Top Finishes on Architectural Fabrics: Performance Differences

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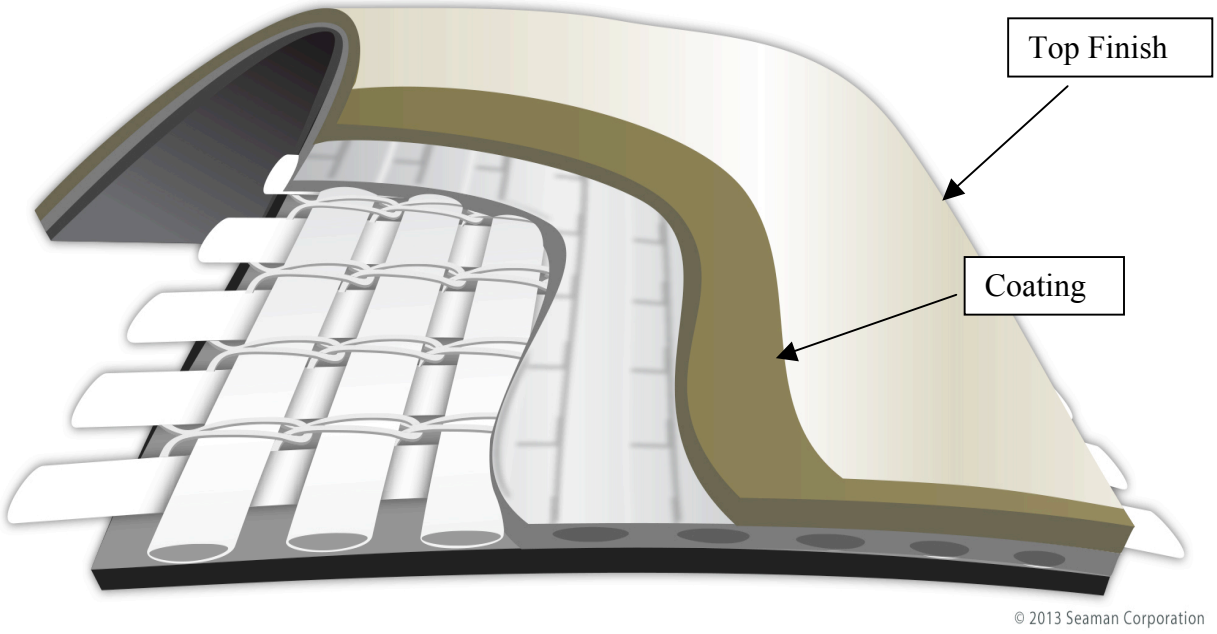
Overview

Designers, fabricators and users have the option to extend the life expectancy, reduce the maintenance, and increase the aesthetics of an architectural fabric structure by specifying a top finish. Top finishes are used as a surface treatment in conjunction with a high-performance architectural coated fabric. Many fabricators and designers are familiar with top finishes from actual experience; this paper provides an in-depth view into the differences in the chemistry, performance, sustainability, and use of top finishes protecting the under layers of the architectural coated fabric.

Figure 1: Top Finish on the surface of an architectural fabric



History of Top Finishes

Top finish resins have been serving the building market for over 80 years. Poly methyl methacrylate (PMMA), the common resin used in acrylic top finishes for architectural fabrics, was first brought to the market in 1933, better known as Plexiglas®. Soon after fluoropolymers were developed and have played a significant part in extending the life-expectancy of architectural fabrics.

In 1961, DuPont introduced the fluoropolymer polyvinyl fluoride (PVF), better known as Tedlar®, into the market place. The PVF film based on Teflon® technology has played a key role in protecting residential and commercial buildings for over 40 years. The architectural fabric

community has recognized PVF as a superior finish providing for long-term high aesthetic structures.

