secondary importance. For most application areas, it is entirely sufficient to know the corresponding viscosity value of the solutions at certain concentrations and the content of polyvinyl alcohol. It is thus vital that both the viscosity and the polyvinyl alcohol content remain within the limits set down in the stringent specifications for each grade; this is ensured for the Mowital and Pioloform grades by our quality assurance system.

**DISTINGUISHING FEATURES**

**COMPARISON OF OUR POLYVINYL BUTYRALs AND THEIR PROPERTIES**

<table>
<thead>
<tr>
<th>B 16...</th>
<th>B 20...</th>
<th>B 30...</th>
<th>B 45...</th>
<th>B 60...</th>
<th>B 75...</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ molecular weight</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ solution viscosity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ melting and softening range</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ toughness</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>B...T</th>
<th>B...H</th>
<th>B...HH</th>
</tr>
</thead>
<tbody>
<tr>
<td>✓ water resistance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ solubility in non-polar solvents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>✓ compatibility with non-polar polymers</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Water absorption of Mowital/Pioloform

Since the polymer properties can be exactly controlled, Mowital types meet the requirements for a wide range of industrial applications. The degrees of polymerisation and acetalisation determine the basic properties as well as combinatorial and reactivity qualities of polyvinyl butyral.

Mowital is colourless, transparent and light-fast. The glass transition temperature of the Mowital types decreases with increasing content of the acetal groups and decreasing degree of polymerisation. Values between 60°C and 73°C are measured for the individual types. The mixed acetal type BL 16 achieves even 84°C.

The melting range starts with the low-viscous types at about 130°C and ends with the high-viscous types at approximately 220°C.

Thanks to their low melting temperature and excellent flow qualities, Mowital and Pioloform types are easy to use in, for example, moulding.®

---

**Melt flow index**

<table>
<thead>
<tr>
<th>Type</th>
<th>Melt flow index [g/10 min]</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 16 H</td>
<td>2.20</td>
</tr>
<tr>
<td>B 20 H</td>
<td>2.10</td>
</tr>
<tr>
<td>BL 16</td>
<td>2.00</td>
</tr>
<tr>
<td>B 30 H</td>
<td>1.90</td>
</tr>
<tr>
<td>B 30 T</td>
<td>1.80</td>
</tr>
<tr>
<td>B 45 H</td>
<td>1.70</td>
</tr>
<tr>
<td>B 45 M</td>
<td>1.60</td>
</tr>
<tr>
<td>B 60 H</td>
<td>1.50</td>
</tr>
<tr>
<td>B 60 HH</td>
<td>1.40</td>
</tr>
<tr>
<td>B 75</td>
<td>1.30</td>
</tr>
</tbody>
</table>

**Water absorption (%)**

- at 23°C / 50% r. H.
- at 23°C / 98% r. H.

- HH type: 11–14 % OH content
- H type: 18–21 % OH content
- M type: 21–24 % OH content
- T type: 24–27 % OH content
- BX 860: 18–21 % OH content
- BL 16: 14–18 % OH content
Comparision of viscosities

Viscosities at different concentrations using different solvents

Dissolved in butanol
Viscosity (mPa · s)*
10000
1000
100
10
0
0 5 10 15 20
Concentration (wgt.%)

Dissolved in isopropanol
Viscosity (mPa · s)*
10000
1000
100
10
0
0 5 10 15 20
Concentration (wgt.%)

Dissolved in ethanol
Viscosity (mPa · s)*
10000
1000
100
10
0
0 5 10 15 20
Concentration (wgt.%)

Mowital B 16 H

* dynamic viscosity
(DIN 53015, 20 °C)
**VISCOSITY OF PORTFOLIO PRODUCTS**

Viscosity of portfolio products (mPa · s)

- Ethanol 10%
- Ethanol-toluene 1:1, 10%

<table>
<thead>
<tr>
<th>Product</th>
<th>Viscosity (mPa · s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>B 16 H</td>
<td>63</td>
</tr>
<tr>
<td>B 20 H</td>
<td>64</td>
</tr>
<tr>
<td>BL 16</td>
<td>70</td>
</tr>
<tr>
<td>B 30 T</td>
<td>70</td>
</tr>
<tr>
<td>B 30 H</td>
<td>68</td>
</tr>
<tr>
<td>B 30 HH</td>
<td>63</td>
</tr>
<tr>
<td>B 45 M</td>
<td>73</td>
</tr>
<tr>
<td>B 45 H</td>
<td>73</td>
</tr>
<tr>
<td>BX 860</td>
<td>69</td>
</tr>
<tr>
<td>B 60 T</td>
<td>72</td>
</tr>
<tr>
<td>B 60 H</td>
<td>70</td>
</tr>
<tr>
<td>B 60 HH</td>
<td>65</td>
</tr>
<tr>
<td>B 75 H</td>
<td>73</td>
</tr>
</tbody>
</table>

* 5% Viscosity

**Temperature (°C)**

- Glass Transition Temperature (DSC method)

- 63 64 70 70 84 68 63 69 66 72 70 65 73
Average molar mass and degree of polymerisation

Viscosity of portfolio products and softening range

Glass Transition Temperature (DSC method)

Softening range (ring and ball method, DIN ISO 4625)
Viscosity dependence on temperature

