SCS PARYLENE PROPERTIES

High performance conformal coatings.

INNOVATIVE SOLUTIONS FROM THE LEADER IN PARYLENE

With over 45 years of experience in Parylene engineering and applications, Specialty Coating Systems (SCS) is the world leader in Parylene conformal coating technologies. We're a direct descendant of the companies that originally developed Parylene, and we leverage that expertise on every project – from initial planning to process application.

SCS employs some of the world's foremost Parylene specialists, highly experienced sales engineers and expert manufacturing personnel, working in state-of-the-art coating facilities in 11 countries worldwide. Our extensive, proactive approach to production and quality requirements gives our customers peace of mind and minimizes the resources they need to meet even the most challenging requirements and specifications.

>45 years

11 countries

4 continents

>1,000 employees

SCS PARYLENE COATINGS

Parylene is the name for members of a unique polymer series. The basic member of the series, Parylene N, is poly(para-xylylene), a completely linear, highly crystalline material. Parylene N has superior dielectric properties, exhibiting very low values for dielectric constant and dissipation factor that are invariant with frequency. The ability of Parylene N to coat in and around tight spaces is second only to that of Parylene HT®. The Parylene structures are shown in Figure 1.

Parylene C, the second commercially available member of the series, is produced from the same raw material (dimer) as Parylene N, modified only by the substitution of a chlorine atom for one of the aromatic hydrogens. Parylene C has a useful combination of electrical and physical properties and a very low permeability to moisture and corrosive gases.

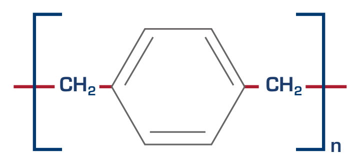
Parylene D, the third available member of the series, is produced from the same raw material as Parylene N dimer, modified by the substitution of chlorine atoms for two of the aromatic hydrogens. Parylene D is similar in properties to Parylene C with the added ability to withstand slightly higher use temperatures and an enhanced barrier capability against hydrogen sulfide.

Parylene HT® replaces the alpha hydrogen atoms of the N dimer with fluorine. This variant of Parylene is useful in high temperature applications (short-term up to 450°C) and those in which long-term UV stability is required. Parylene HT also has the lowest coefficient of friction and dielectric constant, and the highest penetrating ability of the Parylenes.

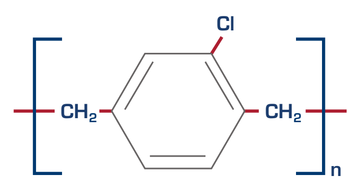
ParyFree®, the newest and a unique member of the series, replaces one or more hydrogen atoms of the Parylene N dimer with non-halogenated substituents. This halogen-free variant offers the advanced barrier properties of Parylene C and adds improved mechanical and electrical properties compared to other commercially-available Parylenes. ParyFree optimizes the critical combination of barrier, electrical and mechanical properties to provide robust protection against moisture, water, corrosive solvents and gases, while complying with halogen-free requirements of select industries worldwide.

Due to the uniqueness of vapor phase deposition, the Parylene polymers can be formed as structurally continuous films from as thin as several hundred angstroms to 75 microns.

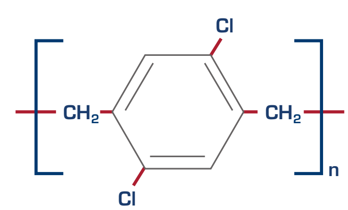
FIGURE 1: Parylenes N, C, D and Parylene HT Chemical Structures



