Multifunctional barrier coating systems created by multilayer curtain coating

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ABSTRACT: Functional coatings are applied to paper and paperboard substrates to provide resistance, or a barrier, against media such as oil and grease (OGR), water, water vapor as measured by moisture vapor transmission rate (MVTR), and oxygen, for applications such as food packaging, food service, and other non-food packaging. Typical functional barrier coatings can be created by applying a solid coating or extruded film, a solvent based-coating, or a water-based coating to the paper substrate using various means of coating applicators.

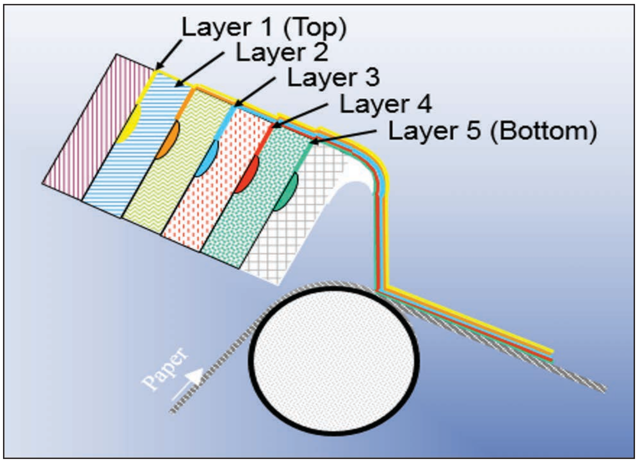
This paper focuses on water-based barrier coatings (WBBC) for OGR, water, MVTR, and oxygen barriers. The main goal was to create coated systems that can achieve more than one barrier property using multilayer curtain coating (MLCC). Curtain coating has emerged as the premier low-impact application method for coated paper and paperboard.

This paper provides examples using MLCC to create coating structures that provide multiple barrier properties in a single coating step. Barrier polymer systems studied include styrene butadiene, styrene acrylate, vinyl acrylic, and natural materials, as well as proprietary additives where required to give desired performance. The paper also shows how the specific coating layers can be optimized to produce the desired property profile, without concern for blocking, as the addition of a non-blocking top layer can be applied in the MLCC structure as well. Experiments on base sheet types also shows the importance of applying the multilayer structure on a pre-coated surface in order to improve coating thickness consistency and potentially allow for the reduction of more expensive layer components.

Application: For mills contemplating a new coater, this research shows that an MLCC coater is a cost-effective and technically advantageous coater for production of barrier coated paper and paperboard grades. Also, for companies that already have MLCC coaters, this research shows that WBBC technology is currently available for production of multiple-layered barrier paper and paperboard grades.

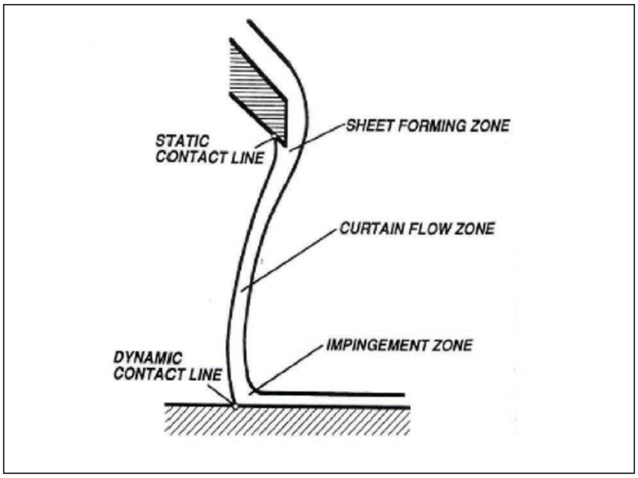
Functional coatings are applied to paper and paperboard substrates to provide resistance, or a barrier, against media such as oil and grease (OGR), water, water vapor as measured by moisture vapor transmission rate (MVTR), and oxygen for applications such as food packaging, food service, and other non-food packaging. Typical functional barrier coatings can be created by applying a solid coating or extruded film, a solvent based-coating, or a water-based coating to the paper substrate using various means of coating applicators.

This paper focuses on water-based barrier coatings (WBBC) for OGR, water, MVTR, and oxygen barriers. The main goal was to create coated systems that can achieve more than one barrier property using multilayer curtain coating (MLCC). Curtain coating has emerged as the premier low-impact application method for coated paper and paperboard. As indicated in **Fig. 1**, coating color is first distributed in the cross-machine direction in a cavity. A uniform pressure distribution is built up until the coating color exits the nozzle. Here, the flow is equalized and a thin liquid film is formed. After flowing over the lip, the film detaches and creates a curtain (**Fig. 2**) as it falls. The flow is accelerated by gravity forces, resulting in a thinner curtain, until reaching the paper surface.

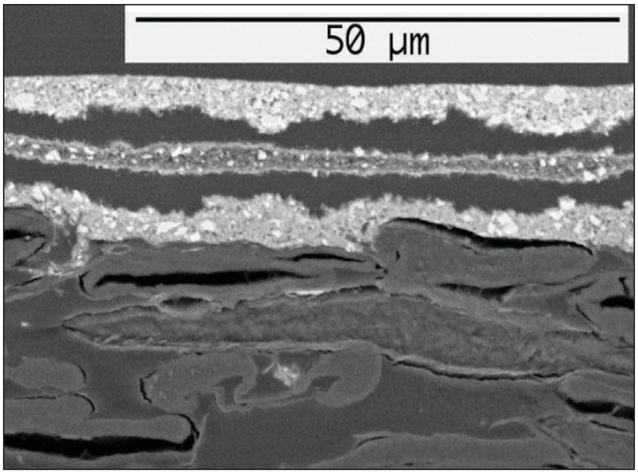


1. Principle of multilayer curtain coating (MLCC) [1].

Significant research work to date and production experience on specialty papers and paperboard has focused on conventional coating techniques or single layer curtain coating. However, MLCC has many advantages over these other methods. One advantage with lower material cost is through the use of functional chemistry in confined layers where performance is optimized within the coating struc-



