

FluoroPel Hydrophobic Conformal Coatings

FluoroPel is a family of nano-coatings designed to protect against water and moisture related premature failure of devices. FluoroPel dries to a very thin film with excellent hydrophobic and oleophobic properties. The coating can be applied by dipping, spraying or syringe dispensing with little or no masking. The application methods and film quality of FluoroPel can be customized by using solvents with boiling points ranging from 50°C to 220°C. Third party customer testing has shown that FluoroPel coated circuit boards in phones can get certification for MIL-STD 810G for working under most environmental conditions. Third party customer testing has also shown that FluoroPel coated devices meet the biocompatibility requirements stipulated in ISO 10993 (Biological Evaluation of Medical Devices) and FDA requirements for 510K submissions.

Temperature and humidity testing method 507.5 has shown that devices can withstand temperatures up to 140°F in 95% relative humidity. Salt Fog Method 509.5 testing has shown that coated devices withstands exposure to salt fog at 98°F for 120 hours with no loss of functionality. FluoroPel coated devices have also been certified IPX5 or IPX7 waterproof per IEC-60529 by third party testing where the device withstands immersion in 1 meter of water for a period of 30 minutes. FluoroPel coated circuit boards in smartphones can achieve IPX5 standards without the use of mechanical seals and gaskets.



Figure 1. Smartphone coated with FluoroPel working under water passes IPX5 or IPX7 water resistance test

Materials and Methods

The FluoroPel was synthesized at Cytonix. FluoroPel is available online, calling or emailing Cytonix. For contact angle measurements a drop of distilled water was placed on coated glass microscope slides and imaged using a low magnification microscope. Each drop was illuminated from behind to obtain a good image for drop image analysis. For solvent resistance analyses coated glass slides were soaked in the solvent of interest for 2 minutes, dried and then contact angle measured.

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Table 1. Properties of FluoroPel Solution

Property	
Names	FluoroPel 0.2 (0.2% solids) and FluoroPel 2.0 (2% solids)
Product Code	800F
Chemistry	C6 fluoro-carbon
Color and clarity	Colorless or yellow liquid and Lightly turbid to clear
Stock Concentration	20% in fluoro-solvent or 100% solid resin
Odor	Light ether-like odor
Flammability	Non-Flammable
Viscosity	>0.41 cP depending on polymer concentration
Solubility	PFC60, PFC80, HFE7100, HFE7200, AE3000
Shelf Life	>5 years stored in original unopened container
Environmental	Low in toxicity, non-ozone depleting
One Part System	Yes
Application Options	Dipping, spraying, brushing, syringe-dispensing

Table 2. Properties of FluoroPel films

Property	
Appearance	Clear, odorless and colorless film
Contact Angle to Water	~115°
Contact Angle to Oil	>55°
Oleophobicity grade	7
Surface Tension	8-12 dynes/cm
Hardness	>2B pencil
Flammability	Non-burning
Tracer	UV tracer for quality control (at request)
Heat stability continuous	150°C
Max heat stability one hour	250°C
Refractive index Surface	~1.34
Toxicity	HMIS Rating Health = 1
Ease of Application	Excellent
Solvent/Chemical Resistance	Excellent after curing
Transparent	Yes
Electric conductivity	Yes (at <0.5 µm film thickness)
Ease of Dry	Dries at room temperature in <5 minutes
Low Labor	Yes
Removable Yes	Yes
Solder-through Repairable	Yes

Table 3. FluoroPel film thickness

Property	
Film thickness at 0.2% polymer	~0.05 µm
Film thickness at 2% polymer	~0.1 µm
Film thickness at 5% polymer	~0.5 µm
Film thickness at 10% polymer	~1.0 µm
Film thickness at 20% polymer	~2.0 µm

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Table 4. Electrical properties of FluoroPel films

Coating Thickness	Surface Resistance (Ω)	Volume Resistance (Ωm)
0.05 μm film	Conductive	Conductive
0.1 μm film	Conductive	4×10^{20}
0.5 μm film	1×10^9	8×10^{20}
1.0 μm film	5×10^{11}	ND
2.0 μm film	2×10^{14}	ND
>100 μm film	2×10^{17}	ND

*Electrical properties determined on aluminum plates. Measures presented are approximate.

Table 5. Water contact angles of 0.5 μm FluoroPel films

	Water Contact Angle*
Air dried for 4-5 hours	114.2°
Baked at 90°C for 15 minutes	116.3°

* Numbers shown are an average of over 4 readings.

Table 6. Solvent and UV-light resistance properties of 0.5 μm FluoroPel films

Exposure	Water Contact Angle*
Toluene – 2 minutes	112.7°
Acetone – 2 minutes	104.8°
De-icing fluid – 2 minutes	100.6°
FC40 – 2 minutes	117.3°
Perfluoropolyether vacuum oil – 2 minutes	Removes coating
UV light – 10 minutes	88.2°
UV light – 20 minutes	71.9°

* Numbers shown are an average of two readings.