Arkema, previously known as Pennsalt, based in Colombes, France, has an extensive history with fluoropolymers in the building envelope as well. It has not been until the past several years that the fluoropolymer polyvinylidene fluoride (PVDF) under the trade name Kynar® has made its way into the architectural coated fabrics community. With the superior long-term performance in the metal building industry, the transition into the flexible membrane market has been forthcoming.

Use on Coated Fabrics

As with metal, industrial polymer coated fabrics utilize surface coatings to protect the aesthetic appearance and improve the cleanability. The flexible coated fabrics used in this market utilize synthetic resins that contain modifiers in the base polymeric matrix to impart elastic properties to the coatings. Over time, these modifiers will migrate and adhere to the surface resulting in dirt accumulation. A membrane that collects dirt loses its aesthetic qualities and provides a venue that promotes fungal growth on the surface.

The following are top finishes that are used in this industry to negate this phenomenon and extend the life expectancy of the architectural structure:

- PVF (Tedlar)
- PVDF (Kynar)
- Weldable PVDF
- Acrylic

Based on the level of protection required, each has its distinct properties and performance characteristics, which are discussed in more detail in the following sections.

PVF

For over 30 years, PVF continues to have an excellent track record in the architectural structure market. Seaman Corporation was the first architectural coated fabric manufacturer to successfully adhere PVF film to coated architectural fabrics. The flexibility of the PVF film adhered to the architectural coated fabric allows for ease of installation.

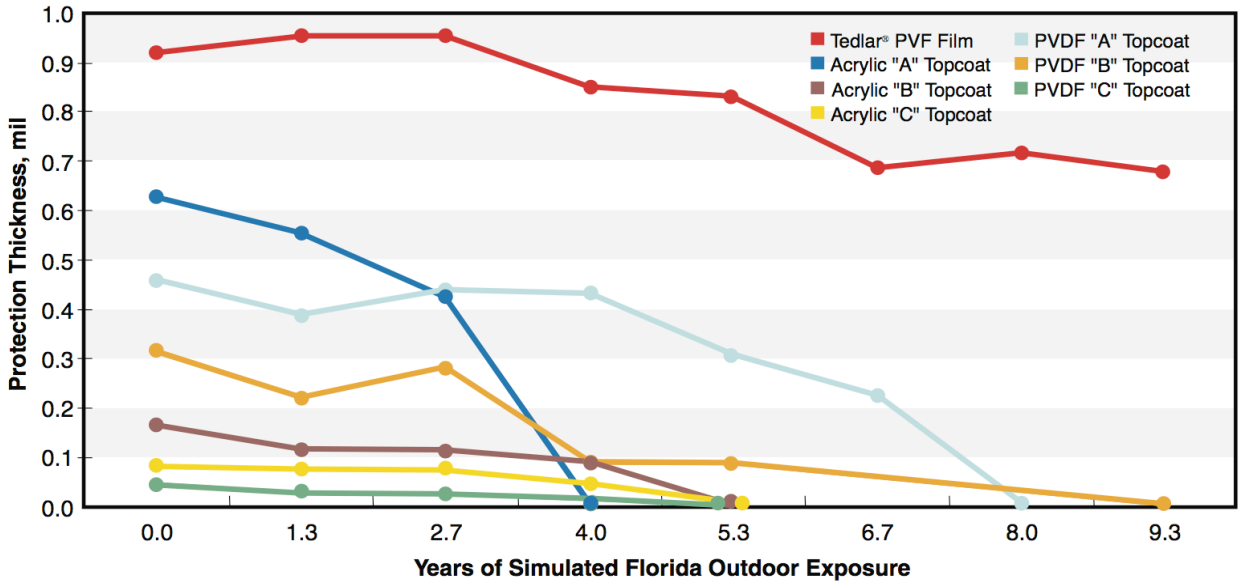
Being in the same polymer family as Teflon, PVF provides an inert surface for long-term durability. *Figure 2* provides performance properties features of PVF film that are critical to long-term performance of architectural structures.