2. MLCC flow zones [2].



3. Cross section of MLCC example with three layers [4].

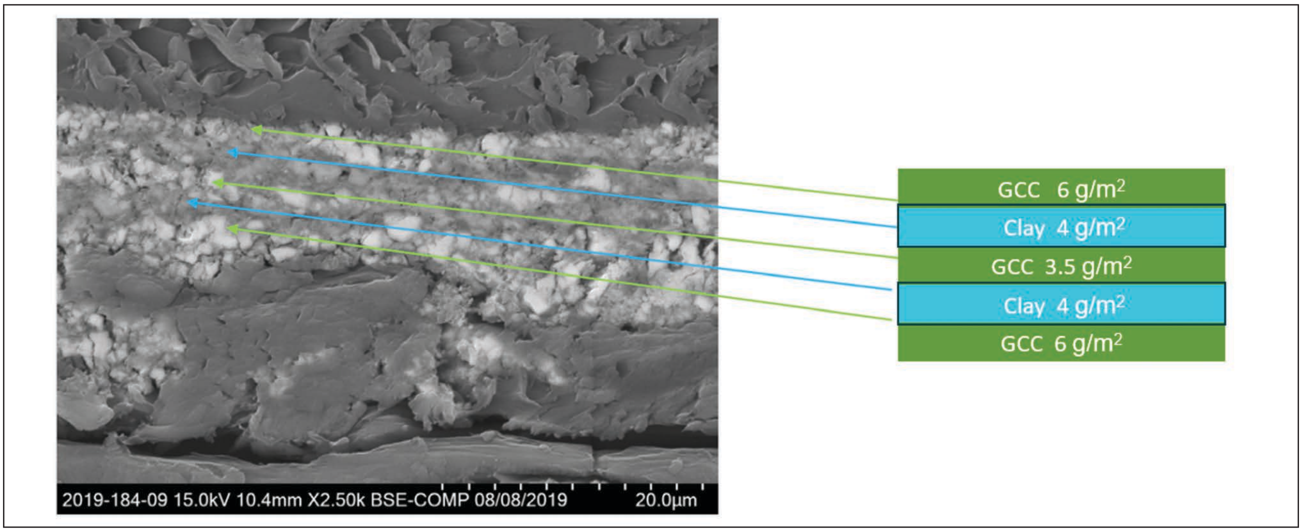
ture. This allows simultaneous application of consecutive layers of different polymer types to achieve the appropriate performance. The MLCC also allows the application of such coatings in one coating operation step, minimizing capital investment and machine footprint. Another advantage is the ability to generate thin "contour" layers that are more economically feasible than what is applicable for common coating technologies where excess material is applied in some regions in order to get the minimum coverage in the areas where the base sheet is thinner. The latter is even more critical when base sheet roughness is not well controlled or is inherent to the available substrate.

In the impingement zone, the curtain is deflected to about 90°. Because of velocity differences between the curtain and the moving web, an extreme acceleration of the coating occurs in the impingement zone. Final extension and contraction of the coating occurs on the web, where it is applied as ideal contour coating if no defects are formed [3].

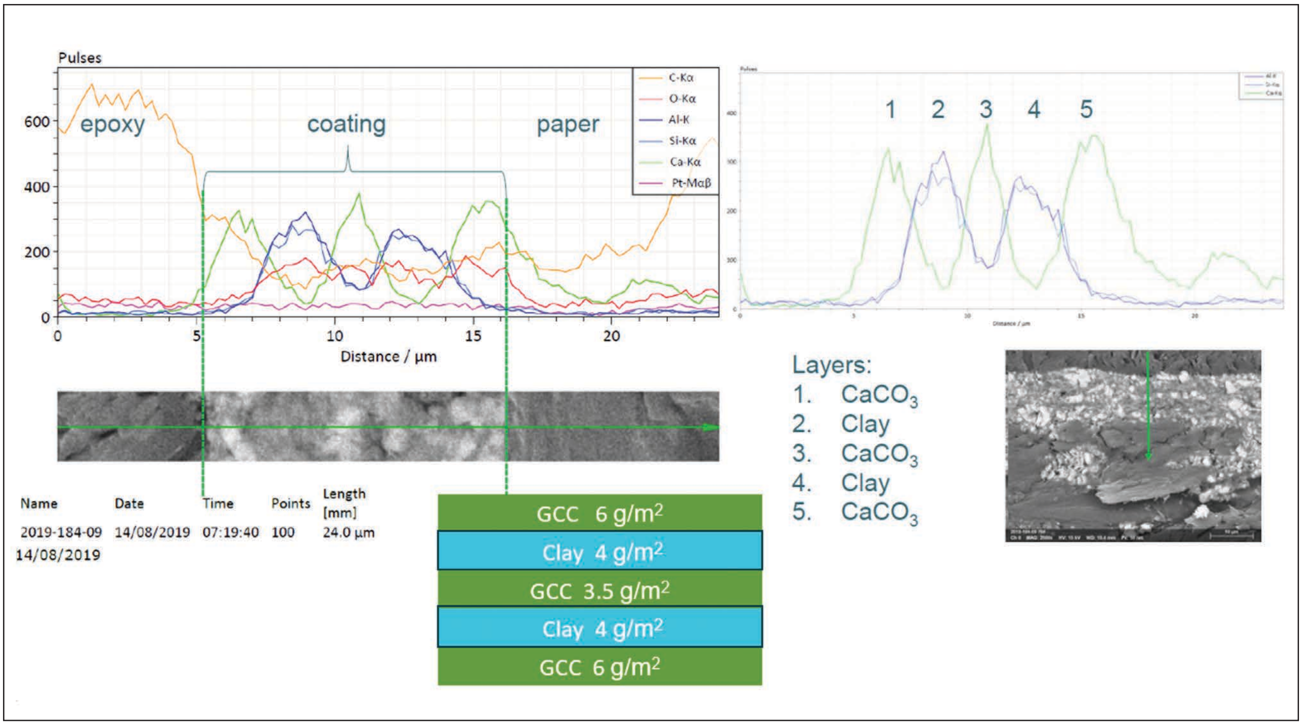
With the slide die coating technique shown in Fig. 1, the simultaneous application of more than 10 layers was the industry standard in the photographic film industry. This suggests the application of up to five layers is achievable in these types of applications. The aim of the undermost layer (also known as the carrier layer) is, in general, to improve runnability by promoting wetting, preventing air entrainment, and controlling heel formation at the impingement zone. A thin top coat may cover visual defects and provide printability aspects. Layers in between may be functional layers that provide barrier properties or act as spacers between those layers.