Table 7. Heptane contact angles of 0.5 μm FluoroPel films

	Average Heptane Contact Angle*
Air dried for 5 hours	26.7°



* Numbers shown are an average of over 4 readings.

Table 8A. FluoroPel films and long-term performance


FluoroPel Coating Date	March 19, 2010	July 1, 2011	October 21, 2014
Contact Angle	>110°	>110°	>110°
Film Quality	Good	Good no-change	Good no-change

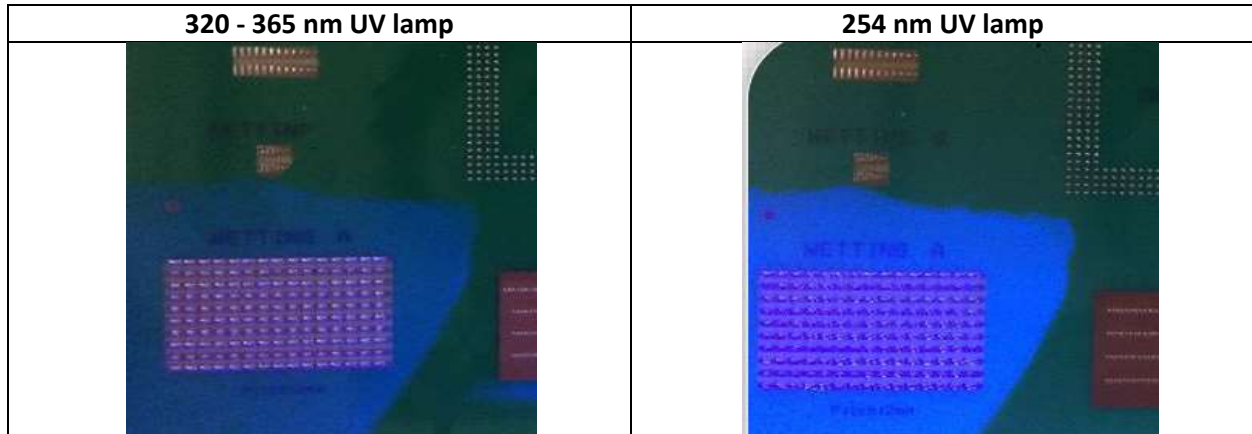
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Table 8B. FluoroPel films and long-term performance

FluoroPel Coating Date	June 2, 2005	
Initial Contact Water Angle	>110°	
Initial Film Quality	Good	
Contact angle on Oct 2014	>110°	
Film Quality on Oct 2014	Good no-change	



Dip Coating Procedure and Application Guide

The environment for the coating process needs to be clean. Dust can negatively affect the coating application process resulting in poor adhesion, voids, and reduction of coating performance.

A. Masking (maybe optional):

Microphones, speakers, camera lenses may need masking using Duraseal (applied by manual labor).

B. Cleaning Process:

Device may need to be cleaned using IPA Wipes and/or compressed air to remove dust.

C. Coating Process:

Dip coat manually or using automated system

- Recommended starting test point immersion speed of 15cm/min
- Recommended starting test point withdrawal speed of 15cm/min
- It is important to control immersion speed to avoid excessive air bubbles. Bubbles can result in voids in the coating.
- Withdrawal speed determines the cosmetic appearance and uniformity of the coating. Slow is good.
- Dry by hanging at room temperature or leaving in basket
- Cure by heating at 60°C for 10 minutes (optional)
- Remove from tray or hook and package
- The coating concentration must be monitored during a production run

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D. De-masking:

- Remove Duraseal with tweezers

E. Coating during assembly:

- It may be useful to apply a drop of FluoroPel using a dropper or syringe to exposed connectors and joints made during device assembly. This will assure that water will be effectively repelled for the life of the device.

F. Safety:

In Case of a Spill: Evacuate unprotected and untrained personnel. Contain spill. Working from around the edges of the spill inward, cover with bentonite, vermiculite, or commercially available inorganic absorbent material. Clean up residue with an appropriate solvent. Place in a metal container approved for transportation by appropriate authorities. Seal the container. Dispose of collected material as soon as possible.

G. Health:

Eye Contact: Contact with eyes during product use is not expected to result in significant irritation.

Skin Contact: Contact with skin during product use is not expected to result in significant irritation.

Inhalation: Thermal decomposition products may be harmful if inhaled.

Ingestion: No health effects are expected.

First Aid: The following recommendations are based on an assumption that appropriate personal and industrial hygiene practices are followed:

Eye Contact: Flush eyes with large amounts of water. If signs/symptoms persist, get medical attention.

Skin Contact: Wash affected area with soap and water. If signs/symptoms develop, get medical attention.

Inhalation: If signs/symptoms develop, remove person to fresh air. If signs/symptoms persist, get medical attention.

If Swallowed: If signs/symptoms develop, get medical attention. No need for first aid is anticipated.

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