Meeting the Sustainability Challenge Without Compromising Barrier Performance

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It is clear by now that retailers are the main drivers of the sustainable packaging movement, and they have put their money where their mouths are. Wal-Mart, Tesco and many others have developed comprehensive sustainability programs, including sophisticated measurement tools and hard targets. The second thing that has become clear is that economics drive sustainability, not vice-versa. Sustainability programs have come to encompass sustaining the economics of the packaging as well as sustaining the environment, which means the most successful offerings will improve the bottom line as well. Consumers and governments continue to apply pressure as well, as they become increasingly green conscious and energy policy has become a major political issue.

The converting industry and CPG's are critical to sustainability's success, and they have both stepped up to develop sustainable solutions for retailers. The movement has high visibility at trade shows, sustainability-related symposia & conferences and industry sustainability groups. Celplast has investigated several sustainability solutions applicable to barrier films.

Biodegradable Films

The most commercially advanced and available biodegradable, renewable resource based film on the market continues to be PLA. It has good clarity, sealability and deadfold, and all commercially available films meet the ASTM D6400 compostability requirements. This film's main drawbacks are its poor temperature resistance and poor barrier properties.

Two possible solutions to the barrier issue are to apply an SiOx clear barrier layer or a metallized barrier layer to the PLA film. Neither of these inorganic nanolayers negatively impact the compostability of the base PLA film. Furthermore, the improvements in barrier properties achievable with these layers are virtually independent of the thickness of the base film. We have measured metallized and SiOx-coated barrier properties on several different gauges of PLA film from several different film suppliers. We have chosen to focus on 80 g, which is the thinnest PLA film that is widely available.

The improvement in barrier properties can be seen in the barrier maps in Figures 1 & 2, and the graphic in Figure 3. The barrier maps compare the barrier properties of the plain 80 g PLA film to the SiOx-coated or metallized PLA, and then the coated PLA laminated to another 80 g PLA layer. These properties are overlayed on a barrier map showing the barrier requirements of typical food packaging applications.

We have shown that it is now possible to achieve truly high barrier all-PLA package with a 2-ply structure of reverse-printed CERAMIS® PLA laminated to a metallized ENVIROMET™ PLA.