The benefits of MLCC that we intend to demonstrate in this work include:

- Ideal contour coating: uniform and homogeneous coverage of a base stock. The ability to generate thin "contour" layers that are more economically feasible than what is applicable for common coating technologies where excess material is applied in some regions in order to get the minimum coverage in the



4. Scanning electron microscope (SEM) cross-section photomicrograph of a coating structure with five layers produced with a slide die curtain coater.



5. Energy dispersive X-ray (EDX) spectroscopic line scan of the SEM cross section in Fig. 4 (GCC = ground calcium carbonate; $CaCO_3$ = calcium carbonate).

areas where the base sheet is thinner.

- Simultaneous application and drying of several wet layers with different functions.
- Because of laminar flow, no mixing of layers occurs (**Fig. 3**). MLCC also allows the application of such coatings in one coating operation step, minimizing capital investment and machine footprint.
- MLCC can also be used to apply two or more latex-rich barrier coatings with a non-blocking top layer.

Novel studies conducted by Kilcher and Dahlvik showed, analytically, the clear separation of pigmented layers in an MLCC structure [5]. **Figure 4** shows a scanning electron microscope (SEM) cross-section photomicrograph of a coating structure made of alternating layers of a carbonate-based coating and a clay-based coating that were produced with a slide die curtain coater. The insert next to it indicates the pigment type and coat weight of each layer. In **Fig. 5**, we see the results of an energy dispersive X-ray (EDX) spectroscopic elemental analysis on this cross section. The EDX analysis is able to clearly show the differentiation of the layers, matching the key element in each layer (Ca for calcium carbonate and aluminum and silicon for clay) with the expected order of the layer and composition.

This paper provides examples of using MLCC to create coating structures with multiple barrier properties in a single machine coating pass. Barrier polymers studied include styrene butadiene (SB), styrene acrylate (SA), vinyl acrylic (VA), and natural materials, as well as proprietary coating additives where required to give desired performance. The paper also shows how the specific coating layers can be optimized to produce the desired property profile, without concern for blocking, as the addition of a non-blocking top layer can be applied in the MLCC structure as well. Experiments on base sheet types also show the importance of applying the multilayer structure on a pre-coated surface in order to improve coating thickness consistency and potentially allow for the reduction of more expensive layer components.

EXPERIMENTAL

A description of the barrier coatings that were used in this study are summarized in **Table I**. It should be noted that the SA coating, SB coating, and the VA coating were formulated for optimum barrier performance.

The barrier formulations were applied onto three different substrates. One was a 40 g/m² (25 lb/3300 ft²) paper (UC-P) that was developed specifically for flexible barrier applications. This base sheet was also pre-coated (C-P) in order to provide a smoother surface for the barrier test coatings and is the second substrate. The pre-coat (see **Table II**) was applied at the Trinseo Binders pilot coater in Midland, MI, USA, using a pre-metered size press, with smooth rod metering, at coat weight of 8.7 g/m² (6.0 lb/3300 ft²) per side. The third substrate was a 10-point solid bleached sulfate (SBS) paperboard that was

Coating Name	Polymer Chemistry	Barrier Type	Coating Solids, %	Brookfield viscosity at 100 rpm (cp)
SA coating	Styrene acrylate	OGR	47.7	380
SB coating	Styrene butadiene	MVTR, Water	50.2	460
VA coating	Vinyl acrylate	OGR	49.1	580
SCE coating	Starch containing emulsion	OGR	44.6	330
OGR = oil and grease; MVTR = moisture vapor transmission rate.				

I. Barrier coatings description.

Formulations	Pre-Coat Parts
Fine carbonate	100
SA binder	20
Thickener (polyacrylate)	0.3
Solids, %	65
pH	8.5

II. Pre-coat formulation applied to base sheet (SA = styrene acrylate).

pre-coated to provide a smoother surface for the barrier test coatings. The same pre-coat was applied at the Trinseo pilot coater in Midland, using the same coater configuration, at a coat weight of 12.8 g/m² (8.0 lb/3000 ft²) per side.

The barrier coatings were applied with a multilayered slide die curtain coater at Trinseo's Samstagern, Switzerland, application lab. Each barrier layer was applied at a coat weight of 5.0 g/m² (3.5 lb/3300 ft²) at a targeted speed of 500 m/min (1600 ft/min).

The barrier coating systems that were studied are summarized in **Table III**. It should be noted that the combination of many layers may or may not be economically feasible or required for many application requirements. However, the work presented here is to demonstrate the flexibility of the MLCC apparatus for barrier or specialty coating applications.

Barrier analysis

A description of the devices and methods used for barrier testing are explained below.

Oil and grease resistance analysis

The "hot oil circle test" is used to analyze oil barrier properties. Preheated oil (canola oil at 60°C) is applied on the barrier surface. Two treatment times were evaluated, 1 h and 24 h. The front (coated) and the back side of the paper samples were evaluated for oil stain penetration. This was carried out at room temperature and in an oven set at 60°C. Visual observations were made on the back side of the paper, and whiteness values were also taken on the front side after removal of the oil. Higher whiteness value equates to less penetration of the oil.

Run	1	2	3	4	5	6	7
Base sheet	C-P	C-P	UC-P	C-P	C-P	UC-P	C-P
Layer 1	SA	SA	SA	SB	SB	SB	VA
Layer 2		SCE			SCE		
Layer 3							
Run	**8**	**9**	**10**	**11**	**12**	**13**	**14**
Base sheet	UC-P	C-P	C-P	C-P	SBS	SBS	SBS
Layer 1	VA	VA	SB	SB	SA	SB	SB
Layer 2		SCE	SA	VA	SCE	SCE	SA
Layer 3			SCE	SCE			SCE
C-P = 40 g/m² pre-coated paper; UC-P = 40 g/m² uncoated paper; SA = styrene acrylate coating; SB = styrene butadiene coating; VA = vinyl acrylate coating; SBS = solid bleached sulfate paperboard; SCE = starch containing emulsion coating.							