Viscosities at different temperatures in ethanol:toluene 1:1, 10% (mPa · s)
### Solubility of Mowital and Pioloform

#### Alcohols
- Methanol
- Ethanol
- Propanol
- i-Propanol
- Butanol
- i-Butanol
- Diacetone alcohol
- Benzyl alcohol

#### Glycol ethers
- 1-Methoxy propanol-2
- Butyl glycol
- 3-Methoxy-butanol-1 (methoxy butanol)
- Dowanol (DPnB)

#### Ethers
- Dioxane
- Tetrahydrofuran (THF)

#### Cellusolve™
- Methyl Celusolve
- Ethyl Celusolve
- Butyl Celusolve

#### Esters
- Methoxy propyl acetate
- Methyl acetate
- Ethyl acetate
- Butyl acetate
- Acetic acid-3-methoxy-n-butylester (Butoxyl)
- Glycolic acid-n-butylester (Polysolvan 0)
- Dibasic esters (DBE)
- Ethyl lactate

#### Ketones
- Acetone
- Methyl ethyl ketone
- Methyl isobutyl ketone
- Cyclohexanone

#### Hydrocarbons
- Aliphatic
- Toluene
- Xylene

#### Others
- Terpineol
- Butyl carbitol
- Acetic Acid
- Dimethyl sulfoxide (DMSO)

---

1) Completely soluble if solvent contains 10% alcohol.
The solubilities stated here refer to the pure solvents (determined in 10% solution – for B 75 H in 5% solution)
In many cases solvent blends have superior dissolving capacity.
Thermogravimetric behaviour of Mowital B 45 H and Mowital B 75 H under air and nitrogen conditions.

**Thermogravimetric Analyses under air**

- **Thermogravimetric Analyses of Mowital B 45 H and Mowital B 75 H**
  - Heating speed 5 K/min, under air

**Thermogravimetric Analyses under nitrogen**

- **Thermogravimetric Analyses under nitrogen**
  - Heating speed 5 K/min, under nitrogen

Legend:
- B 75 H
- B 60 H
- BL 16
- B 20 H
- B 45 H
- green tape based on Mowital B 75 H
<table>
<thead>
<tr>
<th>grade</th>
<th>specification viscosity (10% ethanol) [mPas]</th>
<th>corresponding viscosity range (10% ethanol/toluene 1:1) [mPas]</th>
<th>Hoeppler method</th>
<th>Brookfield method (20 °C / 30 rpm)</th>
<th>PVON content (Hydroxyl)</th>
<th>PVOAc content (Acetate)</th>
<th>glass transition temperature = Tg [°C]</th>
<th>solid [wt%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mowital B 16 H</td>
<td>14.0 - 20.0</td>
<td>9.0 - 14.0</td>
<td></td>
<td></td>
<td>18.0 - 21.0</td>
<td>26.2 - 30.2</td>
<td>1.0 - 4.0</td>
<td>0.7 - 3.0</td>
</tr>
<tr>
<td>Mowital B 20 H</td>
<td>20.0 - 30.0</td>
<td>14.0 - 23.0</td>
<td></td>
<td></td>
<td>18.0 - 21.0</td>
<td>26.2 - 30.2</td>
<td>1.0 - 4.0</td>
<td>0.7 - 3.0</td>
</tr>
<tr>
<td>Mowital B 30 T</td>
<td>30.0 - 55.0</td>
<td>26.0 - 50.0</td>
<td></td>
<td></td>
<td>24.0 - 27.0</td>
<td>33.8 - 37.6</td>
<td>1.0 - 4.0</td>
<td>0.7 - 2.9</td>
</tr>
<tr>
<td>Mowital B 30 H</td>
<td>35.0 - 60.0</td>
<td>24.0 - 42.0</td>
<td></td>
<td></td>
<td>18.0 - 21.0</td>
<td>26.2 - 30.2</td>
<td>1.0 - 4.0</td>
<td>0.7 - 3.0</td>
</tr>
<tr>
<td>Mowital B 30 HH</td>
<td>35.0 - 60.0</td>
<td>23.0 - 41.0</td>
<td></td>
<td></td>
<td>11.0 - 14.0</td>
<td>16.7 - 20.8</td>
<td>1.0 - 4.0</td>
<td>0.8 - 3.1</td>
</tr>
<tr>
<td>Mowital B 45 M</td>
<td>80.0 - 110.0</td>
<td>55.0 - 76.0</td>
<td></td>
<td></td>
<td>21.0 - 24.0</td>
<td>30.2 - 34.0</td>
<td>1.0 - 4.0</td>
<td>0.7 - 2.9</td>
</tr>
<tr>
<td>Mowital B 45 H</td>
<td>60.0 - 90.0</td>
<td>36.0 - 54.0</td>
<td></td>
<td></td>
<td>18.0 - 21.0</td>
<td>26.2 - 30.2</td>
<td>1.0 - 4.0</td>
<td>0.7 - 3.0</td>
</tr>
<tr>
<td>Mowital B 60 H</td>
<td>160.0 - 260.0</td>
<td>120.0 - 200.0</td>
<td></td>
<td></td>
<td>18.0 - 21.0</td>
<td>26.2 - 30.2</td>
<td>1.0 - 4.0</td>
<td>0.7 - 3.0</td>
</tr>
<tr>
<td>Mowital B 60 HH</td>
<td>120.0 - 280.0</td>
<td>80.0 - 190.0</td>
<td></td>
<td></td>
<td>12.0 - 16.0</td>
<td>18.1 - 23.7</td>
<td>1.0 - 4.0</td>
<td>0.8 - 3.0</td>
</tr>
<tr>
<td>Mowital B 60 T</td>
<td>180.0 - 280.0</td>
<td>160.0 - 260.0</td>
<td></td>
<td></td>
<td>24.0 - 27.0</td>
<td>33.8 - 37.6</td>
<td>1.0 - 4.0</td>
<td>0.7 - 2.9</td>
</tr>
<tr>
<td>Mowital B 75 H</td>
<td>60.0 - 100.0</td>
<td>44.0 - 75.0</td>
<td></td>
<td></td>
<td>18.0 - 21.0</td>
<td>26.2 - 30.2</td>
<td>0 - 4.0</td>
<td>0.0 - 3.0</td>
</tr>
<tr>
<td>Mowital BX 860</td>
<td>100.0 - 150.0</td>
<td>60.0 - 90.0</td>
<td></td>
<td></td>
<td>18.0 - 21.0</td>
<td>26.7 - 30.9</td>
<td>14.0 - 18.0</td>
<td>10.5 - 14.1</td>
</tr>
<tr>
<td>Pioloform BL 16</td>
<td>24.0 - 30.0</td>
<td>15.0 - 20.0</td>
<td></td>
<td></td>
<td>14.0 - 18.0</td>
<td>20.8 - 26.3</td>
<td>1.0 - 4.0</td>
<td>0.7 - 3.1</td>
</tr>
</tbody>
</table>