Figure 2: PVF Performance Chart

Feature	Benefit
Thickness (1 mil)	Minimum 2x thicker than standard finishes
Film	Continuous biaxial orientated film to provide increased abrasion resistance
UV Resistant	Acts as a barrier resulting in excellent color stability, resists cracking and crazing
Longevity	Protecting 20+ year old structures
Chemical Resistant	Resistant to harsh environmental conditions
Cleanable	Graffiti-resistant; preserves aesthetics with reduced maintenance
Fire exposure	Reduces rate of burn
Nonstick	Excellent release material reducing dirt accumulation that supports mildew growth
Pigmentation	High reflectivity reduces solar heat gain
Moisture barrier	Low water permeation

PVF film is manufactured for the architectural fabric industry from a thermoplastic polymer with a repeating vinyl fluoride unit containing high-grade TiO2 (white pigment), stabilizers and other additives. This 1 mil film acts as a sealant on the exterior surface of the architectural coated fabric and mitigates liquid modifier migration from the fabric. Excellent resistance to UV and moisture barrier properties preserves the appearance and longevity of the architectural structure. The change in thickness of the PVF film over a simulated 9-year period when compared to acrylic and PVDF/Acrylic top-coat systems is minimal, maintaining its protective nature.

Figure 3: Comparison of Thickness Change in Top Finish Materials.

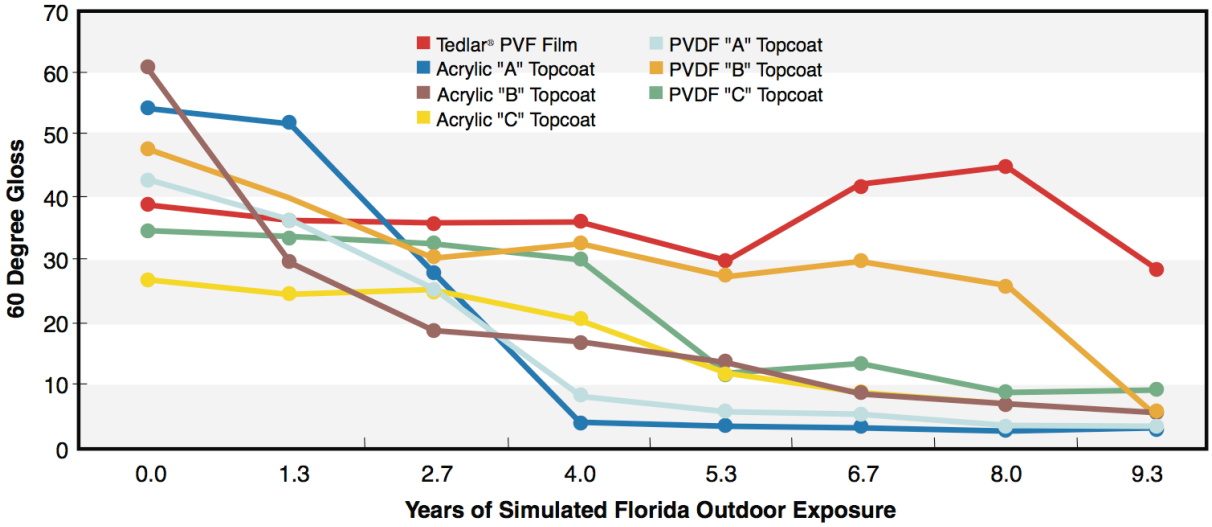


Note: This simulation shows that Tedlar® protective film not only starts out thicker than any of the other protective coatings, but retains superior thickness long after the others eroded completely.

The PVF film retains more than 72% of its thickness, making it thicker after testing than the acrylic and PVDF coatings were at the start of the testing.

Gloss (i.e. surface sheen) is an indicator of top finish surface integrity. As the gloss on the material becomes duller than the original surface gloss, this indicates degradation of the top finish is occurring. In some finishes, it is difficult to differentiate the depletion of the top finish surface as the initial surface is dull due to modifiers that were added to the finish. Once the top finish is depleted, gloss measurements are likely a result of the property of the coating. PVF film shows excellent gloss retention after an equivalency of nearly 10 years.

