



SCS ELECTRONICS COATINGS

Reliable protection for advanced electronics.



SCS

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.

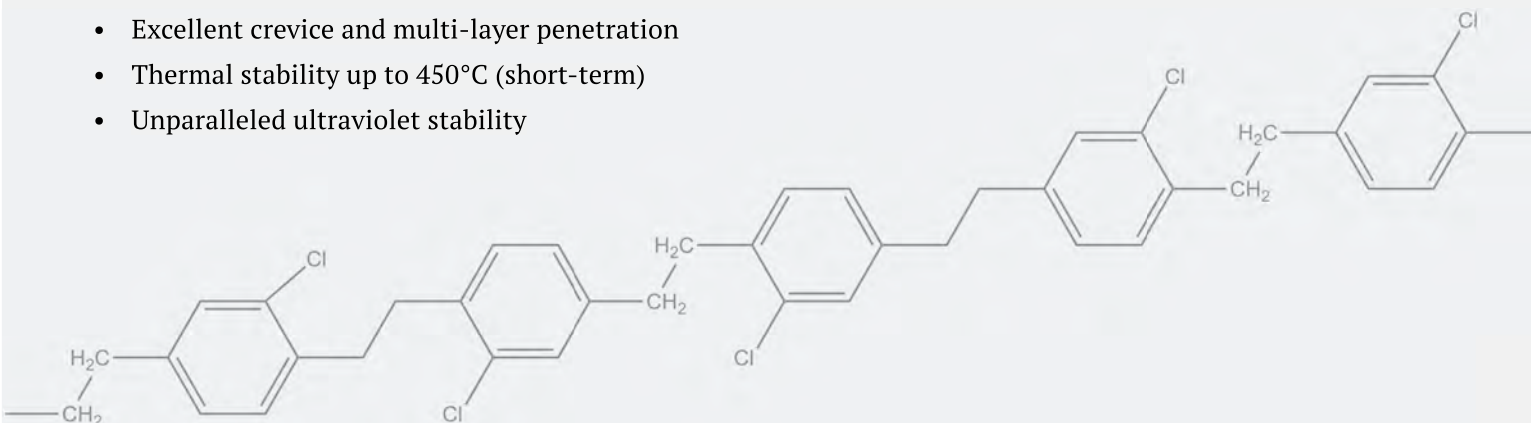
SCS employs some of the world's foremost Parylene specialists, highly experienced sales engineers and expert manufacturing personnel, working in state-of-the-art coating facilities in 11 countries worldwide. Our extensive, proactive approach to production and quality requirements gives our customers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



SCS PARYLENE COATINGS

SCS combines the properties of Parylene with its years of experience, vast technologies and worldwide resources to provide electronics manufacturers with reliable coatings and services. In response to changing industry requirements and regulations, SCS has specifically engineered two new types of Parylene. Parylene HT® provides protection for electronics that operate in harsh environments; ParyFree®, SCS' newest variant, provides advanced barrier protection in a halogen-free Parylene coating. Ultra-thin and pinhole-free, SCS Parylene conformal coatings offer beneficial attributes, including:

- Excellent dielectric properties
- Excellent chemical and moisture barrier properties
- Biocompatible and biostable protection
- Ultra-thin, conformal coating of all exposed surfaces
- Excellent crevice and multi-layer penetration
- Thermal stability up to 450°C (short-term)
- Unparalleled ultraviolet stability



PROTECTION FOR ADVANCED ELECTRONICS

SCS can apply Parylene coatings to virtually any surface material, including metals, elastomers, resins, plastics and ceramics, in thicknesses ranging from a few hundred angstroms to several mils. The coatings polymerize as uniform, thin films that conform to all surfaces, edges and crevices of a substrate, including the interior of multi-layer electronic packages. As a result of their ultra-thin application, Parylenes add little dimension or mass to critical, weight-sensitive components.

SCS employs the Parylenes' unique properties to provide specialized conformal coating solutions to customers in a variety of industries, including:

ELECTRONICS

SCS Parylene coatings are conformal and uniform, ensuring complete coverage of circuit boards, LEDs, wafers, ferrite cores and other electronics packages, including MEMS, labs-on-chips and electrowetting technologies. Parylene's outstanding penetration ability ensures total and uniform encapsulation of all components and crevices, with no meniscus, flowing or edge-effects. SCS offers coating facilities with AS9100 and ISO 9001 certifications to ensure quality processes and coatings.

CONSUMER ELECTRONICS

Consumers rely on the use of advanced electronic technologies for numerous day-to-day activities. Smart electronics, including phones, watches, headphones, wearables, portable speakers, etc., are compact by design and hold hundreds of components that need to operate reliably for everyday use. SCS' ultra-thin Parylene coatings provide superior barrier protection against perspiration, humidity and dust, and have been shown to provide waterproof protection per IPX7 and IPX8 test requirements. In response to industry needs, SCS recently introduced ParyFree, a new halogen-free variant of Parylene that also meets the designations of IPX7 and IPX8. SCS has the resources, global locations and proven experience to service high-volume production customers.