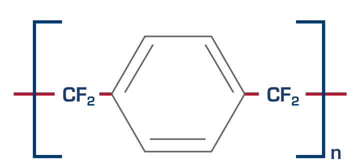
Parylene N



Parylene C

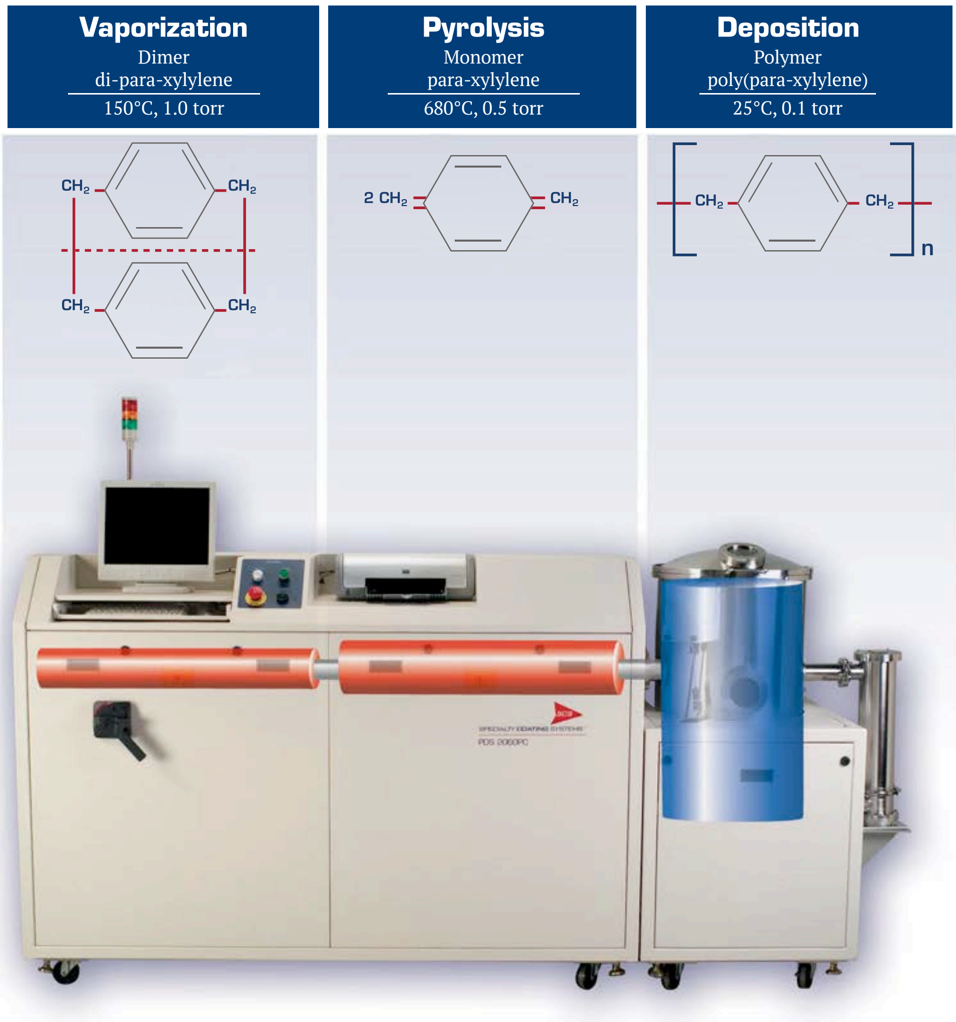


Parylene D



Parylene HT®

FIGURE 2: Parylene Vapor Deposition Polymerization (VDP) (Parylene N illustrated)



THE DEPOSITION PROCESS

The Parylene polymers are deposited by a process that resembles vacuum metallization; however, while vacuum metallization is conducted at pressures of 10^{-5} torr or below, the Parylenes are formed at around 0.1 torr. Under these conditions, the mean free path of the gas molecules in the deposition chamber is on the order of 0.1 cm. Since the deposition is not line-of-sight, all sides of an object to be coated are uniformly impinged by the gaseous monomer, resulting in a truly conformal, pinhole-free coating. Substrates to be coated are required to have only a reasonable vacuum tolerance.

The Parylene deposition process consists of three distinct steps as outlined in Figure 2.

The first step is the vaporization of solid dimer at approximately 150°C. The second step is the quantitative cleavage (pyrolysis) of the dimer vapor at 680°C, which breaks the two methylene-methylene bonds and yields the stable monomeric diradical, para-xylylene. Finally, the monomeric vapor enters the room temperature deposition chamber where it spontaneously polymerizes on the substrate. The substrate temperature never rises more than a few degrees above ambient.

No liquid phase has ever been isolated, therefore Parylene suffers none of the fluid effects that can cause pooling, flowing, bridging, meniscus or edge-effect flaws. Parylene also contains no solvents, catalysts or plasticizers that can leach or outgas from the coating.

PROPERTIES

The electrical, barrier, mechanical, thermal, optical, biological and other properties of the Parylenes are discussed below. These properties are compared to those reported for other conformal coating materials such as acrylics, epoxies, polyurethanes and silicones.

A. ELECTRICAL PROPERTIES

The electrical properties of Parylene are shown in Table 1.

1. *Thin Film Dielectric Properties*
   One of the features of Parylene coatings is that they can be formed in extremely thin layers. Table 1 shows that Parylenes, even in very thin layers, have excellent dielectric withstanding voltages. It has also been demonstrated that the voltage breakdown per unit thickness increases with decreasing film thickness.

2. *Circuit Board Insulation Resistance*
   A critical test of the protection afforded by a Parylene coating is to coat circuit board test patterns (as described in MIL-I-46058C) and subject them to insulation resistance measurements during a temperature-humidity cycle (MIL-STD-202, methods 106 and 302). In brief, this test consists of 10 cycles (one cycle per day), with each cycle consisting of seven steps. The seven steps range from low temperature, low humidity (25°C, 50% RH) to more severe conditions (65°C, 90% RH). Resistance readings are taken initially and at the 65°C, 90% RH step for each cycle of the 10-day test.

   Results are shown in Table 2 for Parylene C coating thicknesses from 50.8 µm to 2.5 µm. It is interesting to note that even for the very thin coatings (2.5 µm), the insulation resistance values are about one order of magnitude above the prescribed specification.

B. BARRIER PROPERTIES AND CHEMICAL RESISTANCE

1. *Barrier*
   The barrier properties of the Parylenes are given in Table 3. The water vapor transmission rates (WVTR) are compared with those of other conformal coating materials. The WVTR for Parylene C and ParyFree are superior to the most common polymeric materials.

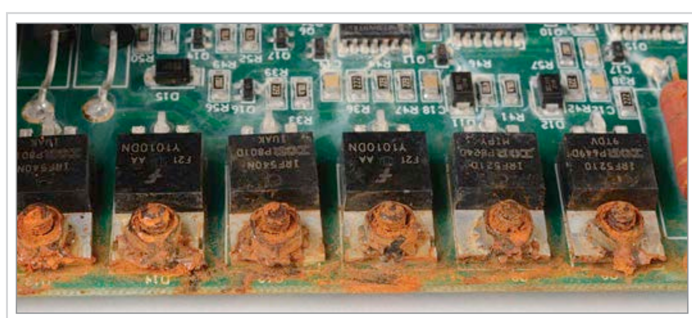
   Parylene-coated electronics have been tested by an independent facility in accordance with the applicable requirements of IEC 60529, test conditions 14.2.7 and 14.2.8 for IPX7 and IPX8 designations, which demonstrates protection from harmful effects due to the ingress of water. The uncoated (control) electronics functionally failed during the test, but the Parylene-coated electronics passed both test conditions, functioning normally both during and after testing. These results indicate that Parylene conformal coatings are suitable to protect electronics and other devices against water splash and water immersion for more than 30 minutes at a depth of 1 m (IPX7) and 1.5 m (IPX8).

