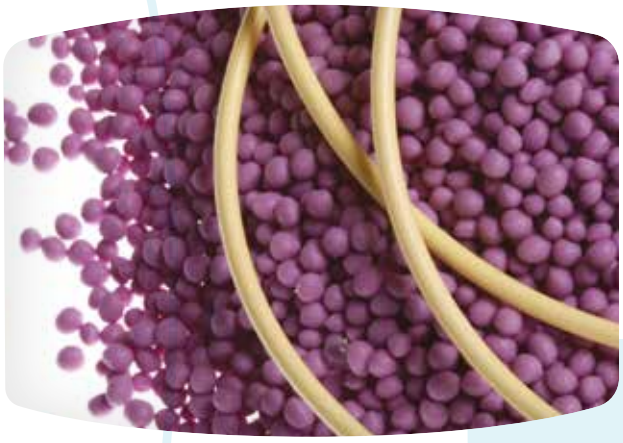
HEALTH

MEDICAL DEVICE SOLUTIONS

Thermoplastic Polyurethane (TPU)

LUBRIZOL LIFE SCIENCE

Table of Contents



About Lubrizol Life Science Health

Lubrizol Life Science Health (LLS Health) is a total solutions provider for medical device manufacturers. We specialize in helping customers from idea to execution, and offer innovative materials, drug-eluting device development and best-in-class contract manufacturing services.

When customers partner with LLS Health, they benefit from working with us at every stage in their development process. Our long history of polymer expertise and continued investment in research and manufacturing, means we offer a smooth and streamlined approach to the development of innovative medical solutions:

- **Polymers -** Our extensive polymer expertise allows us to create comprehensive, customized and application-specific medical grade materials for countless customer innovations.
- **Medical Device Product Development -** We offer a comprehensive suite of services focused on the development and support of advanced drug delivery solutions. We are experts in complex drug-eluting devices.
- **Manufacturing -** Our contract manufacturing capabilities include precision medical extrusion, sub-assembly and braided tubing for minimally invasive medical devices, as well as full-service silicone component and medical device manufacturing including long-term implants.

Medical Grade TPU

LLS Health maintains a robust Quality Management System (QMS) for medical grade thermoplastic polyurethanes to ensure patient safety and long-lasting reliability.

Specifically formulated for superior biostability, biocompatibility and processing versatility, LLS Health's polymer systems are utilized by global leaders throughout the industry. This comprehensive line of medical grade TPUs are ideal for use in cardiology, urology, orthopedics, wound care and many other applications.

LLS Health's medical grade TPU solutions include:

- Quality consistent with the expectations and needs of the medical device industry
- Products manufactured in ISO 9001 certified facilities
- Assistance with regulatory and product compliance requirements
- Biocompatibility test results
- Ethylene Oxide, Gamma and E-beam sterilization compatible
- A wide range of physical properties available
- Custom colors, radiopaque filler and performance additives

Aromatic TPU for Processing and Performance

Tecothane™ and Pellethane® medical grade polymers are known for their flexibility and offer a wide range of properties for medical and healthcare products. Tecothane TPUs are available in natural, radiopaque and custom colors. Pellethane TPUs are provided as natural but can be compounded to add radiopaque fillers and/or colors.

Benefits:
- Long history of use in medical applications
- Chemical resistance
- Strength/toughness, abrasion resistance
- Hydrolytic stability
- Available in both molding and extrusion grades

Example Applications:
- Catheters and tubing
- Film and sheet
- Wound care
- Long-term implantables
- Balloons

Tecothane™

Product	Hardness	Flex Modulus*	Elongation**
Aromatic Polyethers			
TT-1074A	75A	1,300	550
TT-1085A	85A	3,000	450
TT-1095A	94A	8,000	400
TT-1055D	54D	18,000	350
TT-1065D	64D	26,000	300
TT-1069D	69D	44,000	310
TT-1072D	74D	73,000	275
TT-1075D-M	75D	180,000	150

Pellethane®

Product	Hardness	Flex Modulus*	Elongation**
Aromatic Polyethers			
2363-80A	81A	–	550
2363-80AE†	85A	–	650
5863-85A-R1	85A	4,200	570
5863-87A-R1	87A	5,600	500
2363-90A	90A	11,000	500
2363-90AE†	90A	10,000	550
2363-55D	55D	25,000	390
2363-55DE†	53D	22,000	450
2363-65D	62D	32,000	450
2363-75D	76D	190,000	380
Aromatic Polyesters			
5855-92A	92A	10,800	450
5855-70D-WF	70D	115,000	300

*Flexural Modulus (psi): ASTM D790, **Elongation (%): ASTM D412, †Product specially formulated for extrusion processing
Note: 20% and 40% barium sulfate-filled are available for most products.