TRANSPORTATION

Ultra-thin Parylene coatings protect critical sensors, circuit boards and other electronic components from harsh chemicals, fluids and gases, even withstanding high temperatures encountered during prolonged use in engines and systems. SCS Parylene HT shows no



degradation or discoloration after more than 2,000 hours of accelerated UV testing. Additionally, SCS has extensive experience in transportation quality standards, including PPAP processes.

AEROSPACE AND DEFENSE

SCS Parylenes offer durable protection in severe environments, being used in many aerospace and defense applications, including equipment for international space programs. Parylenes are also excellent coatings for electronics used in defense vehicles and equipment to protect against elements such as moisture, dust, sand and chemical and biological agents. SCS Parylenes are listed on the QPL for MIL-I-46058 and are also recognized as meeting the requirements of IPC-CC-830.

MEDICAL

SCS Parylenes protect medical electronic components and devices from moisture, biofluids and biogases that can cause assemblies to fail prematurely. Such protection extends device life, prevents costly repairs and reduces the risk of failure.

SCS Parylenes N, C and Parylene HT provide an ideal surface modification for implantable medical devices such as cochlear implants, pacemakers and neurostimulation devices. The coating protects medical devices and components and serves as a biocompatible surface for tissue contact. SCS maintains U.S. FDA Device and Drug Master Files, which contain ISO 10993 biocompatibility data. These files are available for FDA reference on behalf of submissions made by SCS commercial coating service customers. The company also maintains cleanroom facilities that conform to ISO14644.

SCS PARYLENE PROPERTIES

	Method	Parylene N	ParyFree	Parylene C	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	5,400	3,500	2,200	3,500	2,000
Dielectric Constant	60 Hz	2.65	2.38	3.15	2.21	–	3.3 – 4.6	4.1	3.1 – 4.2
	1 KHz	2.65	2.37	3.10	2.20	–	–	–	–
	1 MHz	2.65	2.35	2.95	2.17	2.7 – 3.2	3.1 – 4.2	3.8 – 4.4	3.1 – 4.0
Dissipation Factor	60 Hz	0.0002	0.00001	0.020	<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	0.0020	–	–	–	–
	1 MHz	0.0006	0.0007	0.013	0.0010	0.02 – 0.03	0.004 – 0.006	0.068 – 0.074	0.003 – 0.006
Water Vapor Transmission Rate (g•mm)/(m²•day)	3,4,5,6	0.59	0.09	0.08	0.22	13.9 ^c	0.94 ^c	0.93 – 3.4 ^c	1.7 – 47.5 ^c
Water Absorption (% after 24 hours)	7	<0.1	<0.1	<0.1	<0.01	0.3	0.05 – 0.10	0.6 – 0.8	0.1
Service Temperature	Continuous	80°C	80°C	100°C	450°C	–	–	–	–
	Short-Term	60°C	60°C	80°C	350°C	82°C	177°C	121°C	260°C
UV Stability	9	≤100 hrs	≤100 hrs	≤100 hrs	≥2,000 hrs	–	–	–	–
Coefficient of Friction	Static	0.25	0.23	0.29	0.15	–	–	–	–
	Dynamic	0.25	0.23	0.29	0.13	–	–	–	–
Tensile Strength (psi)	11	7,000	9,600	10,000	7,500	7,000 – 11,000	4,000 – 13,000	175 – 10,000	350 – 1,000
Penetration Ability^d		40 x dia.	10 x dia.	5 x dia.	50 x dia.	Spray or Brush	Spray or Brush	Spray or Brush	Spray or Brush
Rockwell Hardness	12	R85	R136	R80	R122	M68 – M105	M80 – M110	68A – 80D (Shore)	40A – 45A (Shore)
USP Class VI Polymer		Yes	Not Yet Available	Yes	Yes	Varies	Varies	Varies	Varies
Biocompatibility^e		ISO 10993	Not Yet Available	ISO 10993	ISO 10993	Varies	Varies	Varies	Varies

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.

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

d. Depth into tubing and crevices.

e. Contact SCS Marketing for specific results.

Test Methods:

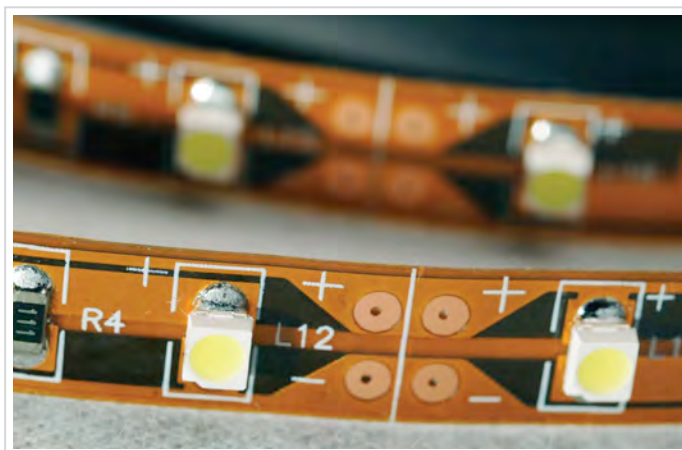
1. ASTM D149
2. ASTM D150
3. ASTM E96 (at 90% RH, 37°C) (Parylene N only)
4. ASTM F1249 (at 100% RH, 37°C) (ParyFree only)
5. ASTM F1249 (at 90% RH, 37°C) (Parylene C only)
6. ASTM F1249 (at 100% RH, 38°C) (Parylene HT only)
7. ASTM D570
8. TGA/FTIR, DSC and thermal endurance testing
9. ASTM G154
10. ASTM D1894
11. ASTM D882
12. ASTM D785