   Circuit boards coated with ParyFree were salt-fog tested by an independent facility. The coated boards suffered no corrosion, salt or heavy iron oxide deposits after 144 hours of exposure in accordance with ASTM B117-(03) (See Figure 3). Boards coated with SCS Parylenes C and Parylene HT exhibited similar results.

2. *Chemical Resistance*
   The Parylenes resist chemical attack and are insoluble in all organic solvents up to 150°C. Parylene films minimally swelled with exposure to a host of chemicals, including harsh automotive and aviation fluids; however, the swelling completely reversed after the solvents were removed by vacuum drying. (Characterization of swelling was conducted using FTIR analysis.) Additional testing indicated no resulting changes in the films' physical or chemical properties.

FIGURE 3: Circuit boards after 144 hours of salt-fog exposure

Coated with SCS ParyFree



Uncoated

TABLE 1: Parylene Electrical Properties

	Method	Parylene N	ParyFree	Parylene C	Parylene D	Parylene HT	Acrylic (AR)[a,b]	Epoxy (ER)[a,b]	Polyurethane (UR)[a,b]	Silicone (SR)[a,b]
Dielectric Strength V/mil	1	7,000	6,900	5,600	5,500	5,400	3,500	2,200	3,500	2,000
Volume Resistivity ohm•cm, 23°C, 50% RH	2	1.4 x 10^{17}	2.8 x 10^{16}	8.8 x 10^{16}	1.2 x 10^{17}	2.0 x 10^{17}	1.0 x 10^{15}	1.0 x 10^{16}	1.0 x 10^{13}	1.0 x 10^{15}
Surface Resistivity ohms, 23°C, 50% RH	2	1.0 x 10^{13}	2.4 x 10^{15}	1.0 x 10^{14}	1.0 x 10^{16}	5.0 x 10^{15}	1.0 x 10^{14}	1.0 x 10^{13}	1.0 x 10^{14}	1.0 x 10^{13}
Dielectric Constant	3									
60 Hz		2.65	2.38	3.15	2.84	2.21	–	3.3 – 4.6	4.1	3.1 – 4.2
1 KHz		2.65	2.37	3.10	2.82	2.20	–	–	–	–
1 MHz		2.65	2.35	2.95	2.80	2.17	2.7 – 3.2	3.1 – 4.2	3.8 – 4.4	3.1 – 4.0
Dissipation Factor	3									
60 Hz		0.0002	0.00001	0.020	0.004	<0.0002	0.04 – 0.06	0.008 – 0.011	0.038 – 0.039	0.011– 0.02
1 KHz		0.0002	0.0009	0.019	0.003	0.0020	–	–	–	–
1 MHz		0.0006	0.0007	0.013	0.002	0.0010	0.02 – 0.03	0.004 – 0.006	0.068 – 0.074	0.003 – 0.006

a. *Handbook of Plastics, Elastomers, and Composites*, Chapter 6, "Plastics in Coatings and Finishes," 4th Edition, McGraw Hill, Inc., New York, 2002.

b. *Conformal Coating Handbook,* Humiseal Division, Chase Corporation, Pennsylvania, 2004.

(International conversion chart on back cover.)

Test Methods:
1. ASTM D149
2. ASTM D257
3. ASTM D150

TABLE 2: Parylene C Circuit Board Screening

Insulation Resistance (ohms), MIL-STD-202, Method 302

Parylene Thickness (µm)	Initial Measurement	Precycle	Step 5 Cycle 3	Step 5 Cycle 7	Step 5 Cycle 10	Step 7 Cycle 10
	25°C, 50% RH	25°C, 90% RH	65°C, 90% RH	65°C, 90% RH	65°C, 90% RH	25°C, 90% RH
50.8	2.0 x 10^{14}	1.8 x 10^{13}	2.3 x 10^{12}	2.5 x 10^{11}	1.4 x 10^{11}	7.5 x 10^{12}
38.1	5.0 x 10^{14}	2.4 x 10^{13}	8.6 x 10^{11}	1.9 x 10^{11}	1.1 x 10^{11}	5.2 x 10^{12}
25.4	2.0 x 10^{14}	9.2 x 10^{12}	8.1 x 10^{11}	3.4 x 10^{11}	1.3 x 10^{11}	6.3 x 10^{12}
12.7	5.0 x 10^{14}	2.3 x 10^{13}	4.1 x 10^{12}	2.4 x 10^{11}	1.1 x 10^{11}	4.7 x 10^{12}
7.6	5.0 x 10^{14}	2.7 x 10^{13}	4.4 x 10^{12}	9.0 x 10^{10}	4.7 x 10^{10}	2.9 x 10^{12}
2.5	5.0 x 10^{14}	3.2 x 10^{10}	1.3 x 10^{11}	1.1 x 10^{11}	6.4 x 10^{10}	2.3 x 10^{12}

(International conversion chart on back cover.)

TABLE 3: Parylene Barrier Properties

Polymer	Gas Permeability at 25°C, (cc•mm)/(m^2•day•atm)[a] N_2	O_2	CO_2	H_2	Water Vapor Transmission Rate (g•mm)/(m^2•day)
Parylene N	3.0	15.4	84.3	212.6	0.59[e]
ParyFree	<0.2[b]	3.4[c]	7.8[d]	86.2[b]	0.09[f]
Parylene C	0.4	2.8	3.0	43.3	0.08[g]
Parylene D	1.8	12.6	5.1	94.5	0.09[e]
Parylene HT	4.8[b]	23.5[b]	95.4[b]	–	0.22[h]
Acrylic (AR)	–	–	–	–	13.9[i]
Epoxy (ER)	1.6	2.0 – 3.9	3.1	43.3	0.94[i]
Polyurethane (UR)	31.5	78.7	1,181	–	0.93 – 3.4[i]
Silicone (SR)	–	19,685	118,110	17,717	1.7 – 47.5[i]

a. ASTM D1434 (except where noted)
b. MOCON MULTI-TRAN 400
c. ASTM D3985
d. ASTM F2476
e. ASTM E96 (90% RH, 37°C)
f. ASTM F1249 (100% RH, 37°C)
g. ASTM F1249 (90% RH, 37°C)
h. ASTM F1249 (100% RH, 38°C)
i. *Coating Materials for Electronic Applications,* Licari, J.J., Noyes Publications, New Jersey, 2003.