1) 5% viscosity
2) calculated
Mowital is a thermoplastic material that is soluble in a large number of organic solvents and can be cross-linked with other reaction partners. The cross-linking capacity depends on the number of OH groups available for the reaction. Phenolic, epoxy, and melamine resins are used as reaction partners to produce high quality stoveing enamels. For systems cured at room temperature, phenolic, urea, and melamine resins as well as polyisocyanates are used in combination with acid catalysts. These reactions are shown in the following equations using structural formulas. Cross-linking polyvinyl butyrals yields an improved

1) solvent resistance
2) chemical resistance
3) temperature resistance

**CROSS-LINKING REACTIONS**

**REACTION WITH PHENOLIC RESINS**

**REACTION WITH EPOXY RESINS**
**REACTION WITH MELAMINE RESINS**

```
OH → HOCH₂
\[\text{melamine resin}\] → CH₂OH → HO
```

**REACTION WITH POLYISOCYANATES**

```
OH + OCN-(R)-NCO → HO → + NR₃
```

**REACTION WITH DIALDEHYDES**

```
OH → OHC-(R)-CHO → HO → + H⁺ → - H₂O
```

- PVB
- melamine resin
- OCN-(R)-NCO
- PVB
- PVB
- dialdehyde
Mowital and Piooloform, materials that form a strong bond
Polyvinyl butyrals fit the check list for an enormous number of applications. Among other things, Mowital and Pioloform are an essential constituent of lightfast, highly transparent, elastic and tear-proof films. Mowital / Pioloform film is pressed between two glass panes to create fracture-resistant and shatterproof laminated safety glass used mainly in the building and automobile industries. The automobile industry is also where polyvinyl butyral grades exhibiting a long-lasting adhesive action are used; these grades are especially suitable as a component of stoving enamels. Used as a constituent of anti-corrosive primers, Mowital and Pioloform protects steel against rust and promotes the adhesion of the topcoat. In printing ink it ensures adhesion to a wide variety of surfaces, e.g. to plastic packaging for foodstuffs and heat-sensitive products. Furthermore, Mowital can be used to build up retroreflecting layers in traffic signs and road markings - an application resulting in greater safety on our roads. Owing to its outstanding binding power and elasticity, Mowital is an excellent material for the manufacture of ceramic slurry and green tape. Since it combusts with virtually no residue, it is an ideal temporary binder for the manufacture of high-performance ceramics.
The table gives an overview of the wide range of Mowital and Pioloform applications. Properties and applications depend mainly on the degree of acetalisation and the viscosity of a Mowital or Pioloform grade. The numerical suffix of the grade designation (16, 20, 30, 45, 60 and 75) indicates the increasing degree of polymerisation (and thus the increasing viscosity). The designations T, H and HH indicate different degrees of acetalisation.
Mowital®
Pioloform®

Main application area
Possible application area

Inkjet printing inks
Flexographic/special gravure inks
Pigment preparations
Thermo-transfer inks
Temporary binder materials
Foundry aids
Adhesive additives/rheology modifiers
Hotmelt binders
Binder for abrasive papers
Light bulb cement
Structural Adhesives
Cardboard packaging impregnations
Candle coatings
Prepregs/Composites
Thermoplastic processing

Strippable packaging coatings
Automotive refinishing coatings
Can coating/stoving enamels
Film lacquers
Electrostatic spray primers
Corrosion protection/shop primers/wash primers
Heat-sealable lacquers
Radiator primers/topcoats
Wood sealing varnishes
Plastic surface finishes/nitrocellulose lacquers
Gear paints/paper varnishes/adhesives/oil-resistant lacquers
Road marking paints
Additive for powder coatings
Coil coatings
Zinc-rich primers

Modern primers and lacquers have to do more than adhere well. They should be easy to work with, harmonise with numerous binders, and serve additional functions such as corrosion protection. Mowital and Pioloform is the ideal basis for all these applications.

