Text: Dennis Richard

Highlights

- Western encapsulation and backsheet makers are starting to manufacture in China to stay close to module manufacturers
- Only three companies of the 22 participants manufacture backsheets exclusively with Tedlar, while the others offer alternates as well
- Coveme has not only stopped promoting Tedlar-based backsheets, it is terminating the use of fluoropolymers altogether
- NovoPolymers offers a white ethylene vinyl acetate (EVA) film – the first of its kind
- Polyethylene terephthalate (PET) is emerging as a strong competitor to fluoropolymers

The right chemistry

Market survey on encapsulation material sees a new trend, with companies moving toward alternatives to Tedlar, while EVA still holds its ground

When you get a headache, do you ever swallow an asprin? If you do, you are ingesting a pill that started life as a brandname, trademarked by Germany's Bayer AG early last century.

Though it may not be a good idea to swallow the product known as Tedlar – a polyvinyl fluoride (PVF) resin extruded into backsheets for PV modules – the history of this chemical compound is similar to aspirin. In Tedlar's case, the inventor is DuPont Photovoltaic Solutions. As a part of the huge US-headquartered conglomerate, this PV subsidiary has profitted over the years as its Tedlar trademark has become synonymous with the backsheets layered on modules.

But old age seems to be catching up with Tedlar, now celebrating its 50th birthday. As DuPont's Tedlar loses its grip on the PV backsheet market, more and more alternatives, equally strong and

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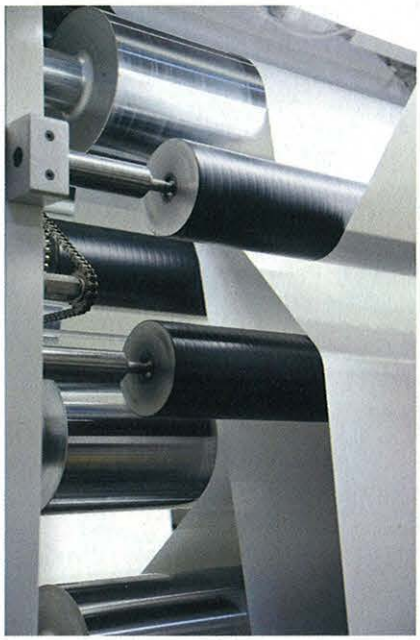
▲ So much to choose from: Our market survey offers module makers, like CSG in China, the choice between 114 backsheets and 59 encapsulation foils.

mostly less costly, have surfaced to fill the void. Of the 22 companies in our annual market survey on backsheets – five manufacturers are listed here for the first time – nearly all have either turned their backs on the one-time market leader or are in the process of doing so. Eight produce Tedlar, but have also added surrogate products to their portfolios; half now solely offer alternatives to Tedlar. Indeed, only three Asian manufacturers exclusively produce Tedlar-based products.

Among the encapsulants, ethylene vinyl acetate (EVA) is still the market leader. The reason is its low-cost, optimized properties. There is also polyvinyl butyral (PVB). While basically used for the struggling silicon thin-film module sector, PVB manufacturers are now eying the crystalline backsheet sphere. But this is an unlikely development, given the extra expense of PVB. Ionomers, a thermoplastic co-polymer of ethylene and (meth)-acrylic acid, have the advantage of good transparency for letting more sunlight through to the module. But, again, that is an expensive option. Another alternative to the market leader – albeit another costly option – is thermoplastic polyurethane (TPU), which not only has good transparency attributes, but decent elasticity as well. Silicone, which has largely been absent from the market for some time, is making a comeback due to its UV stability and a very low UV cut-off value. For emerging cell technologies, such as selective emitters, this product opens the gate to improving solar module efficiencies, as it does not hamper the enhanced blue response – although it also comes at a rather high cost.