Figure 4: Comparison of Gloss Change in Top Finish Materials



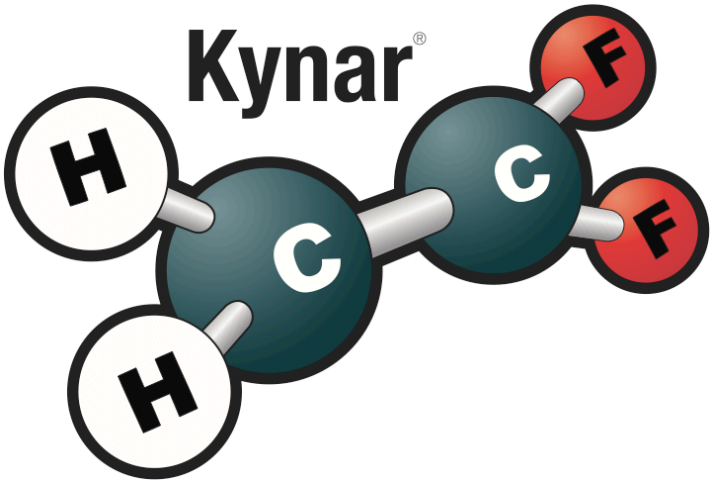
The Tedlar® PVF film shows excellent gloss retention after the equivalent of nearly 10 years of exposure, while the coating materials have failed to maintain their integrity. In fact, because the protective layers of the coating materials have been essentially depleted, both color and gloss measurements on these systems are probably the properties of the PVC substrate alone.

PVDF (Kynar®)

PVDF (Kynar®) is well known for its protective properties against corrosion and superior color fastness in the metal structure market for over 40 years. Now in the architectural coated fabric market, Arkema produces and controls the proprietary formulations of the Kynar coatings to provide a consistent, high-performance finish for the end product. Unlike weldable PVDF, in which the major resin is acrylic, this film carries the inert properties of the Kynar resin and is not weldable to synthetic resins. The percent by weight of the resin content found on the surface is a minimum 70% PVDF. This allows the crystalline structure to form that provides superior barrier properties as compared to typical PVDF finishes found in the market.

Kynar's molecular structure, as well as the percent weight of resin content, determines the overall performance characteristics. Kynar contains carbon-fluorine(C-F) bonds, one of the strongest and most stable chemical bonds known, the C-F and C-H bonds are alternating.

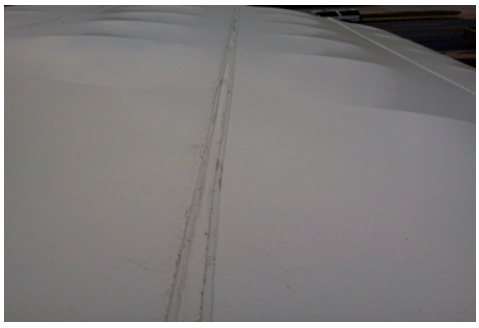
Figure 5: Kynar Molecular structure



Source: Arkema, Inc.

The alternating C-F bond results in a higher polarity on the surface to resist environmental degradation and dirt accumulation. The very low surface energy and low coefficient of friction of the Kynar finish resists soiling as compared to weldable PVDF finishes. The lack of dirt accumulation and the non-nutrient value of PVDF (Kynar) to support fungal growth further inhibit mildew development. The photos in *Figure 6* show architectural fabrics in similar applications, PVDF (Kynar) vs. Standard PVDF after less than 3 years of exposure in the Southern United States.