**COMBINATION WITH OTHER BINDERS**

Owing to their excellent compatibility with phenolic resins, Mowital grades B 30 T and B 60 T are frequently used as combination partners for stoving enamels in the packaging industry. Whereas Mowital H grades exert a greater plasticising effect, the Mowital T grades achieve better crosslinkage. Mowital B 30 HH is a binder that exhibits a high tolerance of aromatic solvents and a broad spectrum of compatibility with other raw materials used in coatings. As a result, it can be used to produce primers which can be cured with polyamine or isocyanates. For polyamidoamine or polyamine curing, Epikote 1001 is an especially suitable combination partner. Mowital serves to accelerate the physical drying phase and does not react with polyamines at room temperature.

To produce high-quality coatings, Mowital B 30 HH can be combined with Epikote 1001 in proportions ranging from 3:1 to 1:3 (solid:solid). As the percentage of epoxy resin rises, the water resistance increases while the elasticity decreases. When isocyanates, e.g. Desmodur N 75, are used, curing occurs via a reaction of the OH group of the polyvinyl alcohol part of the Mowital B 30 HH molecule. Plasticisation is advisable; it can be carried out, for example, with epoxy resins in the ratio of 1:1 to 1:2 based on polyvinyl butyral. In this case, however, the solvents used must not contain any OH groups or water. Frequently, 5-20% of the stoichiometrically required amount of Desmodur N 75 is sufficient for curing.

**ADHESIVE STRENGTH**

Mowital and Pioloform films display a very good adhesion to steel, iron, zinc, aluminium and other light metals. Nevertheless, adhesive strength and corrosion protection can be further improved via combinations with phenolic resins, epoxy resins and phosphoric acid. Adhesion and corrosion protection can be enhanced, moreover, via the addition of zinc phosphate or zinc chromate. Phenolic resins, e.g. Uravar FB 250, and epoxy resins, e.g. Epikote 1001, boost the storage stability, body and pigment acceptance of the primer. Owing to the risk of discolouring, however, Uravar FB 250 should not be used under light-coloured stoving enamels.
The risk of discolouring of the stoving enamel topcoat can be eliminated by replacing phenolic resins with urea resins. The good adhesion of these primers on metallic substrates is due to a binder-pigment-phosphoric acid-metal complex. Phosphoric acid reacts with zinc chromate to form ‘inhibitor complex acids’. If the metallic substrate and the polyvinyl butyral are involved in the formation of the complex via the hydroxyl groups, this is known as an adhesion inhibitor complex. In addition, Mowital and Pioloform films have outstanding adhesion to glass and many plastics.

PROCESSING
Prior to processing, Mowital and Pioloform has to be dissolved in a blend of suitable solvents such as butanol and - if necessary and possible - xylene and methoxy propanol. The primers can be coloured with suitable fine-grained, electrolyte-free pigments and fillers such as iron oxide red, titanium dioxide and talc each in combination with zinc-containing active pigments. When Mowital is combined with phenolic resins such as Uravar FB 250 or epoxy resins, it is advisable to disperse the pigments in one of these resins before adding the Mowital / Pioloform solution. These resins possess superior wetting properties and thus shorten the dispersing time for the pigments significantly. Mowital is mixed with phenolic or epoxy resins in the proportions of 70:30 to 30:70 (solid:solid).

In cases where the production process calls for Mowital and Pioloform to be dispersed along with the pigments, it is advisable to use ceramic grinding media or perl mills with stainless steel mixers. This is because prolonged contact between Mowital and Pioloform and iron may have a detrimental effect on the adhesion strength of the finished product. The amount of phosphoric acid added depends on the concentration of reactive binder. With both one-pack and two-pack primers, good experience has been gained with additional amounts of approx. 5% phosphoric acid (85%) calculated on the basis of Mowital and its particular combination partner (solid:solid). The phosphoric acid must always be diluted with alcohol, however, before being added to the primer.

OVER-COATING PROPERTIES
Practically all of the common types of lacquers and paints adhere to cured primer films. Problems may occur when over-coating with nitrocellulose and certain copolymerisate or two-component epoxy resins. In such cases, the inter-coat adhesion can be enhanced by adding epoxy resins such as Epikote 1001 and/or melamine resins.
A distinction is made between one-pack and two-pack primers. In one-pack primers the curing agent is already added to the primer during manufacturing. These primers contain a relatively small percentage of phosphoric acid; this results in a longer shelf life and greater water resistance during the initial stage of drying. These primers must be supplied in containers which are either made of a material resistant to phosphoric acid or contain a liner made of such a material.

In two-pack primers the phosphoric acid curing agent is supplied in a separate container. This curing agent consists of phosphoric acid diluted with a solvent. The proportions of phosphoric acid and solvent have been adjusted such that the curing agent will contain the amount of acid calculated for the particular amount of resin after the two components have been mixed. After the curing agent has been added, the two-pack primer has a pot life of only a few hours. In two-pack primers the percentage of phosphoric acid should be between 5 and 10% based on the binder. A further increase in the percentage of phosphoric acid may have a negative effect on the product’s water resistance and over-coatability.