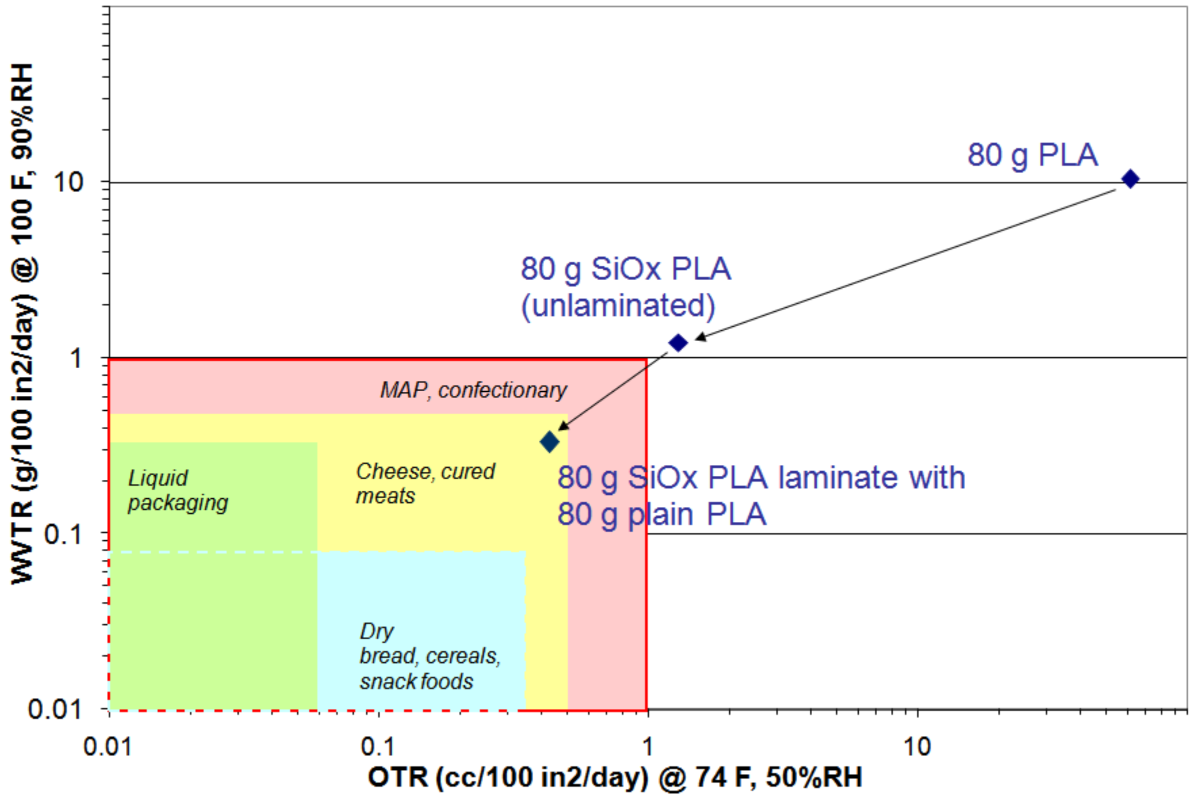


Figure 1: CERAMIS® PLA Barrier Properties

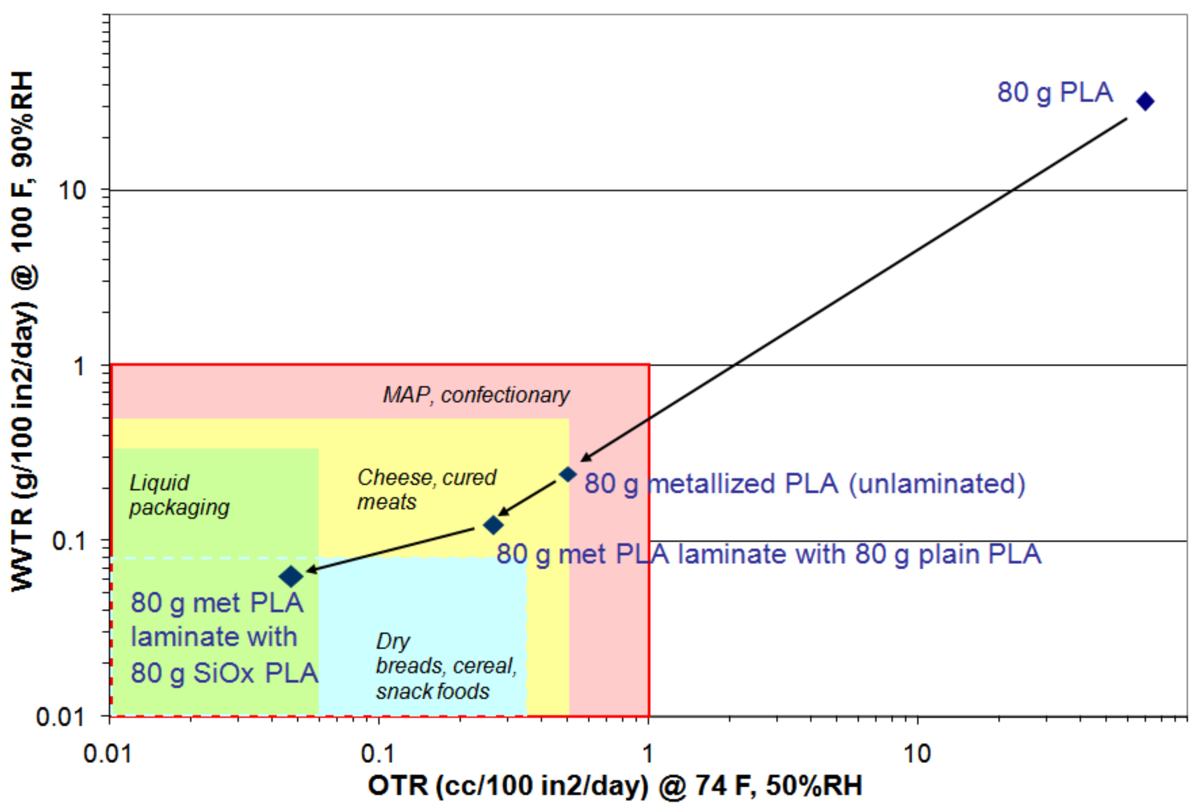


Figure 2: ENVIROMET™ PLA Barrier Properties

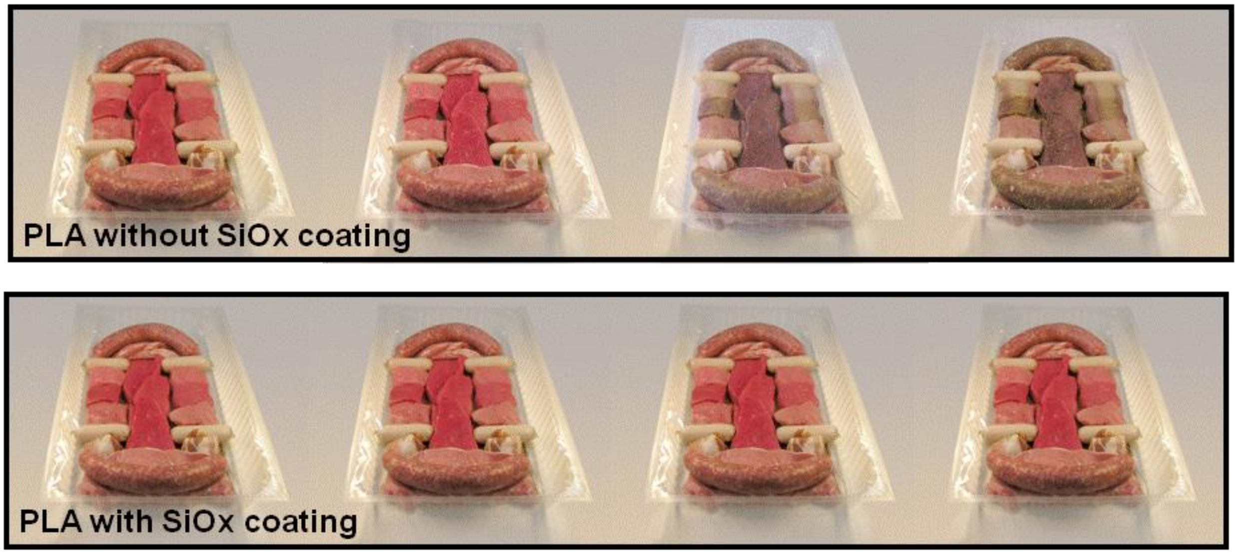


Figure 3: CERAMIS® PLA in the Real World – a One Week MAP Shelf Life Study

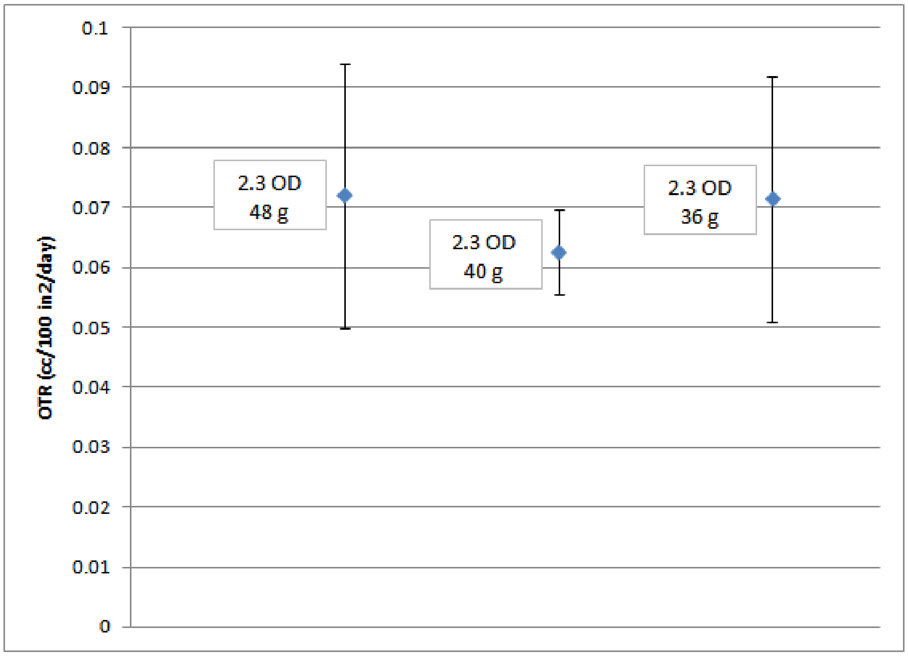
Source Reduction

We have already mentioned that packaging economics are the largest driver of sustainability. One way to marry these two concepts together is through source reduction. There are three main approaches that can be taken for metallized films:

- Downgauging
- Less aluminum
- Layer elimination

In the first case, the vast majority of barrier food packaging applications in North America continue to utilize 48 g PET. It is the most readily available and one of the most cost effective gauges on the market. Recently, several PET suppliers have been developing their thinner gauge PET films, and Celplast has put greater effort into metallizing these films in a high quality, reproducible, cost effective manner.

As with PLA film, the barrier properties of the metallized PET films are almost independent of the base film gauge. This is proven in Figure 4, which show OTR & WVTR values of three different PET gauges, all metallized on the non-treated side under similar metallizing conditions and at a 2.3 target OD. Error bars represent 95% confidence intervals based on several measurements on each base PET gauge. OTR measurements were carried out at 73.4°F and 50%RH. WVTR measurements were carried out at 100°F and 90%RH. All testing was carried out on unlaminated films.