An emerging backsheet composite is polyethylene terephthalate (PET), consisting of polymerized units of the monomer ethylene terephthalate. This product is not new to the PV industry, as it has been used as the core layer between backsheets as a result of its electrical insulation properties. Recently, backsheet manufacturers have only been offering PET layers or PET combined with other fluoro- or non-fluoro-based polymers. Then there is Kynar, based on polyvinylidene fluoride (PVDF), one of the closest fluoropolymers to Tedlar. Fluoropolymers, such as ethylene-tetrafluoroethylene-copolymer (ETFE), ethylene chloro-trifluoroethylene (ECTFE) and other fluoride films, are also preferred by several companies for use in backsheets.

In short, it is obvious that DuPont has to watch its back when it comes to its Tedlar business. A major reason for this changing of the guard is simply that a few years ago DuPont abused its once-leading position – it added a new Tedlar model produced with casting that DuPont's customers did not want without expanding capacities for its successful extruded Tedlar product. But capacities did not meet demand. Moreover, it increased prices. In the end, DuPont simply could not supply as much Tedlar product as the solar market hungered for.



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◄▲ Bound for China: An increasing number of Western encapsulation and backsheet makers, such as Coveme (see photo), 3M and Solutia, are heading to China to be closer to their clients in the world's largest PV hub and to be able to respond quicker to sudden demand peaks as panel makers try to keep material inventories low.

And that was the starting point for other fluoro- and non-fluoropolymer makers to move into this void. Consider the woes of Tedlar-based backsheet manufacturer Isovoltaic AG, which recently just pulled out of a planned April launch for an initial public offering (IPO) on the Vienna Stock Exchange (see PI 5/2011, p. 114). In 2009, the Austrian producer said it had become the market leader in backsheets with a share of 39 percent, a position it still claims to hold. But now Coveme SpA, a maker non-Tedlar backsheets, claims that it has taken over the mantle with a 16-percent market share, which it expects to increase to 22 percent by the end of 2012 due to plans for setting up a manufacturing facility in China. This realignment reflects the willingness of module manufacturers to move away from Tedlar as their backsheet of choice.

Last year, Solutia Inc., which manufactures PVB in China and also started EVA production in June, claimed a worldwide market share of 20 percent. This year, however, marketing manager Doug Marren, says it is extremely difficult to put a number on market share, especially due to the slowdown in the industry. Still, he claims, Solutia is »clearly the market leader in Europe« for encapsulation material and is growing its business elsewhere.

Which is not to say that DuPont has given up on meeting the market demands for Tedlar. Last year, DuPont announced plans to invest $295 million to more than double its total production capacity of Tedlar. As part of that, in August last year, DuPont started production of PVF polymer resin, a critical raw material used to make Tedlar film, at its Fayetteville Works facility in North Carolina, in the US. And in June this year, DuPont announced that it expanded the rights to its technology license agreement with UK-based Toppan Printing Co. Ltd. to double Toppan's immediate supply capability for the full-scale commercial production of Tedlar PV2400 PVF film.

The quick rise of PET

But as DuPont pursues this plan, for now the company's long run of Tedlar glory is fading fast as many solar module makers are in dire straits of needing to economize to survive. The result is a phasing out of as many expensive components in PV panels as possible in the search for cost-effective, optimized products. That means they not only want to replace Tedlar with another fluoro-based foil, but want to try to ditch these foils altogether. Their alternative is PET. As an example, two new companies, Aluminium Féron GmbH & Co. KG from Germany and Micel Films from France, not only offer Tedlar products and Kynar, but PET as well. In addition, Coveme, one of the largest backsheet manufacturers, has stopped producing Tedlar-based products completely. Until last year, Coveme was offering four backsheets with Tedlar, which it has replaced with PET. But despite Coveme's departure from Tedlar, one company from the DuPont Group still profits from the subsitute, as the Italian company uses specifically produced PET made by DuPont Teijin Films based in Japan. Coveme manufactures its dyMat PYE series in different versions. These include the dyMat PYE 3000 with an ability to withstand 3,000 hours of damp-heat testing. In addition, it has the dyMat H PYE, dyMat Hd PYE and dyMat H2d PYE, which are all thicker than the standard dyMat PYE model with a thickness of 295 µm, depending on the applications. This year, it also launched a clear backsheet for building-integrated (BIPV) applications, which is also an all-PET product. Cesar Campos, Coveme's chief commercial officer, claims that his company is the largest supplier of backsheets with a market share of 16 percent. He adds that though the company has a variety of products, its dyMat PYE launched in 2007 constitutes almost 80 percent of its production.