Adhesion promotion primers offer excellent adhesion and a long-lasting anti-corrosive effect. This increase in quality is obtained by raising the solid content of the primer. This can be achieved by adding compatible low-viscous phenol-formaldehyde resins or epoxy resins. Adhesion promotion primers with formulations of this kind can easily be applied in dry film layers with a thickness of 30 to 40µm and a superior consistency.

Electrostatic sprayable primers

In comparison with the other Mowital grades, Mowital B 30 HH displays a distinctly higher solubility in aromatic solvents. Since only small amounts of alcohol are required, it is also possible to formulate electrostatic sprayable adhesion promotion primers without conductivity problems, for example.

Shop primers

Shop primers are primers that are applied to steel parts shortly after manufacturing and permit pore-free welding. The primer coat should protect the steel surface against corrosion for at least three months and, ideally, for a year. Combinations of Mowital B 30 H or B 30 HH with suitable epoxy resins, e.g. Epikote 1001, or suitable phenolic resins, e.g. Uravar FB 250, satisfy these requirements.

Wash primers

Wash primers consist of combinations of polyvinyl butyral, phosphoric acid and active anti-corrosive pigments. Previously, they were applied with a sponge or rubber wiper - hence the name “wash primers”. Today they are applied with a spray gun in dry films with a thickness of 8 to 15µm. The main purposes of wash primers are to promote adhesion between the substrate and subsequent coatings and to provide temporary protection against corrosion. Today the trend is toward adhesion promotion primers of such high quality that they obviate the necessity for additional primers (see adhesion promotion primers).
**ADDITIVE FOR POWDER COATINGS**

Powder coatings containing a few percent of Mowital are usually sufficient to plasticize it. Furthermore, some Mowital grades can be used as a structuring agent for special-effect coatings, like hammer finish. Other Mowital types are used to improve edge bonding. Another benefit using Mowital for powder coatings is given as a general aid to homogenize and disperse all ingredients during the extrusion the powder, since Mowital is a real thermoplastic. The free hydroxyl groups in the PVB are able to react and x-link with often used epoxy base polymer. By that chemical, solvent and thermal resistance is improved.

**ADHESIVE LACQUERS**

Here, as in the stoving enamel sector, Mowital can be used to produce air-drying semi-glossy to glossy high adhesion topcoats. The preferred combination partners are phenol-formaldehyde resins, epoxy resins, plasticisers and nitrocellulose. The combination of Mowital B 30 HH and Epikote 1001, cured with aliphatic polyamines, unites the rapid physical drying of Mowital with the chemical and mechanical resistance of epoxy resin two-component coatings in a single system.

**AUTOMOTIVE REFINISHING COATINGS**

During automotive repair work the paint is often sanded down to the bare metal, which then requires pre-treatment with a passivating primer. Simply spraying over the original paint may lead to serious intercoat adhesion problems; these can be exacerbated by automobile paint cleaning and polishing products. In either case, adhesion promotion primers based on Mowital-phenolic resin-epoxy resin combinations have proved to be highly effective.

**HEAT-SEALABLE LACQUERS**

Heat sealing of papers, foils, metatized films and other materials coated with Mowital finishes does more than seal the package; it can also enhance surface quality, improve gloss and presentation, and create special effects via embossing. The heat-sealing temperature depends on the softening point of the Mowital grade used in the particular case (see graphic on page 14); heat sealing should not be carried out at temperatures much above this.

**NITROCELLULOSE LACQUERS**

Alcohol-soluble nitrocellulose displays a good compatibility with Mowital and improves the surface hardness of Mowital films. Mowital, in turn, increases the adhesion and flexibility of nitrocellulose lacquers.
OIL-RESISTANT LACQUERS
Mowital B 20 H, for example, exhibits a good resistance to gear oil. Rapidly drying gear paints can be formulated by combining this Mowital grade with suitable body-enhancing types of Novolak.

PACKAGING LACQUERS, FILM LACQUERS AND LACQUERS FOR ELECTRICAL INSULATION
To ensure pore-free coating on large heavy containers, it is advisable to apply several coats. Stoving is generally carried out at temperatures between 160 and 200 °C for 10 to 20 minutes. If multi-layer coatings are applied, the first coat should not be fully stoved to ensure a good intercoat adhesion.

PAPER VARNISHES
Like foils, paper can be coated with plastified Mowital lacquers. Such lacquer coatings can be heat-sealed if necessary, display excellent light fastness and grease resistance, and enhance the brilliance of printing inks.

PLASTIC SURFACE FINISHES
The main problems encountered when painting plastic surfaces are a) poor adhesion of the paint to the plastic and b) dissolving of the plastic surface by the solvent contained in the paint. Owing to its good solubility in alcohol, Mowital is an especially versatile constituent of plastic surface finishes. The most important applications in this area are the pre-treatment of PS, ABS, PMMA, PC and moulded phenol-formaldehyde compounds prior to vacuum metalisation. This pre-treatment is usually followed by a protective coating based on the same binder.