Figure 6: Shelter-Rite® Brite w/Kynar® vs. Standard PVDF finish



Shelter-Rite® Brite® w/Kynar®

Standard competitive PVDF finish

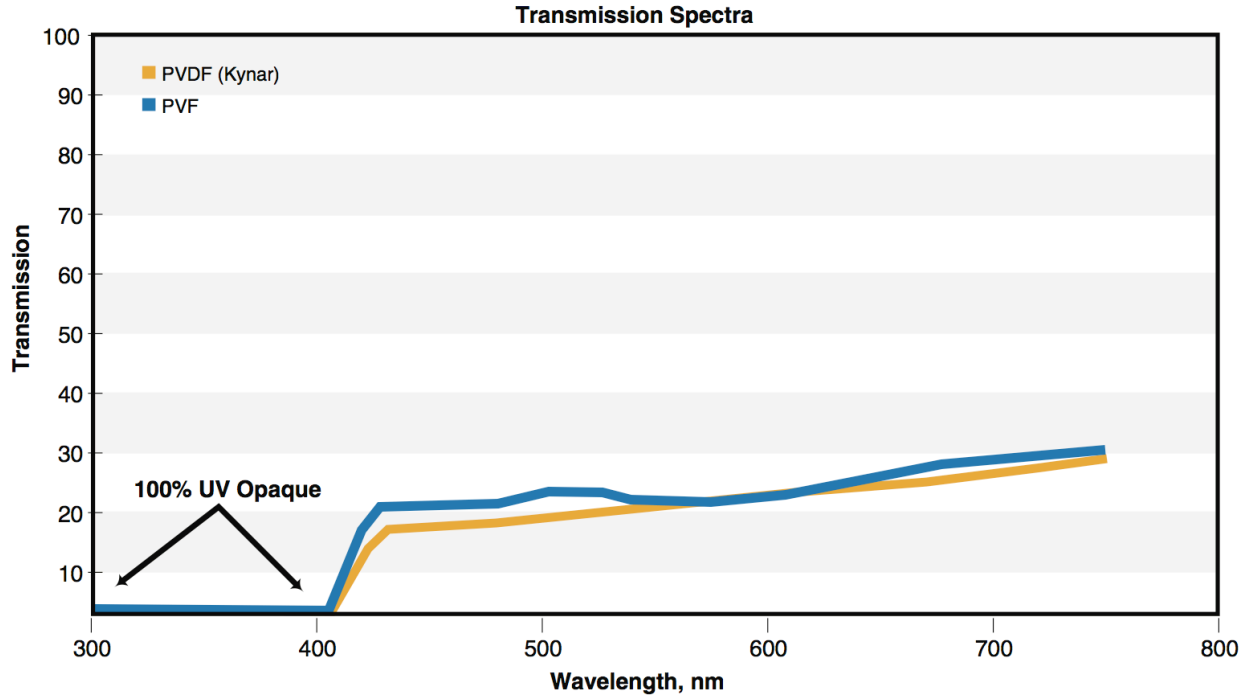
One of the major differences that separate PVDF (Kynar) from the rest of the finishes in the industry is the availability of *colors other than white* on an architectural coated fabric. This gives designers and architects the option of incorporating color into an architectural structure that will look like new for many years. Colors on coated fabrics are hard to protect from UV, resulting in color fading and chalking. PVDF (Kynar), used in the metal industry on standing seam roofs, has proven performance and an excellent track record for color stability. There is an array of colors offered on Shelter Rite Brite architectural coated fabrics that carries a 10-year warranty on

colorfastness. Stock and custom colors are available. This is the best, high-quality, color stable solution available to architectural coated fabrics on the market.

PVF and PVDF (Kynar)

High-quality pigments and UV additives are formulated into the finishes to reflect and absorb these harmful rays. UV rays found below 300nm have been determined to cause the most damage to polymeric coatings used in flexible architectural fabrics. UV radiation is the major source of degradation of coating in environmental exposures. The UV blocking capability of the PVF and PVDF (Kynar), shown in the *Figure 7* below, provides excellent protection of the coated fabric as opposed to transparent top finishes found in the industry.