III. Multilayer curtain coating (MLCC) barrier systems.

Value	Description
0	Sheet falls apart without effort.
1	Sample sheets come apart with slight resistance.
2	Sample sheets come apart with slight stickiness.
3	Sample sheets show noticeable stickiness, but no material transfer between sheets. Coated sample sheet appears similar to untested sample.
4	Sample sheets show noticeable stickiness, but with some slight picking or material transfer between sheets. Coated sample sheet appears different than untested sample.
5	Sample sheets show noticeable stickiness and cannot be completely separated without fiber tear (complete transfer of some or the entire sample sheet to the other).

IV. Blocking rating scale.

Substrate	Layer 1	Layer 2	Layer 3	3M Kit, Flat	3M Kit, Folded	Hot Oil, 23°C, 24 h ΔY	Hot Oil, 60°C, 24 h ΔY	MVTR, 23°C, g/m²/24 h	MVTR, 60°C, g/m²/24 h	Cobb, g/m², 2 min	Cobb, g/m², 30 min	Blocking Rating at Various psi				
												300	600	900	1200	1500
Pre-Coated Paper (both sides)				0.0	0.0	47.1	48.3	289	1380	47.5	56.5	0	0	0	0	0
UC-P	SA			10.4	11.4	25.7	30.2	253	1040	24.9	999.0	5	5			
C-P	SA			9.0	8.0	13.6	33.2	153	797	18.6	43.7	5	5			
C-P	SA	SCE		11.0	11.0	-0.6	1.0	89	825	43.1	57.1	1	2	3	3	3
UC-P	SB			9.8	3.8	35.0	38.3	68	519	14.3	999.0	5	5			
C-P	SB			9.0	7.2	15.4	40.9	40	296	6.5	38.1	3	5	5		
C-P	SB	SCE		12.0	10.8	1.8	4.9	33	294	37.7	999.0	1	2	3	3	3
UC-P	VA			5.2	0.0	36.4	38.4	206	1282	31.2	50.1	4	5			
C-P	VA			8.6	6.6	1.6	47.5	162	785	42.4	56.4	4	5			
C-P	VA	SCE		11.8	8.2	2.6	12.2	110	941	38.1	49.2	1	2	3	4	4
C-P	SB	SA	SCE	12.0	12.0	0.0	2.5	32	243	26.3	48.0	2	3	4	4	4
C-P	SB	VA	SCE	12.0	12.0	-0.2	0.1	31	389	29.7	50.2	1	3	3	4	5
Pre-Coated SBS (both sides)				0.0	0.0	46.1	47.1	264	1130	43.6	100.6	0	0	0	0	0
SBS	SA	SCE		12.0	7.0	0.4	0.5	84	875	43.5	128.1	2	3	3	3	4
SBS	SB	SCE		12.0	6.2	0.0	0.3	31	470	41.8	137.1	2	2	3	3	4
SBS	SB	SA	SCE	12.0	11.4	0.2	0.1	28	359	39.7	145.0	3	3	3	4	5

MVTR = moisture vapor transmission rate; C-P = 40 g/m² uncoated paper; UC-P = 40 g/m² uncoated paper; SA = styrene acrylate coating; SB = styrene butadiene coating; VA = vinyl acrylate coating; SBS = solid bleached sulfate paperboard; SCE = starch containing emulsion coating.

V. Full results from all barrier property tests.

Kit test
This test measures the repellency or anti-wicking of paper and paperboard when subjected to various oils/solvents and was conducted per the TAPPI Standard Test Method T 559 "Grease resistance test for paper and paperboard." Kit testing was conducted on flat and folded (creased) samples. The higher the value, the oil and grease resistance is typically better.

Cobb test
Cobb testing, which measures the amount of water absorbed into a substrate, was conducted per the TAPPI Standard Test Method T 441 "Water absorptiveness of sized (non-bibulous) paper, paperboard, and corrugated fiberboard (Cobb test)." The testing times used were 2 min and 30 min. Lower values indicate less water absorption.

Moisture vapor transmission rate test
The MVTR testing was conducted per TAPPI Standard Test Method T 448 "Water vapor transmission rate of paper and paperboard at 23°C and 50% RH" for testing at 23°C (73.4°F) with an atmosphere of 50% relative humidity (RH). Additional testing was performed at jungle conditions per TAPPI Standard Test Method T 464 "Water vapor transmission rate of paper and paperboard at high temperature and humidity" for testing at 37.8°C (100°F) with an atmosphere of 90% RH. Lower values indicate less water vapor transmission.

Blocking analysis
In the paper industry, blocking is defined as the tendency of the coated paper to stick to the uncoated paper back side in a roll. The blocking test in the lab was developed to evaluate the sticking tendency that might correlate with the mill sticking performance. Blocking was measured in the lab using a Carver hydraulic press set at 140°F. A 15 cm x 15 cm coated sheet was placed against the reverse side of another coated sheet and these were then placed between two sheets of blotter paper. This assembly was then placed in the hydraulic press under the desired pressure for 3 min. The test was done at pressures of 300, 600, 900, and 1200 psi. After removing from the press and letting the assembly cool to room temperature, the sheets were separated and evaluated for blocking using the rating scale shown in Table IV. Lower values suggest less blocking.