RADIATOR PRIMERS
The outstanding resistance to yellowing displayed by Mowital-stabilised films even when exposed to heat makes Mowital an ideal component of radiator primers.

ROLLER APPLICATION LACQUERS
Foil coatings are applied predominantly with roller coaters. These lacquers must display a high flexibility and a good adhesion to various metals and plastics; in addition, they must be based on mild solvents which will not cause the rubber roller to swell or disintegrate. Lacquers based on Mowital H types satisfy all of these criteria.

STOVING ENAMELS/CAN COATINGS
From our Mowital product range, both the H and T types are suitable for the manufacture of stoving enamels. The most important combination binders are amine, epoxy and phenol-formaldehyde resins. The Mowital fraction should be between 10 and 40 percent based on solid resin. Mowital boosts the adhesion, flow and elasticity of the films.

STRIPPABLE PACKAGING COATINGS
Despite their otherwise good adhesion properties, Mowital B 20 H or B 30 H grades can also be used to produce strippable lacquers. Combined with approximately 1 to 3% of a suitable separating agent and subjected to a suitable plasticising procedure, these grades of Mowital produce highly elastic lacquer films which can be stripped off without any difficulty after even longer periods of time.

TOPCOATS
Tars and nicotine from cigarette smoke tend to ‘bleed through’ when nicotine-stained walls or ceilings are painted with normal topcoat products. This unwanted effect can be prevented by applying a topcoat containing Mowital dissolved in alcohol.

WOOD SEALING VARNISHES
Cold-curing clear varnishes based on Mowital and melamine resin create light-resistant films with good elasticity and mechanical strength. The curing times can be shortened by adding phosphoric acid or para-toluene sulfonic acid. These single-component varnishes have a shelf life of 6 to 8 months at room temperature. Varnishes of this type can be used as clear or stained sealant for parquet or wood floors.

ZINC-RICH PRIMERS
Owing to its neutral character, Mowital is highly suitable for the production of zinc-rich primers with high storage stability. Since a high pigment volume concentration has to be chosen to ensure cathode protection, a high degree of plasticisation is necessary. The addition of Mowital to zinc-rich primers based on tetra-ethyl silicate (TES) improves the film properties of these products. The amounts added may be as much as 10% based on the amount of TES binder.
Low-viscous grades of Mowital, e.g. B 16 H, B 20 H and B 30 H, are frequently used as binders for flexographic and special gravure printing inks. If necessary, specially developed Mowital grades with even lower viscosity in solution can be made available for this application area.

Since Mowital is absolutely safe for human health, these inks can be used to print on food packagings. The use of Mowital in this application area is governed by:

- EU regulation No. 0010/2011 of 14 January 2011 on plastic materials and articles intended for contact with food (Plastic Implementation Measures, PIM Regulation),
- Council of Europe, Resolution RESAP (2004) 1, formerly AP (96) 5, on surface coatings intended for contact with foodstuffs (list of authorized monomers and starting substances in Appendix II, List 1),

Mowital-based printing inks exhibit excellent adhesion to both organic and inorganic substrates. For this reason, they are suitable for printing on foils made of polyolefins, metal, cellulose acetate, polyester, cellophane, polyamide and polystyrene. Owing to its good adhesive properties, Mowital B 16 H, B 20 H and B 30 H are used for printing on intermediate layers. If necessary, adhesion on difficult substrates, e.g. OPP films surface-treated with homopolymer and ethylene-propylene copolymer coatings, can be improved by the addition of adhesion promoters. Mowital-based printing inks exhibit low solvent retention, good flow properties, and high resistance to water and low temperatures.

Printing inks for heat sensitive packaging (cold sealing) are another important application area for Mowital. Owing to their good solu-
Flexographic printing inks for food packaging – attractive protection for a fresh taste

ibility in alcohol, moreover, the Mowital grades can be used to formulate alcohol-based printing inks. These inks do not corrode the printing plate and can be used on solvent-sensitive plastic surfaces. Suitable solvents here are alcohols, e.g. ethanol, isopropanol, n-butanol and diacetone alcohol, and esters, e.g. methyl, ethyl and n-butyl acetates.

INKJET PRINTING INKS
By virtue of their low solution viscosity, low-viscous Mowital grades are suitable for the manufacture of inkjet printing inks.

PIGMENT PREPARATIONS
Organic pigments and special pigment preparations can be used for this purpose. The good flow properties and pigment wetting properties of Mowital B 20 H and B 30 H make these grades highly suitable for the manufacture of predispersed pigment preparations. When Mowital-based pigment preparations are used, the printing ink is made by simply diluting the preparation with varnish.
Mowital can be used alone or in combination with alcohol-soluble nitrocellulose. Furthermore, additional resins can be worked into the formulation. Mowital displays a good compatibility with ketone resins, alkyd resins, maleic resins and natural resins such as shellac and dammar. Appropriate trials need to be conducted to evaluate the suitability of such resins for particular applications.