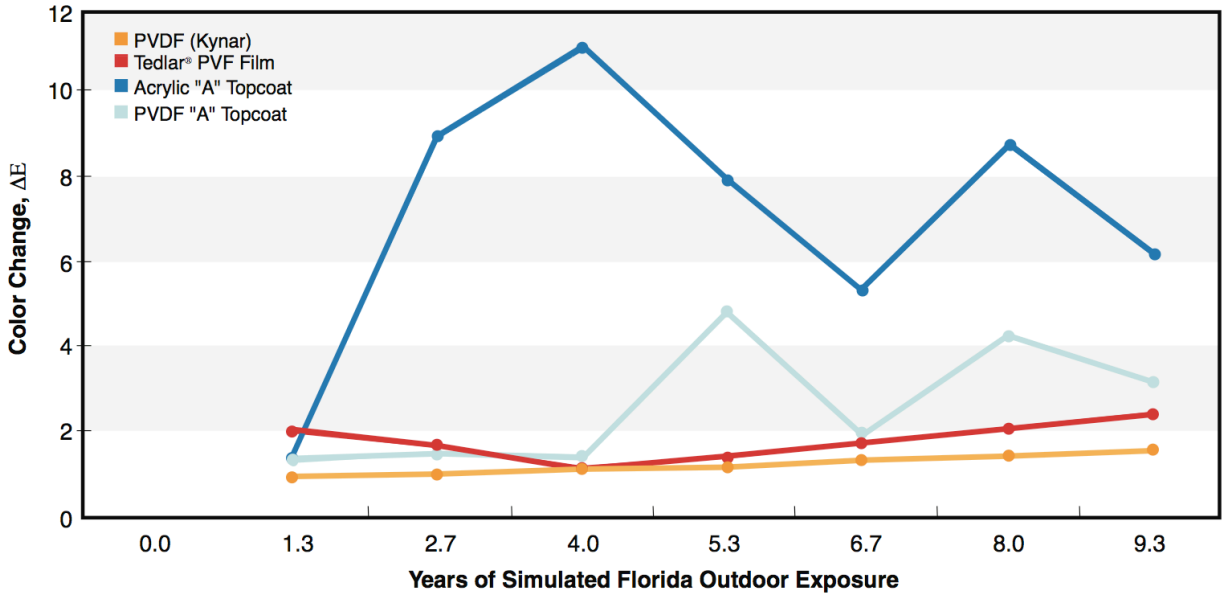
Figure 7: PVF and PVDF (Kynar) Transmission Spectra



The weathering characteristics are critical when evaluating surface coating for long-term performance in the architectural market. The PVF and PVDF (Kynar) provides resistance to UV degradation, moisture penetration, and dirt accumulation, all of which can be found in environmental exposure. With the use of accelerated weathering equipment, exposure of top finish coated fabric samples has been performed that correlates to over 10 years in south Florida. The results overall illustrate a lower change in color shift of the PVF and PVDF (Kynar) in combination with a flexible coated fabric used in the architectural structure market. The color shift seen on typical transparent finishes is the result of color change in the coating (*Figure 1*) of

the fabric. *Figure* 8 illustrates laboratory data confirming the stability of PVF and PVDF (Kynar) when used in conjunction with Shelter Rite architectural fabric.

Figure 8: Color Stability of Top Finishes



Color change can be attributed to degradation by UV light and dirt pickup. Note that the Tedlar® PVF film shows no color change after the equivalent of nearly 10 years of exposure.

Weldable PVDF

Weldable PVDF systems are considered by many to provide improved performance, while still allowing thermal bonding to other synthetic resins. As PVDF is inert, acrylic resins are blended with PVDF to provide a composite that will adhere to other resin systems. In fact, the percent of PVDF resin found in this system is typically less than 30% by weight resin content, with the remainder being primarily acrylic. The overall thickness is slightly higher than acrylic at 0.2 mil to 0.4 mil. Weldable PVDF systems, generally non-pigmented, are considered to be a step up from the acrylic systems as the PVDF resin does offer some unique characteristics. The low amount of PVDF provides for some hydrolysis resistance and allows ultraviolet wavelengths to pass through it increasing the weathering capability of the finish. Since the acrylic resin is the major polymer in the system, the properties inherent with acrylic polymers result in the degradation of the surface coating system. In addition, studies have shown that at the low PVDF content, mechanical properties, and toughness are sacrificed due to disruption of the crystallinity of the molecular structure.