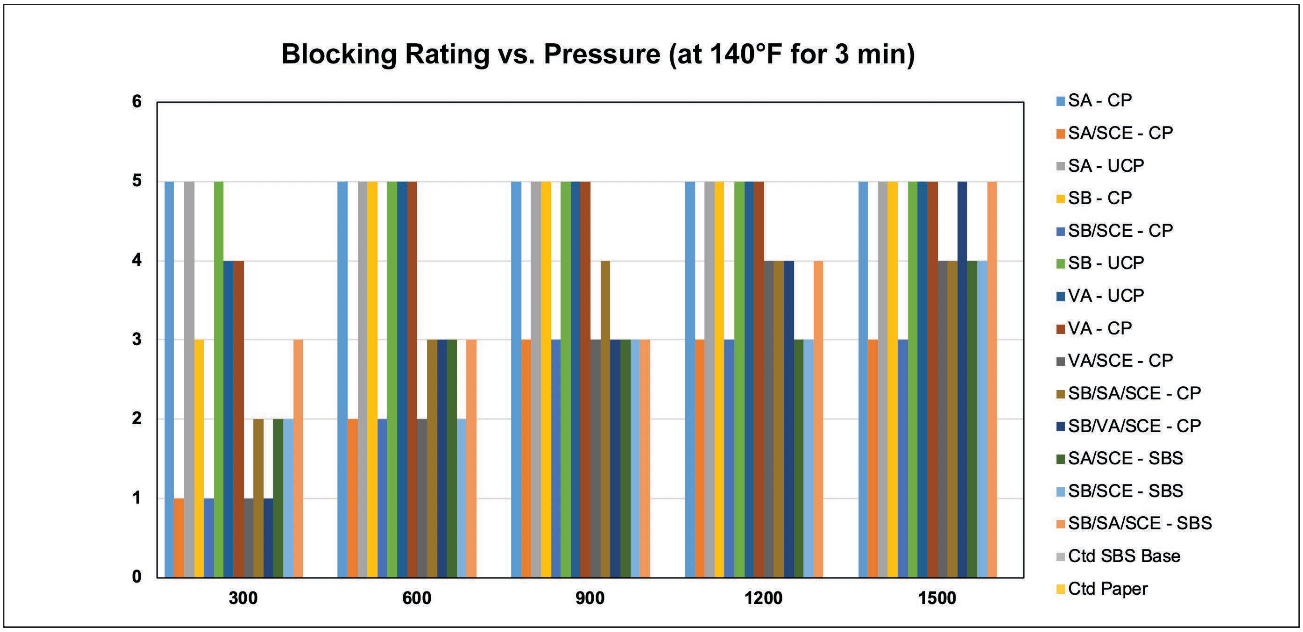
Test data
The full results from all the barrier property tests are summarized in the **Table V**.

RESULTS AND DISCUSSION
MLCC coating
A summary of the observations from the production of each of the trial conditions is shown in **Table VI**. As can be seen, line speed and flow rates were adjusted, when neces-

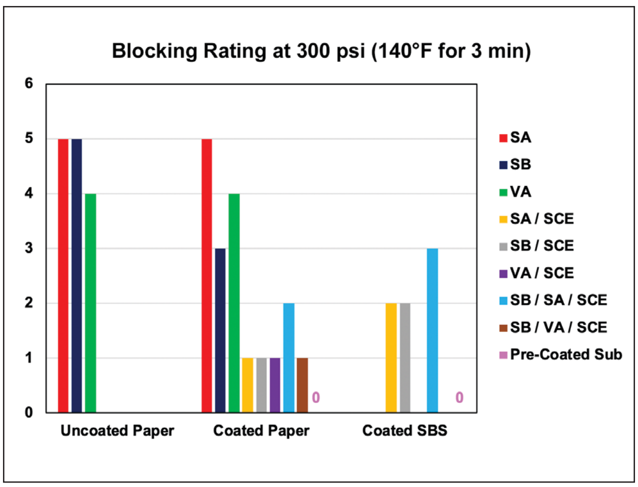
Run	Base Sheet	Layer 1	Layer 2	Layer 3	Observations
1	C-P	SA	-	-	Increased speed to 600m/min to get better quality.
2	C-P	SA	SCE	-	Some teapot occurrence, but stable overall.
3	UC-P	SA	-	-	Increased speed to 600 m/min to get better quality.
4	C-P	SB	-	-	Increased speed to 700 m/min to get better quality.
5	C-P	SB	SCE	-	Some teapot occurrence, but stable overall.
6	UC-P	SB	-	-	Increased speed to 700 m/min to get better quality.
7	C-P	VA	-	-	Increased speed to 600 m/min to get better quality.
8	UC-P	VA	-	-	Increased speed to 600 m/min to get better quality.
9	C-P	VA	SCE	-	Some instability in curtain (teapot tendency).
10	C-P	SB	SA	SCE	Good curtain quality at 500 m/min.
11	C-P	SB	VA	SCE	Some teapot occurrence, but stable overall.
12	SBS	SA	SCE	-	Good curtain quality at 500 m/min.
13	SBS	SB	SCE	-	Good curtain quality at 500 m/min.
14	SBS	SB	SA	SCE	Good curtain quality at 500 m/min.

C-P = 40 g/m² pre-coated paper; UC-P = 40 g/m² uncoated paper; SA = styrene acrylate coating; SB = styrene butadiene coating; VA = vinyl acrylate coating; SBS = solid bleached sulfate paperboard; SCE = starch containing emulsion coating.

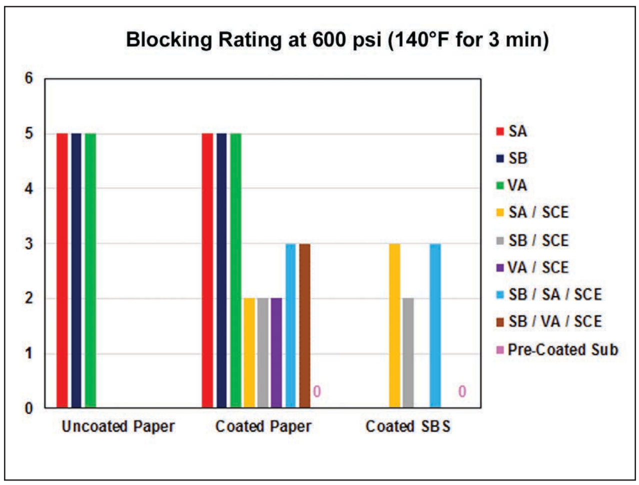
VI. MLCC observations.



6. Blocking data—all pressures (SA = styrene acrylate coating; CP = 40 g/m² pre-coated paper; SCE = starch containing emulsion coating; SB = styrene butadiene coating; UCP = 40 g/m² uncoated paper; VA = vinyl acrylate coating; SBS = solid bleached sulfate paperboard).



7. Blocking data at 300 psi.



8. Blocking data at 600 psi.

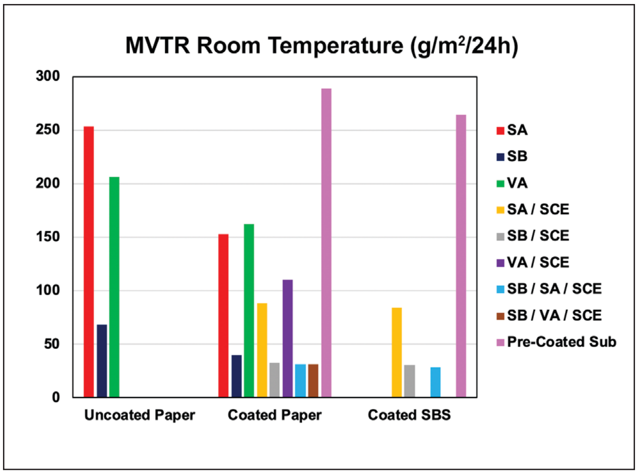
sary, to optimize the curtain stability and coated sheet quality for the applied film thickness and material viscosity profile being applied.