(International conversion chart on back cover.)

C. THERMAL, CRYOGENIC, VACUUM AND STERILIZATION PROPERTIES

1. *Thermal*

   Based on Arrhenius extrapolations of test data, Parylenes N, ParyFree and Parylene C are expected to survive continuous exposure to air at 60°C, 60°C and 80°C, respectively, for 10 years. In oxygen-free atmospheres, or the vacuum of space, the Parylenes are expected to perform similarly with continuous exposure to 220°C. Parylene HT has been demonstrated to survive continuous exposure to air at 350°C, with excursions to 450°C for less than 24 hours.

   In all cases, higher temperatures shorten useful life. If the requirements for your application are near or exceed these time-temperature-atmospheric conditions, it is recommended that you test the complete structure under conditions more closely resembling the actual conditions of intended use.

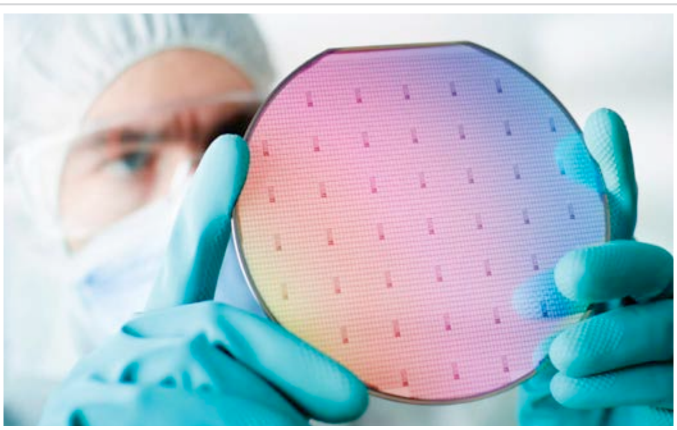
   General thermal properties are summarized in Table 4.

2. *Cryogenic*

   Unsupported 50.8 µm films of Parylene C can be flexed 180° six times at -200°C before failure occurs. Comparable films of polyethylene, polyethylene terephthalate and polytetrafluoroethylene fail at three, two and one flexes, respectively.

   Steel panels coated with Parylene C and chilled in liquid nitrogen at -196°C withstood impacts of more than 11.3 N•m in a modified Gardner falling ball impact test. This compares with values of about 28.2 N•m at room temperature.

   Supported films of Parylene N have been demonstrated to withstand thermal cycling from room temperature to -269°C without cracking, peeling from substrate or the degradation of electrical properties.



3. *Vacuum Stability*

   Testing conducted at NASA's Jet Propulsion Laboratory (at 49.4°C and 10^{-6} torr) indicates Total Mass Loss (TML) of 0.30% for Parylene N. NASA's Goddard Space Flight Center's vacuum stability testing (per ASTM E595) of SCS Parylene C and Parylene HT demonstrates TML of 0.07% and 0.03%, respectively. Corresponding values for Collected Volatile Condensable Materials (CVCM) are 0.0003% and 0.0017%, respectively. For more information on outgassing, please visit http://outgassing.nasa.gov or contact SCS.

4. *Parylene Sterilization*

   Parylenes N, C, and Parylene HT were exposed to a variety of sterilization methods, including steam autoclave, gamma and e-beam irradiation, hydrogen peroxide plasma and ethylene oxide. Post-sterilization analysis evaluated the impact of these sterilizing agents on Parylenes N, C and Parylene HT samples against unsterilized control samples. Electrical, barrier and mechanical properties were evaluated with results indicating these properties remained unchanged for the vast majority of the tests across these Parylene variants.

D. PHYSICAL AND MECHANICAL PROPERTIES

Physical and mechanical properties of the Parylenes are summarized in Table 5.

Because of their high molecular weight (~500,000), melting temperatures and crystallinity, Parylenes cannot be formed by conventional methods such as extrusion or molding. Solubility in organic or other media, except at temperatures above 175°C, is so low that they cannot be formed by casting.

Impact resistance is high when the Parylene polymers are supported on test panels. Gardner falling ball impact test results on 25.4 µm Parylene C-coated steel "Q" panels are in the 28.2 N•m range.

Wear index values (measured on a Taber® Abraser machine using CS-17 "Calibrase" wheel with 1,000 gram weight) are 22.5 for Parylene C and 8.8 for Parylene N. By comparison, polytetrafluoroethylene is 8.4, high impact polyvinylchloride is 24.4, epoxy is 41.9 and polyurethane is 59.5.

Parylenes may be annealed to increase cut-through resistance, increase hardness and improve abrasion resistance. This is the result of polymer density and an increase in crystallinity.