PROPERTIES OF SCS PARYLENE COATINGS

DIELECTRIC PROPERTIES

SCS Parylenes have excellent dielectric properties. Their high dielectric strength is attributable to the fact that they can be formed as thin, continuous films, free from the defects and fillers commonly found in conventional coatings that tend to reduce dielectric strength.

SCS Parylenes have low dielectric constants and dissipation factors and high dielectric strengths, enabling electrical signal transfer without absorption or loss.



THERMAL STABILITY

Many components in the electronics, transportation, aerospace, defense and medical industries require protection, especially when they encounter extreme environments. SCS Parylene HT is specifically engineered to provide long-term thermal stability up to 350°C, with short-term stability up to 450°C. The coating is well-suited for applications that may be used in harsh transportation environments, medical sterilization processes or space applications, to name a few.

BARRIER PROPERTIES

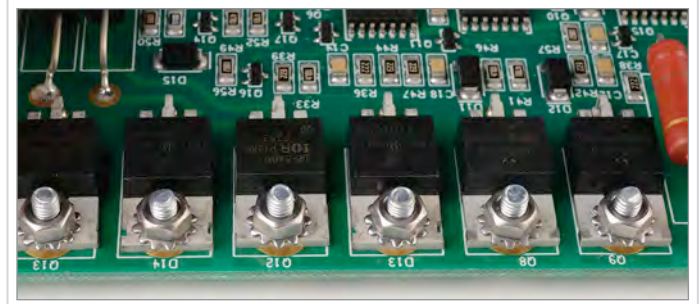
SCS Parylene coatings are excellent moisture and chemical barriers. Applied in the micron range — much thinner than industry standard coatings — Parylenes provide superior pinhole-free, uniform barriers to protect against corrosive liquids, fluids, gases and chemicals, even at elevated temperatures.

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

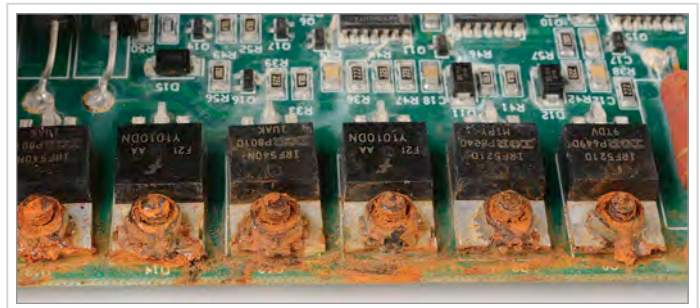
against water splash and water immersion for more than 30 minutes at a depth of 1 m (IPX7) and 1.5 m (IPX8).

Circuit boards coated with ParyFree were salt-fog tested by an independent facility. The coated boards exhibited no corrosion, salt or heavy iron oxide deposits after 144 hours of exposure in accordance with ASTM B117-(03) (See Figure 1). Boards coated with SCS Parylenes C and Parylene HT exhibited similar results.

FIGURE 1: Circuit boards after 144 hours of salt-fog exposure



Coated with SCS ParyFree



Uncoated

ENVIRONMENT-FRIENDLY COATINGS AND PROCESSES

SCS COMPLIES

As worldwide industry requirements and directives continue to evolve, SCS is at the forefront, ensuring our products and services comply with relevant regulatory, environmental and biological standards.

SCS Parylenes comply with the European Union's RoHS (Restriction of Hazardous Substances) and REACH regulations. For more information about SCS certifications and standards, visit SCScomplies.com.

METAL WHISKER MITIGATION

As a result of industry directives, pure metal plating is replacing lead in the solders used throughout the worldwide electronics industry. While safer for the environment, metal plating is known to form whiskers, which cause reliability problems for electronic systems. Parylene coatings suppress the formation of metallic whiskers, OSEs (odd shape eruptions) and dendrites.

THE PARYLENE PROCESS

SCS Parylene coatings are applied in a room temperature vacuum chamber via a vapor deposition polymerization (VDP) process. Components to be coated are only required to have a reasonable vacuum tolerance. There are no solvents, catalysts or plasticizers involved in the coating process; since Parylene coatings require no elevated temperature cure cycle, there are no associated cure stresses. Unlike Parylene coatings, conventional dipped, sprayed or brushed coatings may require catalysts, cross-linking, elevated temperatures or UV cure cycles to improve coating properties.



Room Temperature



Molecular-level
Deposition



No Solvents, Catalysts
or Plasticizers



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