Blocking rating

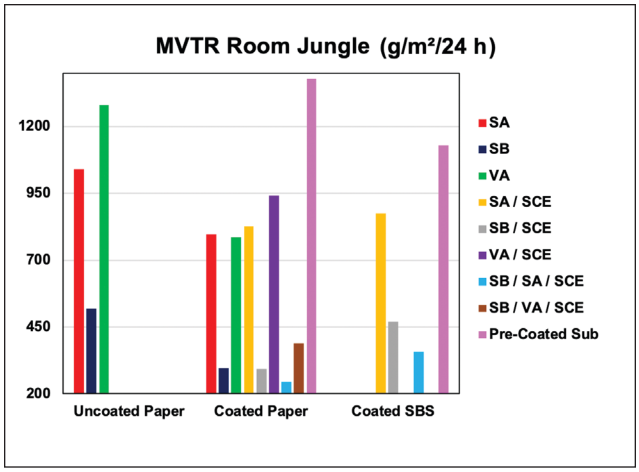
All of the blocking data is summarized in **Fig. 6**, where it is plotted as blocking rating versus press pressure. The pre-coated paper and the pre-coated SBS substrates were tested for blocking and each substrate had a zero rating at all pressures, suggesting no blocking as expected. For the barrier coated samples that do not completely block at 300 psi, the general trend is increased blocking with increased pressure. At the highest pressure, the only samples that do not block completely are the ones with the starch containing emulsion (SCE) coating on the top layer. **Figures 7** and **8** show the blocking rating at 300 psi and 600 psi, respectively, where the samples are sorted by substrate type. On both the uncoated and coated paper, the barrier systems with only the SA, SB, or VA coatings have significant blocking. With the SCE coating in the top layer, the blocking is reduced significantly, and after pressing at 300 psi, the sheets separate easily. At 600 psi, we see the same trend.

MVTR test

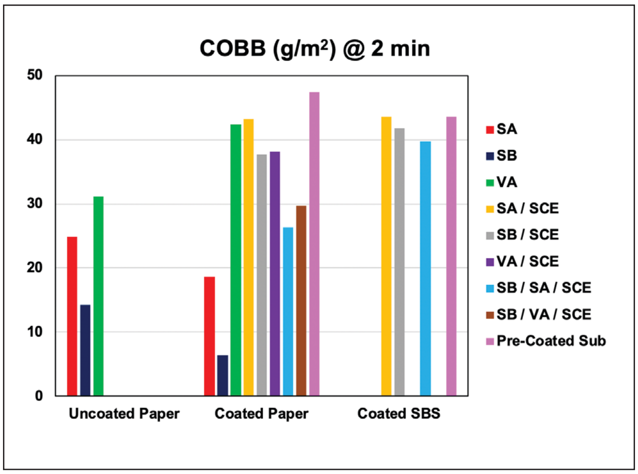
The data from the MVTR testing at room temperature is summarized in **Fig. 9** and the testing at jungle conditions is summarized in **Fig. 10**, each displayed by substrate



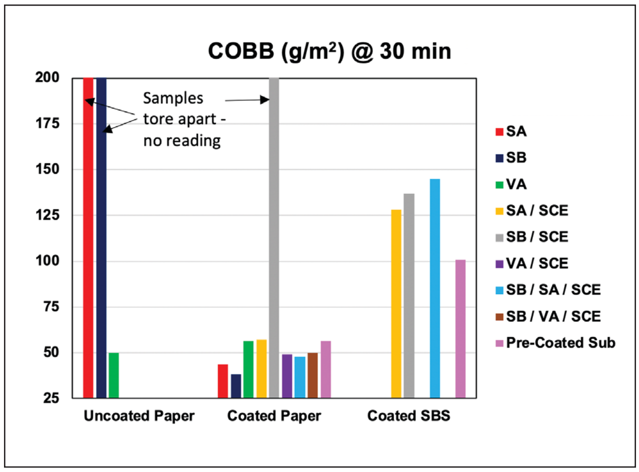
9. Moisture vapor transmission rate (MVTR), room temperature data.



10. MVTR, jungle conditions data.



11. Cobb water absorption, 2 min.



12. Cobb water absorption, 30 min.

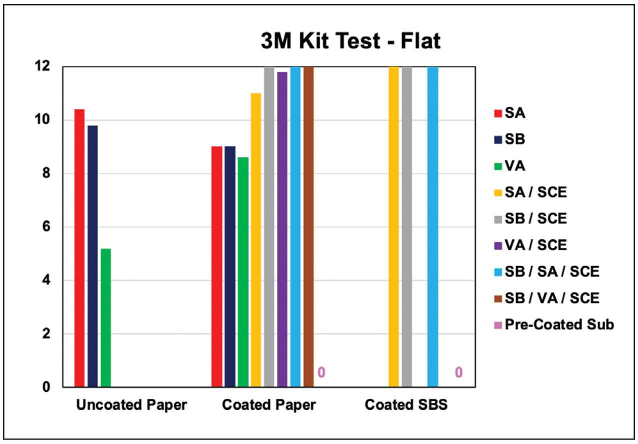
type. As a baseline, both the pre-coated paper and SBS were tested, and both had very high moisture absorption. The data shows that the barrier layers coated on the pre-coated paper substrate have better MVTR than the similar barriers (at same coat weight) coated on uncoated paper. This indicates that the pre-coat allows the laydown of a more consistent thickness barrier coating layer. The best MVTR at room and jungle conditions is with the SB and the SB/SCE systems. Also, the SB/SA/SCE and the SB/VA/SCE have low MVTR. On the SBS substrate, the best systems are the SB/SCE and SB/SA/SCE. Of the chemistries evaluated, SB polymer will tend to be higher in water resistance.