TABLE 4: Parylene Thermal Properties

	Method	Parylene N	ParyFree	Parylene C	Parylene D	Parylene HT	Acrylic (AR)	Epoxy (ER)	Polyurethane (UR)	Silicone (SR)
Melting Point (°C)[a]	1	420	349	290	380	>500	85 – 105[b]	NA	~170[b]	NA
T5 Point (°C) (modulus = 690 MPa)	2, 3	160	136	125	125	377	–	110	~30	~125
T4 Point (°C) (modulus = 70 MPa)	2, 3	>300	270	240	240	>450	–	120	–	~80
Continuous Service Temperature (°C)	4	60	60	80	100	350	82[b]	177[b]	121[b]	260[b]
Short-Term Service Temperature (°C)	4	80	80	100	120	450	–	–	–	–
Linear Coefficient of Thermal Expansion at 25°C (ppm)	5	69	31	35	38	36	55 – 205[b,c]	45 – 65[b,c]	100 – 200[b,c]	250 – 300[b,c]
Thermal Conductivity at 25°C (W/(m•K))	6, 7	0.126	0.140	0.084	–	0.096	0.167 – 0.21[c,d]	0.125 – 0.25[c,d]	0.11[c,d]	0.15 – 0.31[c,d]
Specific Heat at 20°C (J/(g•K))	–	0.837	1.52	0.712	–	1.04	1.04[b]	1.05[b]	1.76[b]	1.46[b]

a. The temperature at which heat flow properties show signs of change.

b. *Handbook of Plastics, Elastomers, and Composites*, Chapter 6,"Plastics in Coatings and Finishes," 4th Edition, McGraw Hill, Inc., New York, 2002.

c. *Coating Materials for Electronic Applications*, Licari, J.J., Noyes Publications, New Jersey, 2003.

d. *Lange's Handbook of Chemistry*, 5th Edition, McGraw Hill, Inc., New York, 1999.

(International conversion chart on back cover.)

Test Methods:
1. DSC
2. Taken from DMA Secant modulus-temperature curve (Parylenes N, C, D)
3. ASTM D5026 (Parylene HT and ParyFree)
4. TGA/FTIR, DSC and thermal endurance testing
5. TMA
6. ASTM C177 (Parylenes N, C)
7. ASTM E1461 (Parylene HT and ParyFree)

TABLE 5: Parylene Physical and Mechanical Properties

	Method	Parylene N	ParyFree	Parylene C	Parylene D	Parylene HT	Acrylic (AR)[a,b]	Epoxy (ER)[a,b]	Polyurethane (UR)[a,b]	Silicone (SR)[a,b]
Secant (Young's) Modulus (psi)	1, 2	350,000	550,000	400,000	380,000	370,000	2,000 – 10,000	350,000	1,000 – 100,000	900
Tensile Strength (psi)	3	7,000	9,600	10,000	11,000	7,500	7,000 – 11,000	4,000 – 13,000	175 – 10,000	350 – 1,000
Yield Strength (psi)	3	6,100	7,600	8,000	9,000	5,000	–	–	–	–
Elongation to Break (%)	3	2-200	2-200	2-200	2-200	2-200	2 – 5.5	3 – 6	>14	100 – 210
Yield Elongation (%)	3	2.5	2.2	2.9	3.0	2.0				
Density (g/cm^3)	4, 5	1.10 – 1.12	1.053	1.289	1.418	1.32	1.19	1.11 – 1.40	1.10 – 2.50	1.05 – 1.23
Index of Refraction (n_D^{23})	6, 7	1.661	1.602	1.639	1.669	1.559	1.48	1.55 – 1.61	1.50 – 1.60	1.43
Water Absorption (% after 24 hrs)	8	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.1	Less than 0.01	0.3	0.05 – 0.10	0.6 – 0.8	0.1
Rockwell Hardness	9	R85	R136	R80	R80	R122	M68 – M105	M80 – M110	68A – 80D (Shore)	40A – 45A (Shore)
Coefficient of Friction	10									
Static		0.25	0.23	0.29	0.33	0.15	–	–	–	–
Dynamic		0.25	0.23	0.29	0.31	0.13	–	–	–	–

a. *Coating Materials for Electronic Applications*, Licari, J.J., Noyes Publications, New Jersey, 2003.

b. *Handbook of Plastics, Elastomers, and Composites*, Chapter 6, "Plastics in Coatings and Finishes," 4th Edition, McGraw Hill, Inc., New York, 2002.

(International conversion chart on back cover.)

Test Methods:
1. ASTM D882 (Parylenes N, C, D)
2. ASTM D5026 (Parylene HT and ParyFree)
3. ASTM D882
4. ASTM D1505 (Parylenes N, C, D)
5. ASTM E1461 (Parylene HT and ParyFree)
6. Abbe Refractometer (except Parylene HT)
7. ASTM D542 (Parylene HT only)
8. ASTM D570
9. ASTM D785
10. ASTM D1894

E. OPTICAL PROPERTIES AND RADIATION RESISTANCE

1. *Optical Properties*
   Parylene exhibits very little absorption in the visible region and is, therefore, transparent and colorless. Below wavelengths of about 280 nm, all the Parylenes absorb strongly, as shown in Figure 4.

   The Fourier Transform infrared spectra for 12.7 µm Parylene films are shown in Figures 5, 6, 7 and 8.

2. *Radiation Resistance*
   Parylenes N, C, D and Parylene HT films show a high degree of resistance to degradation by gamma rays in vacuum. Tensile and electrical properties were unchanged after 1,000 kGy dosage at a dose rate of 16 kGy/hr. Exposure in air leads to rapid embrittlement.

   Although stable indoors, Parylenes N, C, D and ParyFree are not recommended for long-term use when exposed to direct sunlight (UV light). Parylene HT exhibits significant resistance to UV light, with no property degradation from accelerated exposures of up to 2,000 hours in air.

F. BIOCOMPATIBILITY AND BIOSTABILITY

SCS Parylenes N, C and Parylene HT have been tested according to the biological evaluation requirements of ISO 10993. Further, the biocompatibility and biostability of SCS Parylenes have been demonstrated in a wide range of medical coating applications over the past four decades.