THERMOTRANSFER INKS
Mowital grades with a high viscosity in solution are suitable as binders for thermotransfer printing processes. Mowital can be used alone in this context or in combination with other resins such as maleic or ketone resins. The thermotransfer motif is initially printed on paper; the print is then transferred to the textile fabric while applying heat and pressure.
The manufacture of PVB films for laminated safety glass is one of the most important applications of Mowital. Mowital grades with a high molecular weight are combined with special plasticisers in a thermoplastic extrusion process to produce safety glass films. The outstanding properties of these films include toughness, good adhesion to glass, good light resistance and excellent transparency. The films are responsible for the special safety advantages of laminated safety glass: if an object hits a glass pane made of laminated safety glass, the bulk of the object’s kinetic energy will be consumed by the expansion of the tough PVB film. As a result, the object will not go through the glass in most cases. Furthermore, the glass splinters created by the impact will adhere to the film. This effect minimises the danger of injury from glass fragments and splinters. In the automotive industry, films less than 1 mm thick are pressed between float glass panes to form laminated safety glass for car windcreens.
Mowital and Pioloform can be used as binder to make thick film pastes. Basically all Mowital and Pioloform grades are suitable. Typically recommended are medium to high viscous grades to obtain pastes to be used for screen printing. Mowital and Pioloform are acting as binder having already dispersing properties for the conductive metals. Mowital and Pioloform are yielding pastes and thick films which can be co-fired with green tapes in laminated ceramic substrates like multilayer ceramic capacitors (MLCC’s).

Using Mowital and Pioloform as binder for both, for making the ceramic green tapes and the thick films gives best compatibility during co-firing. You will have good dimensional stability before and after firing.

Mowital and Pioloform are used as temporary binder for final applications like electronic devices, flat panel displays, photovoltaic solar cells and solid oxide fuel cells (SOFC’s).
Mowital is a temporary binder especially suitable for the manufacture of high performance single and multi layer ceramics. Within multi layer processes the polymer exhibits various important functions. It is compatible with organic substances used in ceramic slurries. The polar as well as non-polar chemical structure of Mowital enables to produce flexible green tapes with high tensile strength and good elongation behaviour that can be lifted from launching materials such as PET films or metal without damage. During laminating in multi layer processes Mowital supports the fusion of green tape layers. At burning temperatures between 350 and 440 °C Mowital in green tape layers combusts with virtually no residue. In addition, Mowital-based ceramics display a uniform shrinking behaviour.
ADDITIVE FOR ADHESIVES

During the manufacture of epoxy resin adhesives, Mowital is employed as a rheology modifier to improve the elastic and rheological properties of the products. Owing to the excellent adhesion of Mowital to glass and metals, various Mowital grades are used to bond or laminate these materials to other substrates. The Mowital adhesive can be applied as a solution or by fusion (hotmelt). When solutions are used, at least one of the materials to be bonded must be sufficiently absorbent.

HOTMELTS

The adhesive compounds are first prepared from the binder (Mowital), the plasticiser and the appropriate additives in heated kneaders or extruders. These compounds are then applied to one of the substrates with heated rollers, nozzles or spray guns; later they are bonded by applying heat and pressure. When solvent-containing adhesives are used, the bond strength and reaction time can be controlled by using phosphoric acid (metal lamination).

STRUCTURAL ADHESIVES

During the manufacture of epoxy resin based adhesives, Mowital - PVB is employed as rheology modifier to improve the elastic and rheological properties of the products. Owing to the excellent adhesion of Mowital to glass and metals, various Mowital grades are used to bond or laminate these materials to other substrates. Mowital can be used in combination with other thermosetting resins (e.g. phenolic, epoxies, etc.) to provide higher bonding strengths to surfaces.
SPECIAL APPLICATIONS

Mowital®
Pioloform®

BINER FOR ABRASIVES AND SANDPAPER
Mowital is used to bind abrasives and to adjust the viscosity of abrasive pastes.

CANDLE COATINGS
Candles are dipped in a highly diluted plasticised Mowital solution to reduce a tendency to dripping or to colour the outside surfaces.

CARDBOARD PACKAGING IMPREGNATIONS
The water resistance of cardboard packaging can be raised by applying an alcoholic Mowital solution with brush or curtain coaters.

FOUNDRY AIDS
During metal casting Mowital is used as a binder of mineral powder; in particular, it is applied as an alcoholic sizing agent to the interior surfaces of foundry moulds. The pre-treatment of the foundry moulds with Mowital-based coatings leads to good casting results.

Foundry aids as alcoholic solution made with Mowital offer superior smoothness of the treated surface and render cast metal of superior surface quality.

Protective helmets made with Mowital are one-quarter as heavy as steel but provide comparable protection.
Magnetic Tape Coatings

Mowital exhibits good binding and adhesion-promoting properties for magnetised powders and is therefore used for the coating of high-quality recording tapes.

Retro-Reflecting Films

Mowital is used as a binder for retro-reflecting films; these are used, for example, to produce traffic signs and licence plates. Road marking paints. In hotmelt compounds used for road markings, Mowital serves as a melt-flow regulator and flow agent.

Spot Weldable Paints

If adequately pigmented with electrically conductive pigments such as zinc dust and aluminium bronze, Mowital is a suitable binder for the production of spot weldable paints. These paints can be welded perfectly via either direct or indirect spot welding. Owing to the thermoplasticity of the binder, the scorched area around the welded spot is small and free of blisters.