Cobb test

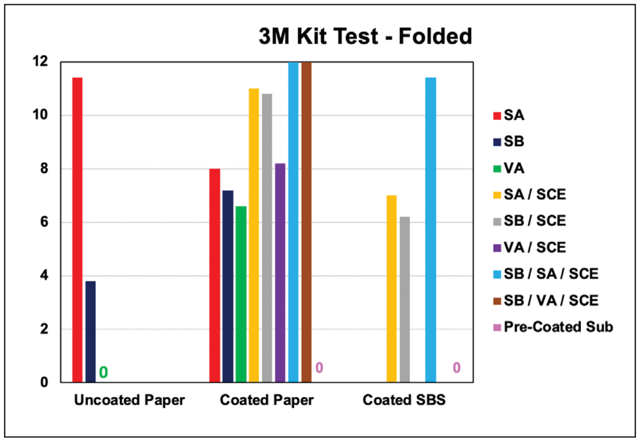
The data from the Cobb water absorption testing at 2 min and 30 min is summarized in **Figs. 11** and **12**, respectively, sorted by substrate type. For Cobb, we also see an improvement in water absorption for the barrier systems on the pre-coated paper substrate. The best barrier system for water absorption is the SB coating. Water absorption is worse for the systems with the SCE top layer, on both the paper and SBS substrates.

Kit test

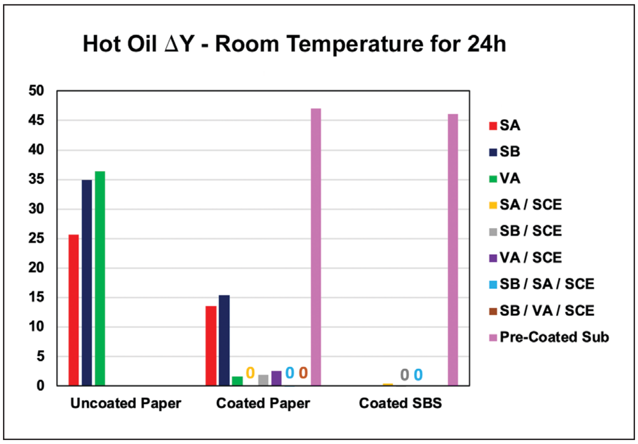
The Kit testing performed on flat and folded samples is summarized in **Figs. 13** and **14**, respectively. As a baseline, the pre-coated paper and pre-coated SBS were tested flat and folded, and both had a zero Kit test for flat and folded. Comparing the SA and SB coating on uncoated and pre-coated paper samples, the flat Kit test is similar. For the VA coating, there is a significant increase on the pre-coated paper. All of the multilayer barrier systems have a flat Kit test between 11 and 12 on the pre-coated paper and SBS systems. In the folded sample Kit testing, the SA system is significantly higher than the SB and VA systems on the uncoated paper, but with the pre-coated paper, these three systems are fairly similar. Most of the multilayer barrier systems have a folded Kit test between 11 and 12 for the VA/SCE system, which may have potentially ex-



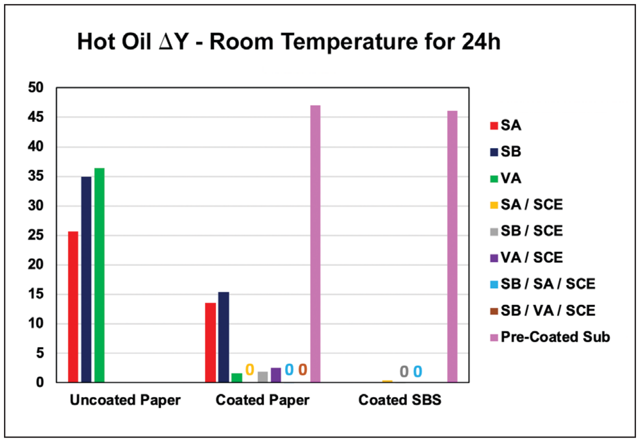
13. Kit test on flat samples data.



14. Kit test on folded samples data.



15. Oil resistance at room temperature.



16. Oil resistance at 60°C data.

perienced cracking. On the SBS substrate, the SB/SA/SCE system had the highest Kit test.

Oil resistance test

The data from the hot oil resistance testing at room temperature and 60°C is summarized in **Figs. 15** and **16**, respectively. As a baseline, both the pre-coated papers and SBS were tested, and both had very high oil absorption. Of the single layer barrier systems, the SA system had the best oil resistance on uncoated and coated paper substrates, both at room temperature and 60°C. At room temperature, the pre-coated single layer barrier systems had better oil resistance. The multilayer barrier systems had the best oil resistance, most likely due to the thicker overall barrier coating thickness.