FIGURE 4: Ultraviolet Spectra of Parylenes N, C, D, HT and ParyFree

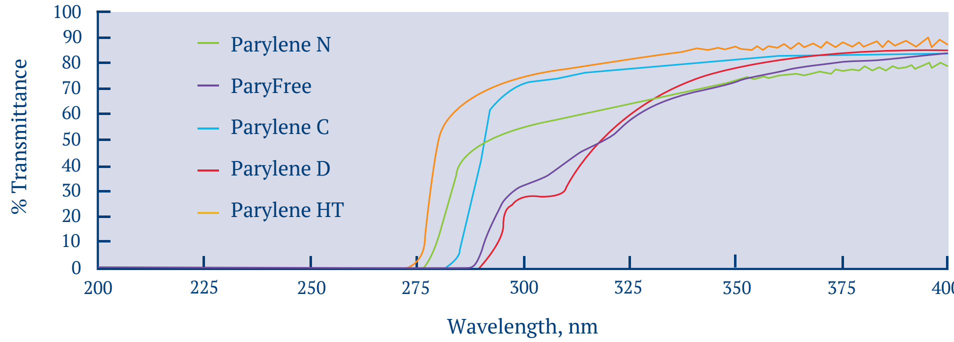


FIGURE 5: FTIR Absorbance Spectrum of Parylene N

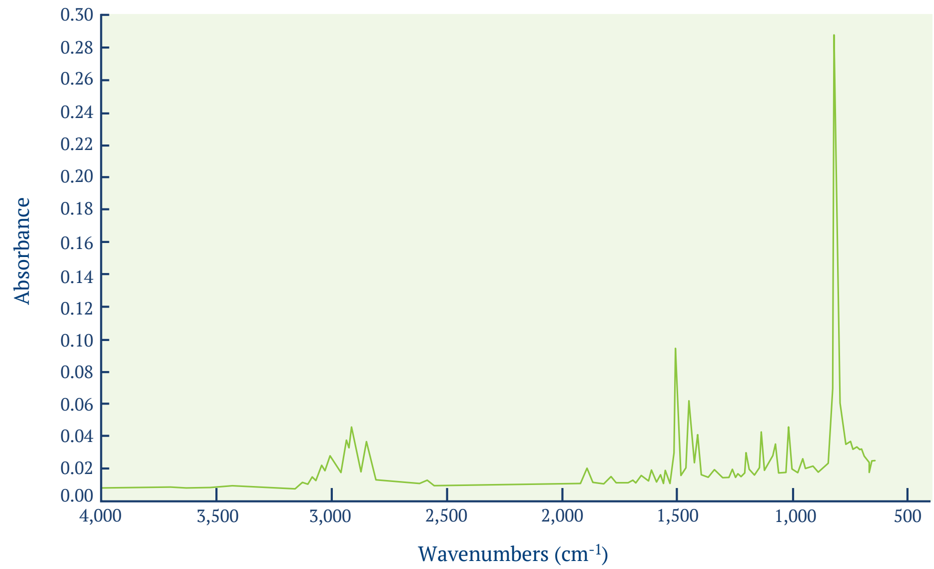


FIGURE 6: FTIR Absorbance Spectrum of ParyFree

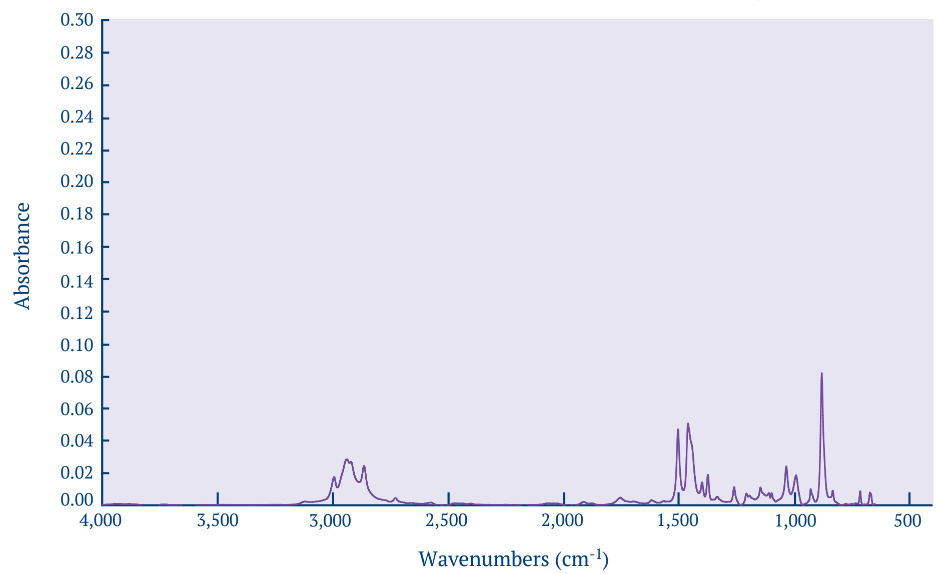


FIGURE 7: FTIR Absorbance Spectrum of Parylene C

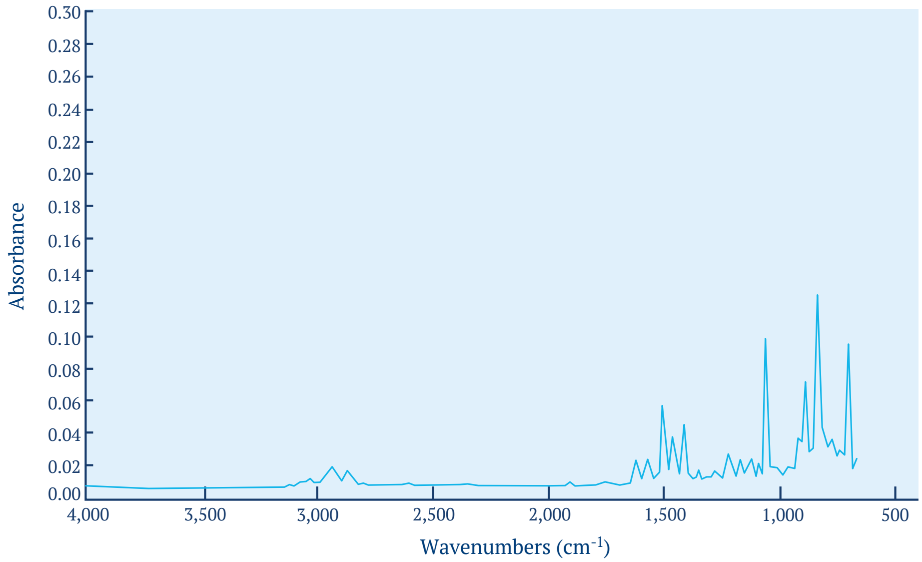


FIGURE 8: FTIR Absorbance Spectrum of Parylene D

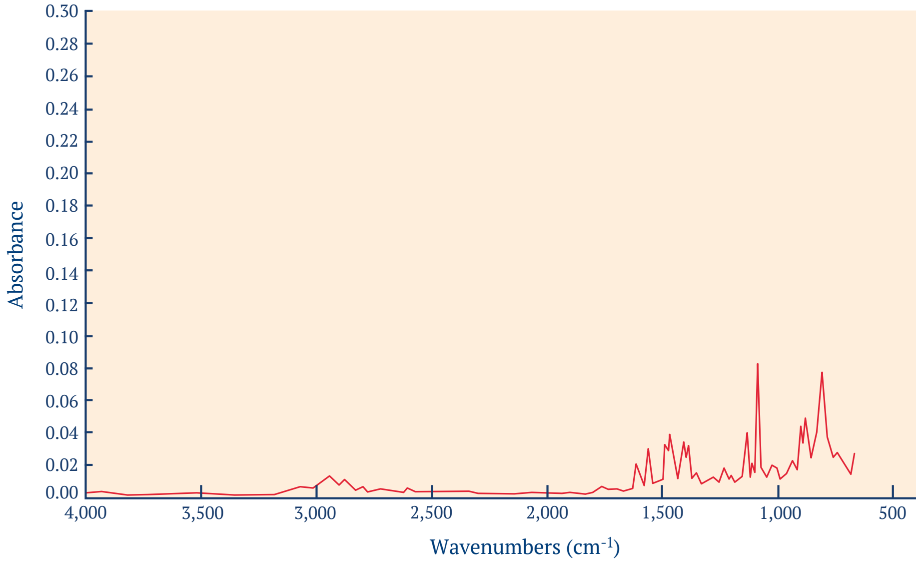
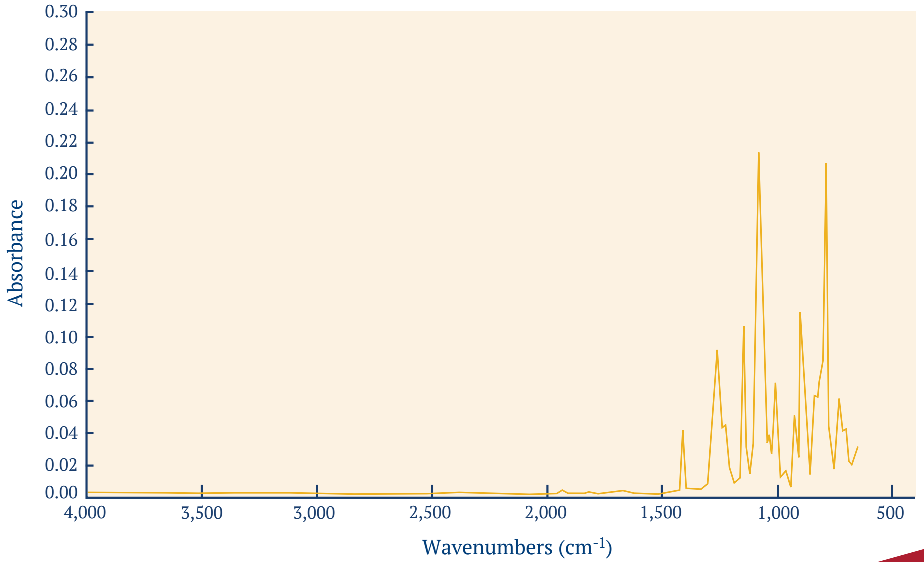