Another company that has completely removed Tedlar-based products from its portfolio is Sweden's Skultuna Flexible AB. The company stopped manufacturing Tedlar-based products in early 2007. Skultuna's sales manager, Mikael Wennberg, says this was because of DuPont's lack of supply. He adds that PET products are so good nowadays, Skultuna no longer needs to use the much more expensive Tedlar. Wennberg says that new module manufacturers and companies focusing on reducing costs are the ones that are willing to use non-Tedlar-based products. Michael Sullivan, the marketing coordinator from US-based Dunmore Corp., says that its European facility in Freiburg, Germany, is moving toward all-PET backsheets. However, in the US market, Tedlar is a well-respected brand, Sullivan adds.

Julien Faldysta, the product manager from Toray Films Europe, one of the major suppliers of PET films for backsheet manufacturers, claims that sales of these films make up almost 90 percent of the PV market in Japan, but still only around 40 percent in Europe. Reacting to

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Dunmore Corporation

▲ Traceability: Dunmore has launched a marking technology that helps module clients to identify backsheets. Today's pricing pressure entices black sheep to get modules certified with high-quality foils, but then use cheap products during mass manufacturing.

▲▲ Using fluoropolymers or PET only?: Since DuPont fell out with its clients a few years ago by changing products, it hasn't been unable to supply enough Tedlar. With increased prices, companies first opted for fluoropolymer alternatives to Tedlar for their backsheet composites. Now, an increasing number, like Coveme, Skultuna and many others, are doing without fluoropolymers and are manufacturing PET-only foils to save on cost.

this, Klaus Bernhardt, the division manager for base materials and special laminates at Krempel GmbH, which strongly believes in fluoropolymers as the better chemical compound for backsheets, says that the reason is that Japanese module makers only offer a 10-year warranty on modules for their local markets. But given the fact that 19 of the 22 companies in the backsheets survey manufacture alternatives to Tedlar, there is no way that DuPont, which first discovered fluoropolymers in 1938 when a team accidentally polymerized tetrafluoroethylene (Teflon), will ever get its Tedlar market share back. The reason is simple – the market is now flooded with fluoropolymers, such as Kynar, ETFE, ECTFE, THV and other fluoride films, which constitute 30 products among the 114 listed in the backsheets survey. In addition, the PET-based backsheets are also becoming more widely accepted by module manufacturers, as indicated by the 28 PET-based products in the survey.

Effect of reducing prices of modules

Although backsheets do not constitute a major portion in the cost of producing a module, module makers are still pressuring the suppliers on price, says Krempel's Bernhardt. The trend is toward lower-cost materials. But he believes that module manufacturers are compromising on quality when they don't use backsheets based on fluoropolymers. The molecular structure of fluoropolymers is based on a chain of carbon atoms, as with all polymers. But in fluoropolymers, this chain is completely surrounded by fluorine atoms, which shield the vulnerable carbon chain. This unusual structure, along with the strength of the carbon and fluorine bond, gives fluoropolymers their unique properties of smoothness, thermal and mechanical strength, and chemical inertness.