Acrylics

Acrylics are a good choice as a top finish on architectural membrane structures. The acrylic resin systems are typically comprised of a blend of polymethyl methacrylate (PMMA), polyvinyl

chloride polymers, modifiers, and a carrier. The thickness of translucent acrylic systems is typically 0.1 mil to 0.2 mil and helps to block the liquid modifier from reaching the surface inhibiting dirt collection. Acrylic resins contain esters and incorporate other functional groups, which are susceptible to photochemical degradation and hydrolysis; both which are found in environmental exposure. These conditions contribute to the ultimate breakdown of the protective acrylic layer.

In general, weldable PVDF and acrylics transparent top finishes rely significantly on the formulation of the coating (*Figure 1*) to reduce light transmission reducing solar heat gain, maintain color stability, and block the majority of the UV rays. PVF and PVDF (Kynar) relies on the finish itself for those characteristics protecting the coating to provide for a superior long-term high aesthetic structure. Only Shelter Rite Brite architectural fabrics offer both, a superior PVF and PVDF (Kynar) top finish and high-quality formulated coating (*Figure 1*).

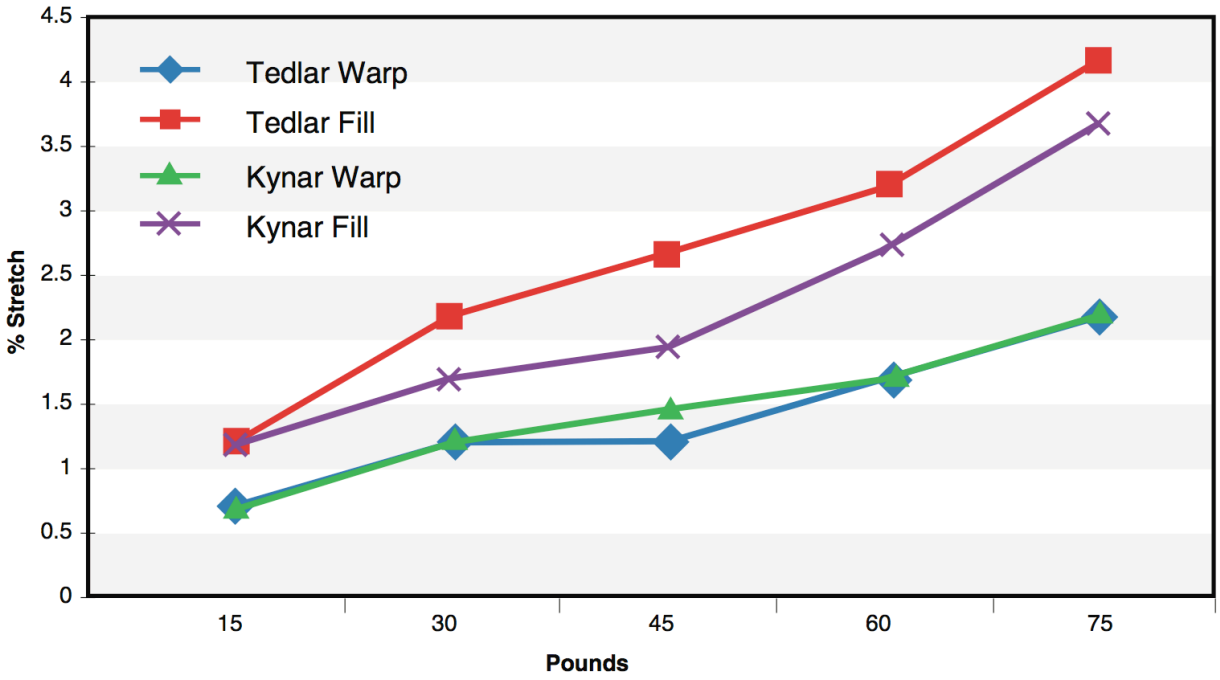
Sustainability

PVF and PVDF (Kynar) films further promote sustainable qualities into the architectural membrane. Natural daylight can be designed into the structure by utilizing the white film over transparent like coatings to block the damaging UV rays. The films used over white coating increases the solar reflectance index (SRI) reducing solar heat gain over the life of the material. Further, PVF and PVDF (Kynar) provides a surface that is low maintenance. The low surface energy provides for minimal dirt collection and natural cleansing, reducing the need to clean with harsh chemicals. The stain repellency of the films helps to preserve the aesthetically pleasing finish by allowing easy removal of markers, food stains and graffiti. In addition, flexible coated fabrics provide high versatility, which allow an architect or engineer the option to design energy savings into the building.

Performance

The strength and stretch characteristics of a fabric are key properties that will influence the final decision of what material will be used in the project. There is a range of materials based on tensile strength that can be selected with the PVF and PVDF (Kynar) finish. The stretch features of a finished membrane are directly related to the base cloth. The PVF and PVDF (Kynar) on coated fabrics has little to no effect on the stretch characteristics. Biaxial stretch tests, stretch properties at a given load on a given fabric, are industry-typical for these top finish systems as illustrated in conjunction with a Shelter Rite Style 8028, shown in *Figure 9*.