FIGURE 9: FTIR Absorbance Spectrum of Parylene HT

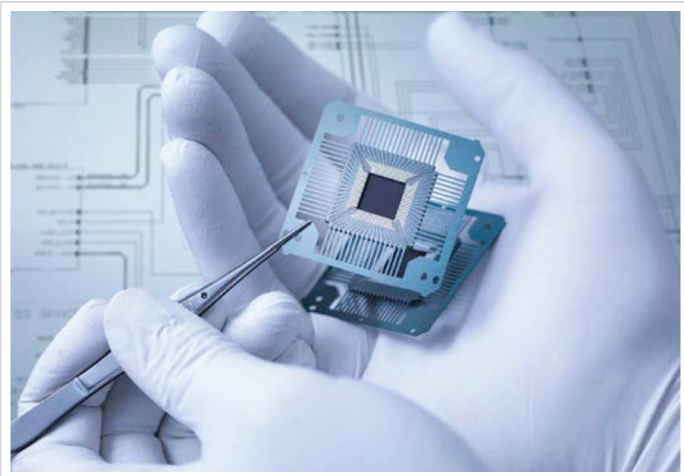


ADHESION

Conformal coatings are used across a spectrum of industries, including electronics, medical device, transportation, aerospace and defense. They are used for protection, biostability and surface modification to enhance the overall reliability of the component assembly or end product. This reliability can be negatively impacted by factors that affect adhesion, e.g., surface contamination, presence of oxide layers and low surface energy substrates.