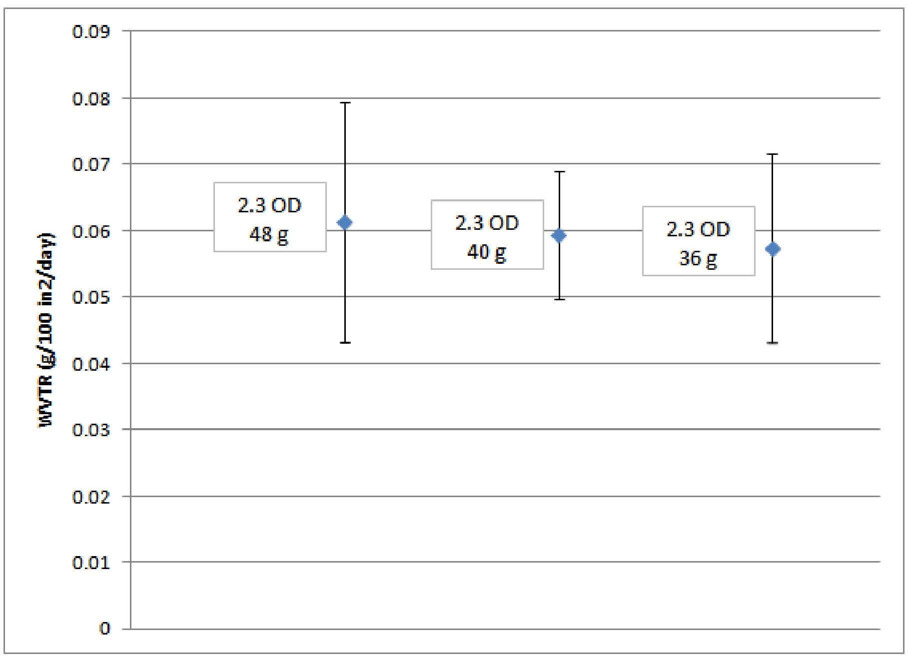


Figure 4: Impact of PET Downgauging on Barrier Properties

Celplast has also systematically investigated applying less aluminum, lowering the optical density (OD) of the metallized layer, without compromising barrier properties. This is possible, as long as the quality of the metal layer is significantly improved. In addition to OD, the density, level of pinholes and adhesion to the substrate all play critical roles in determining the barrier properties of a metallized film. Figure 5 shows the oxygen and water vapor barrier properties of two different sets of metallized PET films, measured under the same OTR and WVTR conditions reported earlier. One set was run under standard metallizing conditions, to a 2.3 OD target. The other set was run on the same metallizing equipment, using the same set of base films, but run to a 2.0 OD target using Celplast’s proprietary “High Efficiency” metallizing process.

Less aluminum not only leads to source reduction, but also means less energy is used in the metallizing process, to heat boats, drive stepper motors, etc.