Rigid TPU

Isoplast® and Tecoplast™ aromatic polyurethanes are designed for rigid polymer applications such as hubs, fittings or other components that require impact-resistant properties. They are available in impact-modified, clear, pre-colored and glass-filled grades and are formulated to produce durable injection molded components exhibiting high tensile and flexural modulus, as well as superior chemical resistance.

Benefits:
- Chemical resistance
- High tensile modulus and impact resistance
- Clarity and practical toughness

Example Applications:
- Catheter hubs and luers
- Dental/orthodontic applications
- Surgical instruments

Isoplast®

Product	Hardness	Flex Modulus*	Feature
2510	116R	260,000	Impact Modified
2530 R1	121R	330,000	Transparent
2531	123R	340,000	Transparent
2540	–	1,500,000	40% Long Glass Fiber Reinforced

Tecoplast™

Product	Hardness	Flex Modulus*	Feature
TP-470 Clear	82D	300,000	Clear/Transparent
OP-770 Opaque	82D	250,000	Opaque/Custom Colors

*Flexural Modulus (psi): ASTM D790

Polycarbonate TPU

Carbothane™ offers excellent oxidative stability for long-term blood contact applications. Carbothane™ is available in aromatic and aliphatic versions with a variety of durometer, color and radiopacifier formulations.

Benefits:

- Superior oxidative stability
- Excellent hydrolytic stability
- Outstanding chemical resistance and physical properties

Example Applications:

- Long-term catheters
- Other long-term implants
- Balloons

Carbothane™			
Product	Hardness	Flex Modulus*	Elongation**
Aliphatic Polycarbonate TPU			
PC-3575A	73A	1,300	480
PC-3585A	83A	1,500	380
PC-3595A	94A	6,500	380
PC-3555D	55D	20,000	350
PC-3572D	71D	130,000	320
Aromatic Polycarbonate TPU			
AC-4075A	77A	1,500	400
AC-4085A	85A	3,500	400
AC-4095A	95A	10,800	370
AC-4055D	56D	27,700	300
AC-4065D	70D	100,000	300
AC-4075D	75D	220,000	250

*Flexural Modulus (psi): ASTM D790
**Elongation (%): ASTM D412
Note: 20% and 40% barium sulfate-filled are available for most products.

Aliphatic TPU for Processing and Performance

Tecoflex™ TPU offers versatile processing and is resistant to yellowing. This aliphatic polyether TPU is available in a variety of durometer, color and radiopacifier formulations.

Benefits:

- Clarity
- Non-yellowing
- Excellent in-body softening
- Wide processing window for extrusion
- Molding and solvent processing grades available

Example Applications:

- Balloons
- Catheters
- Coatings
- Electrospinning

Tecoflex™			
Product	Hardness	Flex Modulus*	Elongation**
Extrusion Grade			
EG-80A	72A	1,000	600
EG-85A	77A	2,300	550
EG-93A	87A	3,200	390
EG-100A	94A	10,000	370
EG-60D	51D	13,000	360
EG-65D	60D	37,000	360
EG-68D	63D	46,000	350
EG-72D	67D	92,000	310
Injection Molding Grade			
MG-8020	79D	165,000	60
MG-8812	83D	230,000	6
Solvent Grade			
SG-80A	72A	1,000	660
SG-85A	77A	2,300	550
SG-60D	51D	13,000	360

*Flexural Modulus (psi): ASTM D790
**Elongation (%): ASTM D412
Note: 20% and 40% barium-sulfate filled are available for most products.

Hydrophilic TPU

Tecophilic™ aliphatic polyether TPU is formulated to absorb 20 to 150% water (by weight) of the dry resin while maintaining physical properties. Solution and extrusion processable grades available.

Benefits:

