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FEATURE

Overcoming the challenges of producing a quality water-soluble film

Ana Juraga Oluic [a], **Julie Holmquist** [b]

[a] Cortec Corporation, Zagreb, Croatia
[b] Cortec Corporation, St Paul, MN, USA

EcoSol® technology represents latest generation of packaging solutions. This water soluble, biodegradable, polyvinylalcohol (PVOH) film is suited for various packaging applications. Water soluble PVOH bags, sachets, or pouches created from this film provide a convenient, safe, and economical delivery system for a wide range of products; including detergents and cleaners, degreasers, concrete additives, pigments, biocides, water-treatment products, agricultural products and others. EcoSol film has very good organic solvent resistance, which allows EcoSol pouches and bags to be used not only for dry powders, but also for liquid products. It offers very good mechanical properties: tensile strength, tear strength, puncture resistance. These properties allow EcoSol film to be used in a wide variety of rigorous applications. After a few minutes of immersion at the specified temperature, film dissolves in water leaving a harmless, non-toxic, aqueous solution of polyvinyl alcohol. Once the liquid solution of PVOH comes into contact with common microorganisms, such as those found in water-treatment plants, conversion to carbon dioxide and water takes place within about 30 days. For example, EcoSol 1.5 mil (37.5 microns) thickness at 68°F (20 °C) begins to dissolve within 30 s and is fully dissolved in 5 min. Mechanical properties of EcoSol film conform the normative of ASTM D 882-02 for Braking factor, Tensile Strength of break, Elongation and Yield Strength; It's Tear Strength is tested according ASTM D 1922-06a and Dart Drop Impact resistance – per ASTM D 1709-04 (Figure 1).

EcoSol® can be used for packaging of: detergents and cleaners, degreasers, concrete additives, pigments, water-treatment products, biocides, agricultural products, soil remediation, bathing products, cosmetic industry (disposable cases), laundry bags for hospitals. EcoSol® produced by Cortec®'s Advanced Films Division has been included in the market study: "Water Soluble Film Market – "Global Trends and Forecasts to 2020" by think tank institution Research and Markets, Inc as the only USA manufacturer.

Quality is a top priority for Cortec Corporation, which vertically integrates many of its production processes to oversee quality from start to finish. Manufacturing a successful water-soluble film is one activity that presents its own challenges. The very nature of EcoSol makes it vulnerable to excessive moisture during production, and this can affect the quality of the end product, as well. If too much moisture is introduced, the film will stick to itself when it is rolled up, causing problems for the customers who try to unroll it. Cortec has to take several precautions to avoid problems like these.

One of the first steps is to test the raw materials for moisture content. If too much moisture is present, Cortec Advanced Films (CAF), in Cambridge, Minnesota, uses driers to remove the excess water content. CAF also keeps one eye on the weather when scheduling production runs of EcoSol. Tim Bliss, the Production Manager at CAF, said he tries to plan EcoSol production a couple weeks in advance, and if the dewpoint is expected to be in the range of 50–70°F (10–21 °C), they will likely choose not to extrude the film. "Winter is the best time to actually run this product," said Bliss. Fortunately for CAF, Minnesota has plenty of dry winter months that make it a good place to manufacture EcoSol most of the year except for a few hot, humid months in the summer.

Even when the weather is at an ideally low humidity level, there are special product handling concerns for EcoSol. CAF has to rigorously clean the extruder before production and then keep a close eye on temperature and time in the extruder. A spe-

E-mail addresses: Oluic, A.J. (ana.juraga@ecocortec.hr), Holmquist, J. (jholmquist@cortecvci.com).

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MECHANICAL PROPERTIES

Property		Test Method	Units	EcoSol
Caliper		ASTM D6988	mil	2.00
Breaking Factor	MD	ASTM D882-02	lbs/in	7.74
	TD			8.1
Tensile Strength at Break	MD	ASTM D882-02	psi	3868.5
	TD			4049
Elongation at Break	MD	ASTM D882-02	%	173.16
	TD			186.37
Yield Strength	MD	ASTM D882-02	psi	1611.27
	CD			2985.33
Tear Strength	MD	ASTM D1922-06a	mN	871.13
	CD			494.43
Dart Drop Impact Resistance		ASTM D1709-04, Test Method A	grams	880.2
Seal Strength			lbs	3.82

FIGURE 1

Mechanical Properties.

cial screw must be used—different from the screws used for CAF's mainstay product, a Vapor phase Corrosion Inhibitor plastic packaging material. Because of the nature of the raw EcoSol material, Bliss commented, "You want this material to get in and out of the extruder as fast as possible . . .. If the extruder even stops for more than three minutes, we will have a real problem." If the product does stay in the extruder too long, or if the temperature is more than 5% higher or lower than the extruder settings, Bliss said the EcoSol mixture will start to stick inside the extruder and the whole extruder will have to be cleaned out. CAF keeps a purging agent on hand for situations like this in case the screw gets stuck.