While other fluoropolymers are not much cheaper than Tedlar, it is obvious that reducing a compound product – traditionally with two layers of Tedlar and one layer of PET compared to a PET-only foil – is much less costly. Generally two debated approaches are followed to reduce the cost of backsheets. One is by simply reducing the number of layers. A typical example is replacing one of the layers of expensive Tedlar in Tedlar/PET/Tedlar (TPT) with EVA to form Tedlar/PET/EVA (TPE), a more economical solution. But Boris Hartig, the marketing operations manager for 3M Deutschland GmbH, claims that reducing the number of layers does not necessarily mean the customer will end up with lower costs for the module. His company produces non-Tedlar-based backsheets called Scotchshield film, made of THV, a polymer of tetrafluoroethylene, hexafluoropropylene and vinylidene fluoride with PET and EVA. Many requirements need to be taken into consideration to provide the best cost/performance ratio, Hartig adds.

The second approach is to reduce the thickness of the layers. But in this time of economic downturn, sticking with Tedlar-based products is problematic, says Toray's Faldysta. The reason is that Tedlar is only available in certain standard

thicknesses, not allowing much room to make it thinner, leaving the backsheet manufacturers with no choice but to reduce the thickness of PET – the core layer of any TPT product – resulting in substandard products, he claims. Faldysta says that to withstand a partial discharge of 1,000 V, it is essential that the PET be at least 190 µm thick and that the whole backsheet is at least 250 µm thick. Krempel's Bernhardt also agrees that thinning the PET layer is definitely not the solution. Still, claims Skultuna's Wennberg, reducing the thickness leads to better heat transfer, resulting in a lower module temperature. However, he adds, manufacturing such thin films requires special types of films, which are more expensive than standard ones.

But given the demands on backsheet manufacturers to reduce prices, they are coming up with innovative solutions. While backsheet compounds typically used to be made with three layers, a couple of years ago the market saw its first two-layer backsheet. However, Germany's Aluminium Féron has now launched a single-layer backsheet that won the Intersolar Europe 2011 Innovation Award in Munich, Germany. Designated the HelioX PV neoX CPC, Aluminium Féron's product is a PET film with double-sided coatings. In the past, backsheets made only of PET were constructed with multiple layers laminated together. What makes Féron's product notable is that it is just a single layer of PET. The company claims that the inner coating offers UV protection, excellent bonding to the encapsulant and no integrated hot-melt film. In the future, it will apply a color setting. The outside coating has good weatherability, good bonding to the junction box, an optimized water-vapor transmission rate, and protection against mechanical and chemical damage. According to Féron, this product is 315 µm thick and has a water permeability of less than 2.4 g/m²d. Additionally, the company also says that its dimensional stability is less than 1 percent with a tensile strength greater than 130 N/mm and, most importantly, it can withstand a system voltage of 1,000 V. Comparing these properties with any TPT product on the market with almost the same thickness, the HelioX PV neoX CPC TPT from Féron's own portfolio is at least similar in performance or even better.

With most of the companies offering both Tedlar and non-Tedlar products, it is quite obvious that both backsheet manufacturers and module makers are ready to accept the change. Toray's Faldysta believes that PET will never replace Tedlar completely and agrees that Tedlar is a better application when it comes to withstanding extremely aggressive climates.This means the use of any type of backsheet has to be application-dependent rather than a general rule of thumb. Faldysta adds that in the coming 2 to 3 years, a clear breakdown of different solutions depending on the application will emerge.

Backsheet expansion

As DuPont tries to win back its market share for Tedlar with its recently announced plans for increasing production, companies such as Coveme and 3M are also increasing their production capacities – and they are shifting production closer to the module manufacturers in China. Coveme is building a new plant for its PET product in China's Jiangsu province, which will produce 4 million m² per month, enough for about 5.2 GW. Coveme's Campos says that the factory is strategically located to be within a 200 km range of almost 80 percent of all Chinese PV producers, including Suntech Power Holding Co. Ltd., Trina Solar Ltd., LDK Solar Co. Ltd. and many more. With the new factory, Campos claims, Coveme will have a total capability of producing 10 million m² of backsheets, the equivalent of about 13 GW of modules.