Optimal adhesion of Parylene to a wide variety of substrates is commonly achieved by a treatment with A-174 silane prior to Parylene coating. Sometimes, however, it fails to meet the highest standards on many of today's difficult substrates (e.g., highly polished stainless steel, titanium, exotic alloys and polyimides, etc.). SCS' AdPro family of technologies increase adhesion between Parylene coatings and historically challenging substrates.

AdPro Plus® and AdPro Poly® are biocompatible and biostable. Additionally, they have demonstrated stability at elevated temperatures, making them excellent adhesion promotion tools for harsh environment applications. The AdPro family of adhesion technologies is available to SCS commercial coating service customers. For more information, contact SCS.



APPLICATIONS

ELECTRONICS

SCS Parylene coatings are conformal and uniform, ensuring complete coverage of circuit boards, ferrite cores and other electronics packages such as MEMS, lab-on-a-chip technologies and sensors. SCS Parylene C coatings have been shown to mitigate the formation of metallic whiskers, OSEs (odd shape eruptions) and dendrites.

MEDICAL

SCS Parylenes are recognized by the FDA and provide an ideal surface modification for implantable and non-implantable devices such as catheters, seals, stents, cochlear implants, surgical tools, pacemakers and components. The coatings protect devices and components from moisture, biofluids and biogases and serve as a biocompatible surface for tissue contact.

TRANSPORTATION

Ultra-thin SCS Parylene coatings protect critical sensors, circuit boards and other components used in consumer automobiles as well as heavy-duty engines and systems. The coatings provide a barrier from harsh chemicals, fluids and gases, even at high temperatures and during prolonged use.

AEROSPACE AND DEFENSE

SCS Parylenes offer unmatched protection for many aerospace and defense applications, including aircraft, space programs and defense systems. The coatings provide reliable barriers against elements such as moisture, dust, sand, and chemical and biological agents.

STANDARDS AND CERTIFICATIONS

Each SCS customer has very unique and exact product and performance requirements that must be met. SCS' experience and expertise is leveraged on every project — from the initial planning phases, to advanced engineering, to the development of customer-specific application processes — in order to meet the most challenging customer specifications and quality requirements.

The following is a brief overview of the standards and certifications to which SCS and/or SCS Parylene coatings comply:

- SCS maintains AS9100 and ISO 9001 certified coating centers.
- SCS maintains cleanroom facilities that conform to ISO 14644.
- SCS coating centers are experienced in the Production Parts Approval Process (PPAP).
- SCS Parylenes N, C and Parylene HT have been tested in accordance to ISO 10993 and USP Class VI requirements.
- SCS maintains comprehensive U.S. FDA Device and Drug Master Files that may be referenced in FDA submissions by SCS commercial coating service customers.
- SCS Parylenes meet the requirements of IPC-CC-830.
- SCS Parylenes are listed on the QPL for MIL-I-46058C.
- SCS Parylene C is UL (QMJU2) recognized.
- SCS Parylenes meet the requirements of IEC 60529, test conditions 14.2.7 and 14.2.8 for IPX7 and IPX8 designations.
- SCS Parylenes are REACH and RoHS compliant.

If you have any questions or would like more detail on the information presented here, please visit SCScomplies.com or contact SCS.

PRODUCT SAFETY

Specialty Coating Systems has compiled the information contained herein from what it believes are authoritative sources and believes that it is accurate and factual as of the date printed. It is offered solely as a convenience to its customers and is intended only as a guide concerning the products mentioned. Because the user's product formulation, specific use application and conditions of use are beyond SCS control, SCS makes no warranty or representation regarding the results that may be obtained by the user. It shall be the responsibility of the user to determine the suitability of any products mentioned for the user's specific application.

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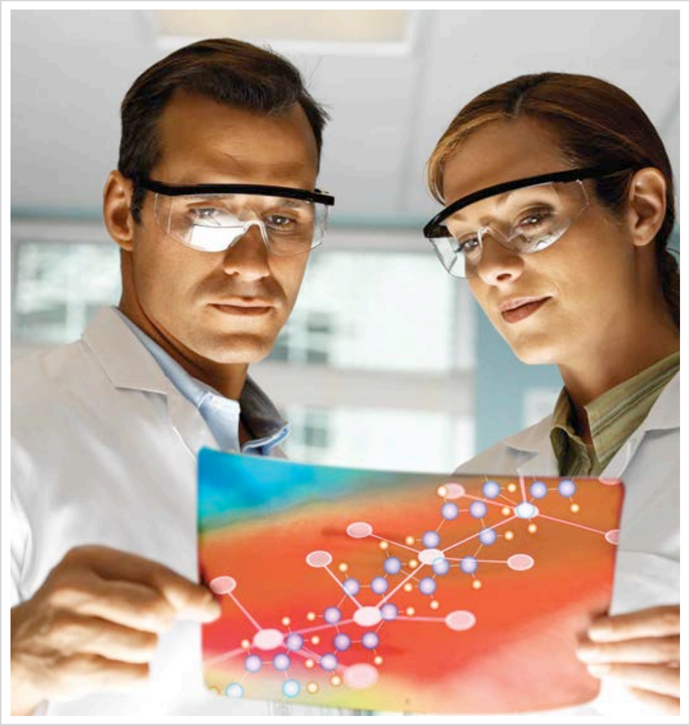

TABLE 6: International Conversions

To convert g/cm^3 to kg/m^3, multiply by 1,000.
To convert psi to MPa, divide by 145.
To convert J/(g•K) to Cal/(g•K), divide by 4.184.
To convert W/(m•K) to Cal/(s•cm•K), divide by 418.4.
To convert (g•mm)/(m^2•day) to (g•mil)/(100in^2•day), multiply by 2.54.
To convert (cc•mm)/(m^2•day•atm) to (cc•mil)/(100in^2•day•atm), multiply by 2.54.

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