During R&D, EcoSol is tested for qualities such as thickness, breaking factor, tensile strength and puncture resistance to see if the formula has what it takes to be a durable packaging material. These physical properties are displayed in Chart 1 and were explained by Stephanie Berg, Quality Control Supervisor at CAF. To test breaking factor, tensile strength, elongation, and yield strength, they cut a 1×4 inch (2.54×10.16 cm) piece of film and place it in the tensile tower. They use the tower to stretch the film vertically and cross-directionally. The tensile tower records how far the EcoSol can be stretched before it breaks (elongation at break) and how much strength it takes to break it (breaking factor) or permanently deform it (yield strength). Puncture resistance is tested by seeing how much force is needed to push a ¼" (0.6 cm) needle with a rounded tip through the film. Tear strength is evaluated by cutting a half circle of film, snipping the bottom, and recording the force required to tear it the rest of the way, thus giving a good indication of the film's durability (Figure 2).

After extrusion, CAF does quality control to make sure the EcoSol is the appropriate length and width, and, if it has been made into bags, manually checks to see if the seal is good. If there are further questions about the integrity of the seal, they can perform the ASTM F88-99 Seal Strength test on the tensile tower for confirmation. The EcoSol is then packaged in foil barrier bags to protect the product from moisture during storage and shipment.

Increasing demand and supply

CAF has recently seen increased demand for EcoSol from customers who want to package concrete admixtures or agricultural additives in water-soluble bags. Cortec is also broadening its sup-

Property		Test Method	Units	2 Mil	1 Mil
Caliper		ASTM D6988	mil	2.00	1.00
Breaking Factor	MD	ASTM D882-02	lbs/in	8.65	6.83
	TD			5.82	3.88
Tensile Strength at Break	MD	ASTM D882-02	psi	4414.00	6212.00
	TD			2773.00	3339.00
Elongation at Break	MD	ASTM D882-02	%	246.94	107.57
	TD			201.29	198.80
Yield Strength	MD	ASTM D882-02	psi	3725.22	4669.97
	TD			2345.25	2696.34
Puncture Resistance	Outside	MIL-STD-3010, TM 2065	lbf	5.15	3.26
Puncture Resistance	Inside	MIL-STD-3010, TM 2065	lbf	6.07	3.30
Tear Strength	MD	ASTM D1922-06A	gram force	536.00	282.40
	TD			1715.20	451.20
Seal Strength	Left	ASTM F 88-99	lbs/in	NA	NA
	Center			3.01	NA
	Right			NA	NA

FIGURE 2

Physical properties of Cortec's EcoSol formulation.

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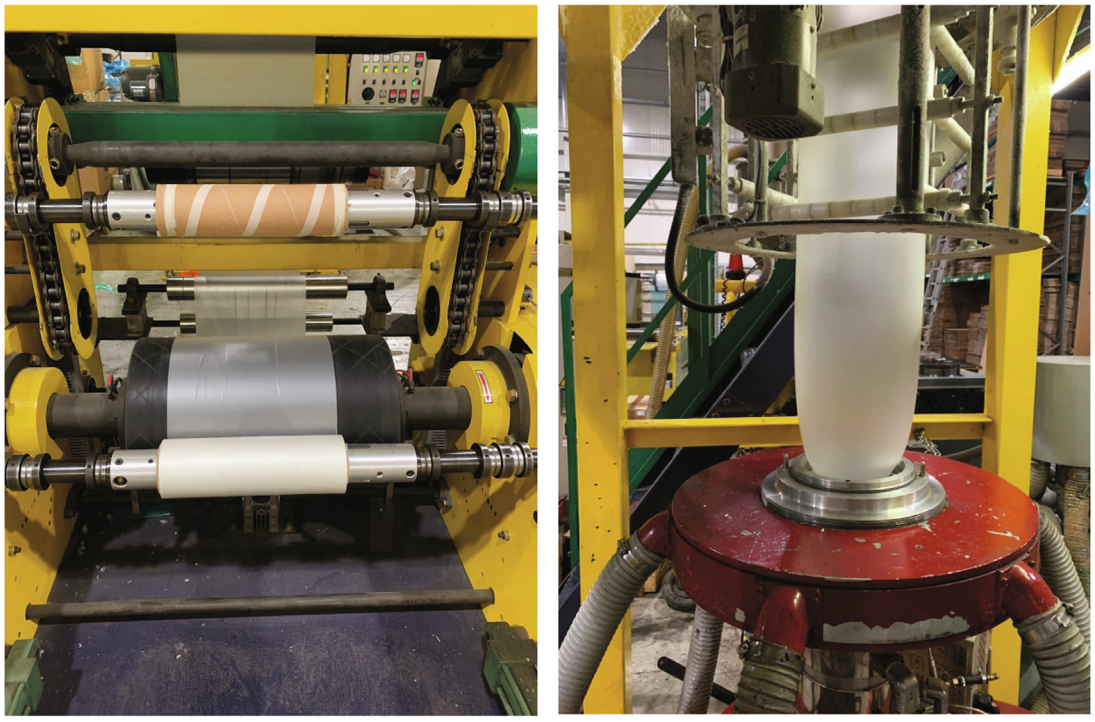

FIGURE 3

Water soluble material from PVOH being extruded to water soluble film – Ecosol, in EcoCortec.