In an April press release, the German division of 3M announced that it plans to build a manufacturing site for solar PV materials, including its backsheets, and other renewable energy products in the Chinese city of Hefei,

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max. system voltage	≥ 1,129 V	> 1,100 V	> 1,000 V	> 1,000 V	> 1,000 V	> 1,000 V
Delivery, order, warranty						
time of delivery	0.5 months	0 - 4 months	0 - 4 months	0 - 4 months	0 - 4 months	0 - 4 months
minimum order	100 m²	–	–	–	–	–
warranty	24 months	–	–	–	–	–
Notes *1 at 150 °C for 30 min	*1 other on req. *2 at 150 °C for 30 min *3 with STR EVA *4 at 40 °C 90% RH	*1 Tedlar PV2400 series *2 IEC15106-3	*1 Tedlar PV2111 *2 IEC15106-3	*1 PVD-coated PET *2 IEC15106-3	*1 Tedlar PV2111 *2 IEC15106-3	*1 Tedlar PV2111 *2 IEC15106-3

in Anhui province, at the Hefei High-tech Park. The company says that the new factory, 3M Materials Technologies Co. Ltd., will be its ninth manufacturing facility in China. The plant will also produce 3M's Scotchshield Film.

The key nowadays, says Campos, is getting closer to the manufacturers. This reduces logistical issues, which in turn helps to decrease the price of its products.

Backsheets for humidity-sensitive products

Thin films have special requirements – a need for added protection from moisture. This can be achieved by either having a very thick backsheet or by adding material such as aluminum (Al), which ensures no moisture transmission, says Skultuna's Wennberg. He adds that while this was typically used for thin films, now the application has spread to crystalline modules that are installed in coastal regions or areas with high humidity. Of the 22 companies in the backsheets survey, 10 suppliers offer products with a metal layer between the backsheets. Skultuna's product, the 2P190 Aluminum, normally has an Al layer with a thickness of 12 µm. Wennberg says this is an optimal Al thickness value for eliminating water transmission. However, Coveme is capable of offering it at a thickness of 9, 20 or 50 µm. Obviously, a higher thickness of Al offers better water permeability, but it also makes the product more expensive. On the other hand, going any thinner than 9 µm makes it difficult to laminate Al foils onto the backsheet.

Dealing with fake products

Big names play a vital role in the sale of modules, since many buyers favor better-known brands. In order to assure their customers of long-term warranties and bankability, large module manufacturers prefer to have these popular brand names – including the makers of backsheet and encapsulation materials – in the certificates from the major testing agencies. However, the bigger outlays needed for premium products make it difficult for small module manufacturers to fit such purchases into their cost structure. The result is that manufacturers are enticed to get their modules certified using backsheets and encapsulation material with the popular brand names, but when it comes to mass production, they use material from local suppliers. This can equal a greater possibility of having substandard modules. To tackle this, Dunmore launched its new technology, DUN-SOLAR ID. It enables immediate module authentication, using a reader to recognize an embedded identity in the backsheet. The aim, says Dunmore's Sullivan, is to eliminate uncertified, counterfeit products.

Backsheets with EVA

There are many companies that offer backsheets with a layer of EVA. But this is usually not about replacing the EVA behind the cells in a module. The most important application of the EVA layer is to increase the adhesion of the backsheet and additionally offer UV protection, as the EVA contains UV stabilizers. However, there are two manufacturers that offer an additional layer of EVA with their protective sheets that reduce the need for normal EVA during module making. One is Skultuna and the other is US-based Saint-Gobain Performance Plastics. Skultuna's 1P200 is a backsheet with an EVA primer layer on the inner side, and hydrolysis and UV-resistant PET on the outer side. Saint-Gobain's LightSwitch is a front sheet made of pre-laminated ETFE/EVA, which replaces the glass. Saint-Gobain did not give any additional data on the LightSwitch, saying only that the front sheet is clear and comes with a 6-month warranty. Though the presence of EVA helps module manufacturers to reduce EVA inventories, its presence only ensures a warranty of 6 months for the front sheet due to its shelf life.

New EVA products

In order to ensure module output, it is necessary for the cell encapsulant to allow as many