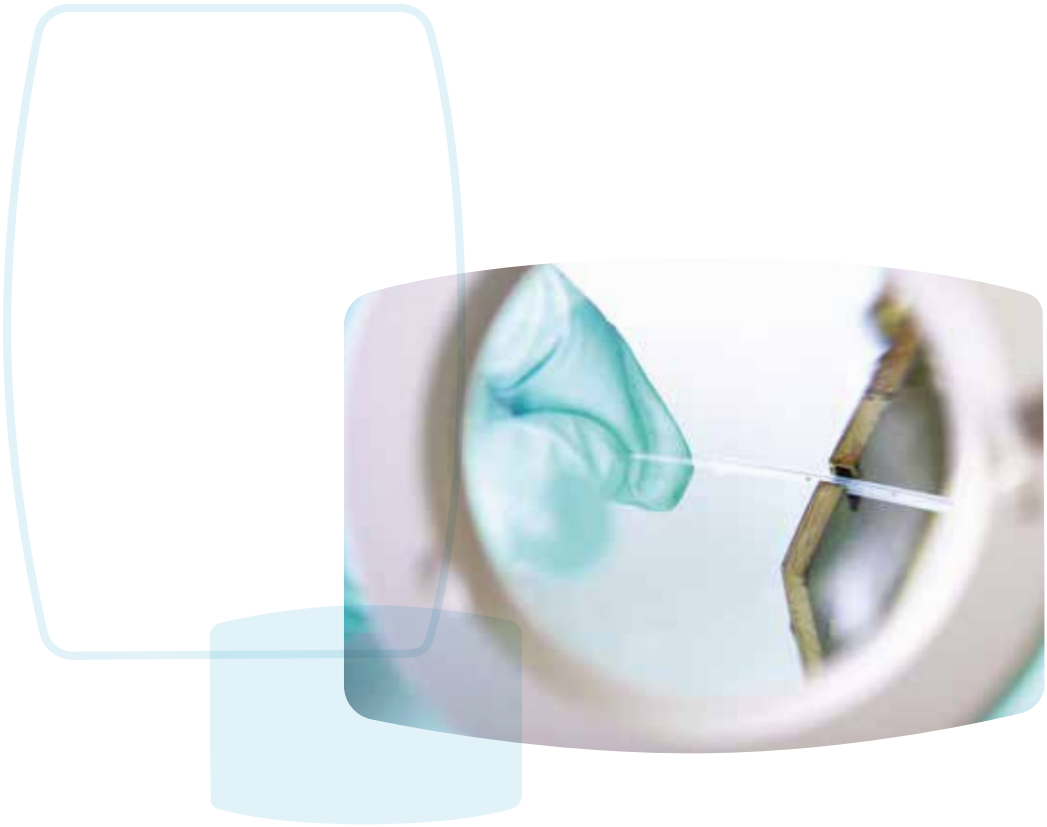
- Hydrophilic
- High moisture vapor transmission rate (MVTR)
- Water swell-able
- Processing flexibility
- High surface lubricity when hydrated

Example Applications:

- Catheters
- Wound care
- Semi permeable membranes
- Balloons

Tecophilic™				
Product	Hardness	Flex Modulus*	Elongation Dry/Wet**	H_2O Absorption***
Extrusion Grade				
HP-93A-100	83A	2,900	1,040/620	100%
HP-60D-20	43D	4,300	430/390	20%
HP-60D-35	42D	4,000	450/390	35%
HP-60D-60	41D	4,000	500/300	60%
Solvent Grade				
SP-80A-150	70A	–	1,000/600	150%
SP-93A-100	83A	–	1,040/620	100%
SP-60D-60	41D	–	500/300	60%

*Flexural Modulus (psi): ASTM D790
**Elongation (%): ASTM D412
***H2O Absorption: Lubrizol Method



TPU for Drug-Eluting Devices

Pathway™ Polymer Excipients - Pathway™ Polymer excipients are a customizable, reliable choice for developing a drug-eluting medical device. Pathway™ has been used to develop everything from drug-eluting device coatings to intravaginal rings, and comes in both hydrophobic and hydrophilic grades; Drug Master Files and regulatory support are available for both.

Benefits:

- Customizable to meet drug delivery needs (drug substance and release rate)
- Exceptional durability, even when soft
- Good chemical resistance
- Superior clarity

Example Applications:

- Drug-eluting devices

For more information about drug-eluting device capabilities, please contact your LLS Health representative.

Specialty Materials

Tecothane™ Soft aromatic polyester hydrocarbon-based TPU delivers distinct surface characteristics, unique physical properties, and chemical resistance.

Benefits:

- Softness
- Hydrophobic, low moisture vapor transmission rate (MVTR)
- Chemical resistant
- Up to 75% bio-sourced

Example Applications:

- Soft-tip tubing
- Silicone alternative
- Balloons

Tecothane™ Soft			
Product	Hardness	Flex Modulus*	Elongation**
AR-75A	79A	2,500	530
AR-85A	89A	6,700	400
AR-95A	97A	21,000	370

*Flexural Modulus (psi): ASTM D790
**Elongation (%): ASTM D412

Tecoflex™ 1-MP Adhesive Grade

Tecoflex™ 1-MP is a one-part adhesive based on a fast-crystallizing polyurethane resin.

Benefits:

- Polyurethanes
- Plasticized vinyls
- Polycarbonates
- Acrylics
- Chlorinated SBR rubbers
- Primed metals

Example Applications:

- Drug-eluting devices

Tecoflex™ 1-MP Adhesive Grade			
Product	Solids (%)	Brookfield Viscosity (cps)	Color
1-MP Adhesive	8	200-300	Light Gray, Translucent

About Lubrizol Life Science Health

The Health business team partners with customers to speed their innovative medical devices and differentiated pharmaceutical products to market. Our dedicated team provides best-in-class polymers and excipients, along with state-of-the-art product design, development, and manufacturing services, with the ultimate goal of creating solutions that improve patient outcomes.

For more information, visit lubrizol.com/Health

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