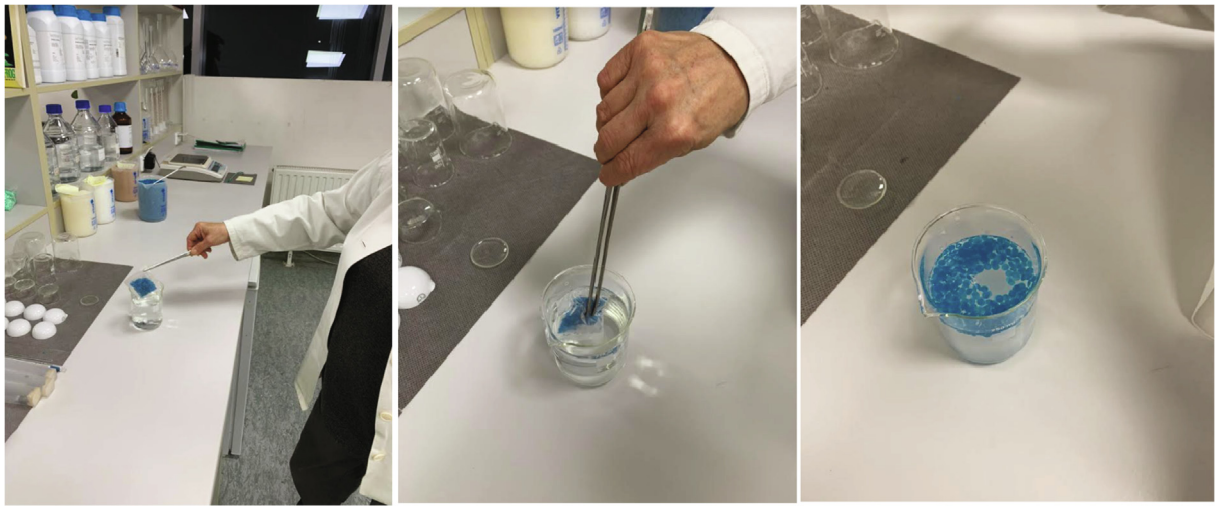

FIGURE 4

Testing of water solubility in EcoCortec's laboratory located at plant's facility. The film has successfully dissolved in the water in 60 s.

ply and distribution capabilities by launching production of EcoSol at CAF's sister plant, EcoCortec, in Beli Manastir, Croatia. Production of EcoSol film was successfully tested and launched in November in EcoCortec plant in Beli Manstir Croatia. This will enable promt delivery of custom made pouches to our European and Asian customers (Figures 3 and 4).

Case history

The Alabama Theatre is a local landmark built in 1927 as a showcase for Paramount Films. It served as a movie palace for 55 years. It was also used to host the yearly Miss Alabama pageant and the weekly meetings of the local Mickey Mouse club. In 1987, the owners declared bankruptcy. The non-profit corporation Birmingham Landmarks, Inc., purchased the theatre. The Alabama Theatre underwent a restoration in 1998 and has lately been hosting more than 150 events annually, attended by 150,000 Birmingham area citizens. The theatre was temporarily shut down in March 2020 due to the global COVID-19 pandemic with hopes of reopening in fall 2020.

Application

Normally, the theatre adds desiccant to the boilers every spring when shutting them down for the season. In 2020, the theatre owners chose to use the Cortec® Boiler Lizard® for seasonal dry

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FIGURE 5

The Boiler Lizard.

layup instead. Cortec's Boiler Lizard® contains Vapor phase Corrosion Inhibitor powder in a polyvinyl alcohol (PVA) water-soluble bag EcoSol. The powder formulation is free of phosphates, heavy metals, nitrites, and free amines. Designed for dry lay-up of boilers, the Boiler Lizard ® protects metals in enclosed spaces. Unlike desiccant, the Boiler Lizard® provides active corrosion protection and does not require removal when the boiler is refilled. The two electric boilers were drained. The Boiler Lizard® was removed from its outer packaging and cut in two—one half for each boiler based on boiler size. The inner water-soluble bag was slit open, and each Boiler Lizard® segment was placed inside the original packaging tube to serve as a chute to direct the Boiler Lizard® as near to the center of the boiler as possible. After Boiler Lizard® placement, the openings to the boilers were closed.

The Cortec® Boiler Lizard® will provide 12+ months of corrosion protection. During this time, Vapor phase Corrosion Inhibitors will vaporize out of the Boiler Lizard® and adsorb as a protective molecular layer on all accessible metal surfaces in the interior cavities of the boiler. When the theatre owners are ready to bring the boiler back online, they can simply refill the boiler as normal.

The Boiler Lizard® will dissolve in the makeup water, the inner PVA bag will dissolve. —no removal necessary—providing an extremely convenient method of layup. The theatre plans to use its second remaining Boiler Lizard® for seasonal layup in spring 2021 (Figure 5).

By anchoring EcoSol production in both North America and Europe, Cortec is increasing the responsiveness with which orders can be filled to facilitate more rapid delivery of the water-soluble packaging material to customers in both continents, as well as the nations in their distribution chains.

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