Writing cores of coloured pencils made with Mowital reduce brittleness, prevent breaking and prolong the lifetime.
THERMOPLASTIC BINDERS
Owing to its high binding capacity for powders and fibres, Mowital is suitable for a wide variety of applications as a thermoplastic binder in flooring, insulating boards or parts formed by compression moulding. Mowital can be shaped, under the combined action of pressure and temperature of approx. 160 to 240 °C, into compression moulded parts.

WELDING ROD IMPREGNATIONS
The sheaths surrounding welding rod take up water easily and thus often detach from the welding device while the diver is still working underwater. Impregnating the rods with a Mowital solution substantially prolongs their service life under water without detracting from their welding properties.

WRITING CORES FOR PENCILS AND COLOURED PENCILS
The ingredients of Mowital, graphite, or pigments and fillers were mixed at approximately 140 °C and subsequently extruded to form a writing core. Writing cores obtained in this manner offer reduced brittleness, prevent breaking, and prolong the lifetime of pencils and coloured pencils. Mowital further benefits the dispersing of graphite or pigments and therefore increases colour strength and brightness.
Polyvinyl butyral for composite applications

Polyvinyl butyral (PVB) is described in many military specifications for the manufacturing of helmets and protective panels, shielding, etc. (e.g. aircraft interior materials, construction materials for vehicles and ships). PVB is used in combination with epoxies and/or phenolics in multilayered impregnated aramid fabric systems. PVB provides high impact resistance, high film strengths, and enhanced binding properties to various engineered and conventional substrates.

HIGH-PERFORMANCE COMPOSITES

(Prepregs – pre-impregnated fabrics)

Polyvinyl butyral (PVB) is used for composite materials, for e.g. prepregs for ballistic applications. Mowital reacts with the thermoset resins based on phenols or epoxies in order to reduce the brittleness of these thermoset compounds. This is a particular advantage for multilayer laminates in the field of ballistic applications. Also in combinations with BPA-based epoxy systems, Mowital can be applied to other composite matrices in order to vary mechanical properties of composites.

For glass-fibre-reinforced composite materials (GRFPs), Mowital can be applied as a thermoplastic low-profile additive for e.g. UP/styrene systems. During the manufacturing of composite materials, shrinkage of the components occurs. This very often leads to either e.g. marbling of coloured systems and/or to significantly reduced dimensional accuracy. By adding Mowital B 30 HH or B 60 HH to styrene-based formulations, the shrinkage is minimized to below 0.05%. This results in smooth and homogenous surfaces.

- High dimensional accuracy for UP/styrene-systems and efficient low-profile-additives (<0.05%)
- Increased dispersing power of pigments or carbon black
- Transparent polymer (for dark or black systems)
- Available in industrial volumes with a consistent high product quality
- Fine and free-flowing powder with good solubility in styrene

The applications may be sheet moulding compounds (SMC), bulk moulding compounds (BMC), pultrusion, resin injection moulding, or resin transfer moulding (RTM).
PVB is provided as a white, free-flowing powder, but also in new delivery forms:

- granules
- plasticizer-free thin films
- non-wovens or filament fibres

The granular delivery forms called Mowital G allow a water-free and dust-free application of PVB. The granules can be used for thermoplastic processing like injection-moulding and also for chemical processes (such as condensation reactions and cross-linking) where residue water might lead to undesired side effects.

Under the name Mowital BF, Kuraray provides thin plasticizer-free PVB films with thicknesses ranging from 50-250 µm.

This delivery form allows a solvent and dust-free application in e.g. roll-to-roll processes enabling the use of the characteristic properties of PVB in a film form:

- excellent adhesion to glass, metals, ceramics, wood, fabrics, etc.
- ideal for thermoplastic lamination
- film surface can be cross-linked with other resins (cross-linking with epoxies, phenolics, isocyanates, etc.)
- no migration of plasticizers

By applying thin plasticizer-free PVB films, tight laminates with various substrates such as glass, metals, ceramics, fabrics (composite materials), etc. can be achieved. Such laminates are obtained through lamination at elevated temperatures and pressure.
This brochure illustrates the wide range of possible applications for Mowital/Pioloform. Among their numerous applications, Mowital/Pioloform are used in paints, lacquers, primers, varnishes, or impregnating agents, printing inks for use on plastic or metal films, adhesives, shatterproof glass and temporary binders. And this list is by no means exhaustive! Many of our customers have carried out development work on the known applications and come up with a wealth of interesting new applications for Mowital/Pioloform.

**HOW ARE YOU USING MOWITAL/PIOLOFORM - AND HOW CAN WE HELP YOU USE IT BETTER?**

We have set up the Mowital/Pioloform dialogue service to provide you with expert advice on the numerous possible applications of Mowital/Pioloform. Simply send us an e-mail. You can find the name of the right person to contact on our website (www.kuraray.eu). We will help you to select the most suitable grade of Mowital/Pioloform for your application and help you put your ideas into practice.
What is important for us?

In today’s fast moving world, it is especially important for us to be available to our customers as a reliable and competent partner. Our customer- and market-oriented business activities, together with our innovative solutions, help you gain the kind of global reach you need to safeguard your company’s success. Take advantage of our services to create a solid foundation for your business - a foundation allowing you to plan, develop and create added value.

FOR FURTHER PRODUCTS OF THE KURARAY GROUP, PLEASE GO TO WWW.KURARAY.EU