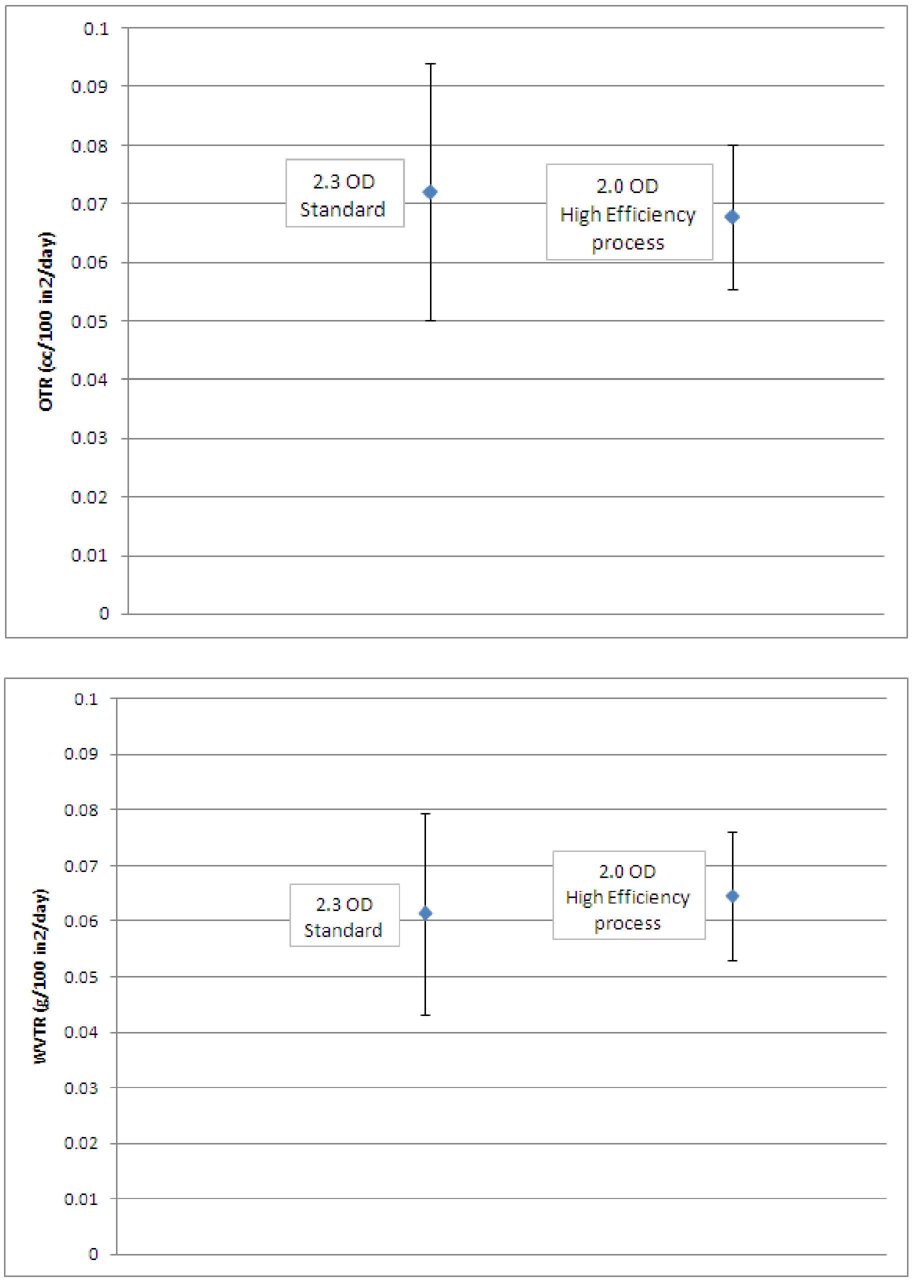


Figure 5: Celplast's High Efficiency Metallizing Process at 2.0 OD

The last form of source reduction we have examined is layer elimination. More specifically, we have looked at combining two separate layers, the barrier and the sealant web, into a single "barrier sealant" layer. This can be used to replace metallized PET in the case of high oxygen barrier applications, or to replace metallized OPP or foil in the case of high moisture barrier applications. Tables 1 exhibits the various layer elimination opportunities available. Table 2 shows barrier and sealant properties achievable in a single ply structure.

Table 1: Layer Elimination Opportunities Using Metallized Sealants

Metallized Sealant	Barrier Target	Typical Applications	Laminated plies being replaced	Thicknesses Available (g)
O2 **Barrier Sealant**	Oxygen	Liquid packaging, fatty or oily foods	Met PET & LLDPE sealant	125 – 250
High Barrier Sealant	Moisture	Dry powder packaging, moist/wet products	Met OPP or foil & LLDPE or LDPE sealant	120 – 225
Barrier Sealant Plus	Moisture	Dry powder packaging, moist/wet products	Met OPP or foil & LLDPE or LDPE sealant	80 – 120

Table 2: Measured Barrier & Sealant Properties

Metallized Sealant	OTR (cc/100 in^2/d)	WVTR (g/100 in^2/d)	Metal Adhesion (g/in)	Sealant COF*	HSIT (F)	Ultimate Seal Strength (lb_f/in)
O2 **Barrier Sealant**	0.04	0.07	400	0.16	220	>4 (destruct)
High Barrier Sealant	4.0	0.02	470	0.3 – 0.4	265	>6 (destruct)
Barrier Sealant Plus	4.0	0.008	>600	0.18	230	>4 (destruct)

*Sealant-to-sealant, kinetic COF

Note that these barrier numbers are only achievable with a high barrier metallizing process. These metal adhesion numbers are only achievable with an adhesion-promoting surface on the metallizable side of the sealant web. Standard sealant webs metallized under standard metallizing conditions will not perform to the specifications outlined above.

Figure 6 shows a typical costing model for a Barrier Sealant product. It allows the converter to pocket the savings of the second lamination pass. Furthermore, the converter no longer has to stock two separate films when a single film will do.

Laminated structure without Barrier Sealant

Layer	Cost ($/msi)
Reverse printed web	x
Laminating adhesive	0.06
48 g metallized PET barrier layer	y
Laminating adhesive	0.06
1.5 mil sealant web	z

Total Cost: 0.12 + x + y + z

Laminated structure with Barrier Sealant

Layer	Cost ($/msi)
Reverse printed web	x
Laminating adhesive	0.06
1.5 mil O2 barrier sealant	y + z

Total Cost: 0.06 + x + y + z

Savings with O2 Barrier Sealant 0.06

Figure 6: The Savings Opportunity From Barrier Sealants

Conclusions

In barrier packaging, there are many opportunities to improve packaging economics while becoming more sustainable. Converters need to make a conscious decision to innovate and work with customers and suppliers to achieve their sustainability goals. When they do, they will find there are several ways in which demanding barrier properties can be achieved in a more sustainable manner. This benefits the bottom line as well as the environment, and will continue to help make flexible packaging the sustainable choice for CPG’s and retailers around the world.

CELPLAST METALLIZED PRODUCTS LIMITED