Figure 9: Shelter-Rite® Brite® w/Tedlar® vs Shelter-Rite Brite w/Kynar® Biaxial Stretch Test



With the variety of finishes in the market, it can be difficult to determine which top finish would best fit the application. All of the finishes contribute some degree of protection to the coated fabric. In order to select the appropriate finish, one must understand the differences that each offer, the long-term performance requirement of the structure, and the customer's expectations. No other factor is as important as meeting the customer's needs from a performance and aesthetic viewpoint. To assist in determining what properties are needed to meet these expectations, *Figure 10* provides a ranking of the performance of top finishes available to this market.

Figure 10: Top Finish Performance

Property	Acrylic	PVDF/ACRYLIC Blend	PVDF (Kynar)	PVF (Tedlar)
Weathering resistance	2	3	4	5
Chemical resistance	1	2	5	5
Water repellant	1	3	5	5
Mildew resistance	2	3	4	5
Dirt pick-up	2	3	4	5
Cleanability	3	3	4	5
Stain resistance	2	3	5	5
Retention of color	-	-	5	5
Abrasion resistance	1	2	4	5

1 being the Worst, 5 Best

The inertness of the PVF and PVDF (Kynar) finish provides excellent environmental resistance. Due to the durable inert finish, it is not directly weldable to synthetic resin coated fabrics. Standard practice is to provide a relief edge on manufactured rolled goods for overlap welding to address the majority of the seams at the fabrication facility. There are simple removal techniques for the PVF and PVDF (Kynar) used by the industry. Experienced welding personnel can perform repairs during fabrication or in the field.

Conclusion

The superior weathering, chemical and dirt resistance characteristic, in addition to sustainability aspects of the PVF and PVDF (Kynar), positions this as the benchmark for surface finishes in the industry. Pairing with high-performance, flexible coated fabrics provide additional capabilities to designers giving them alternatives to standard building materials. PVDF/acrylic blends are widely used and provide acceptable performance in some installations, while PVF and PVDF (Kynar) establish the standard for superior performance in a variety of applications, for those critical factors of low maintenance and excellent appearance, for the life of the structure. When considering the selection of an architectural fabric, the top finish is an important parameter and should be aligned with the project goals.

Sources:
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A Comparative Study: Architectural Fabric Top Finish Performance; Dupont