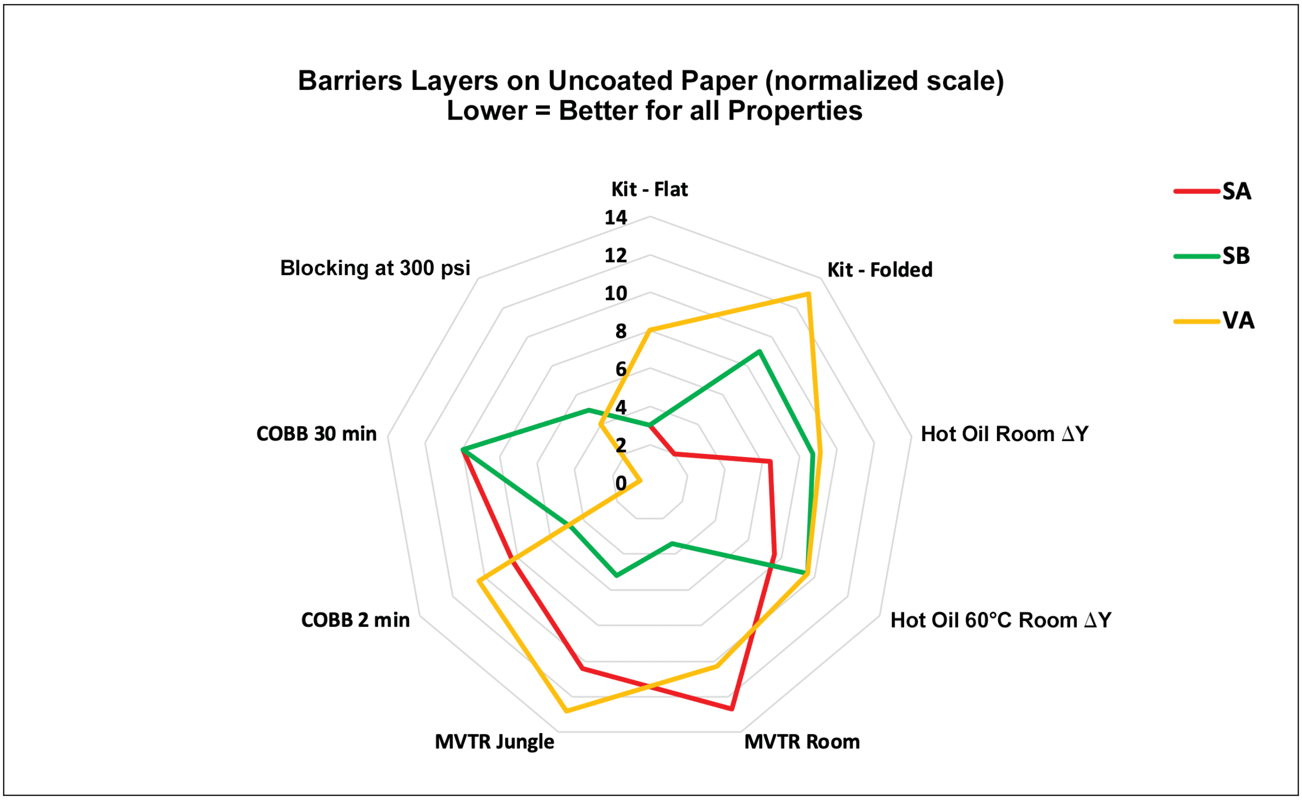
SUMMARY

In **Figs. 17**, **18**, and **19**, we have summarized the overall performance on each substrate type. The values of each property have been normalized for the purpose of this comparison, and for each property, lower values correspond to better performance. So, the closer the data circle is to the center of the radar, the better the overall performance. Using these radar plots, we can determine the best barrier systems. For the uncoated paper substrate in Fig. 17, the best overall candidate for MVTR/water/oil resistance is the SB coating. For oil resistance, the best candidate is the SA system, but all coatings blocked. For the pre-coated paper substrate in Fig. 18, the best overall candidates for blocking/MVTR/water/oil resistance were the SA/SCE, the SB/SA/SCE, and the SB/VA/SCE systems. For the pre-coated SBS substrate in Fig. 19, the best overall candidates for blocking/MVTR/water/oil resistance were the SB/SCE and the SB/SA/SCE systems.

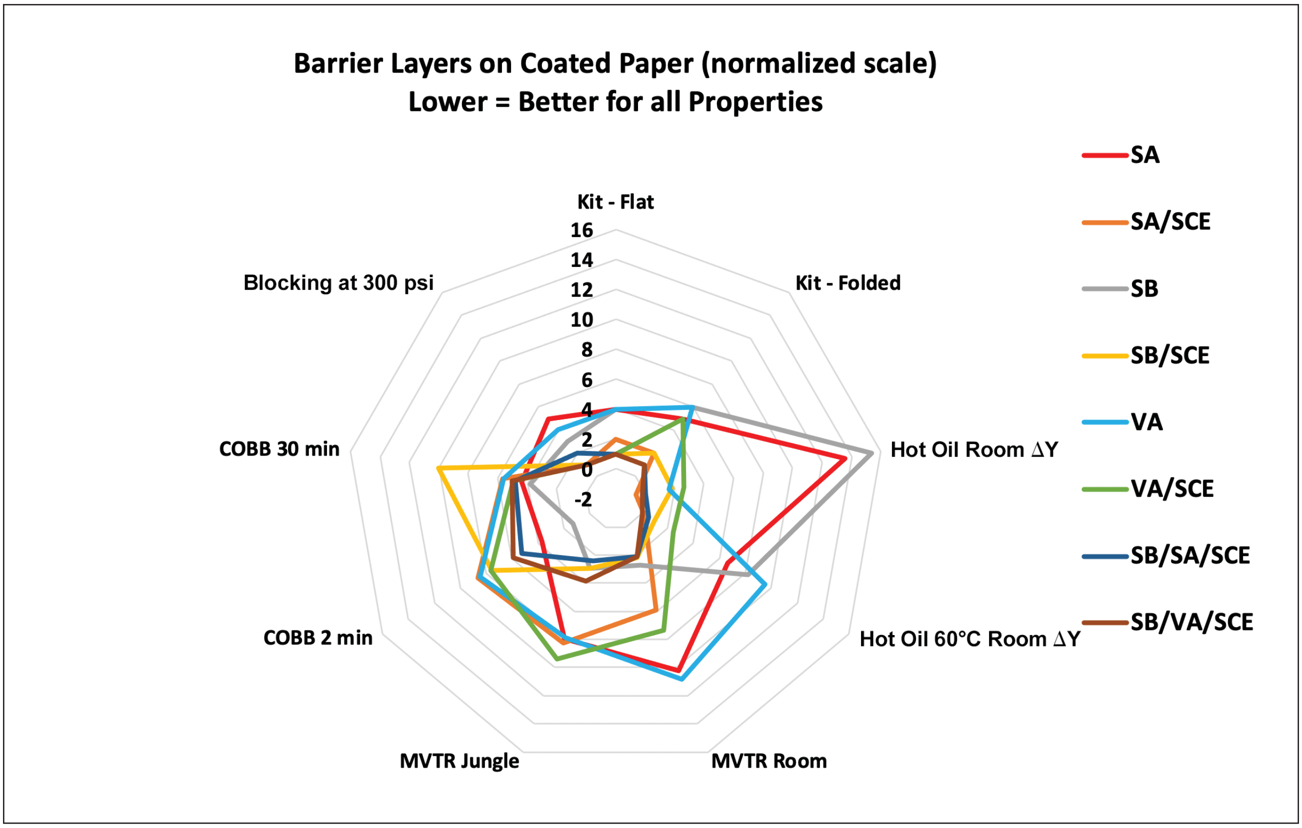
CONCLUSIONS

The conclusions from this research can be summarized as follows:

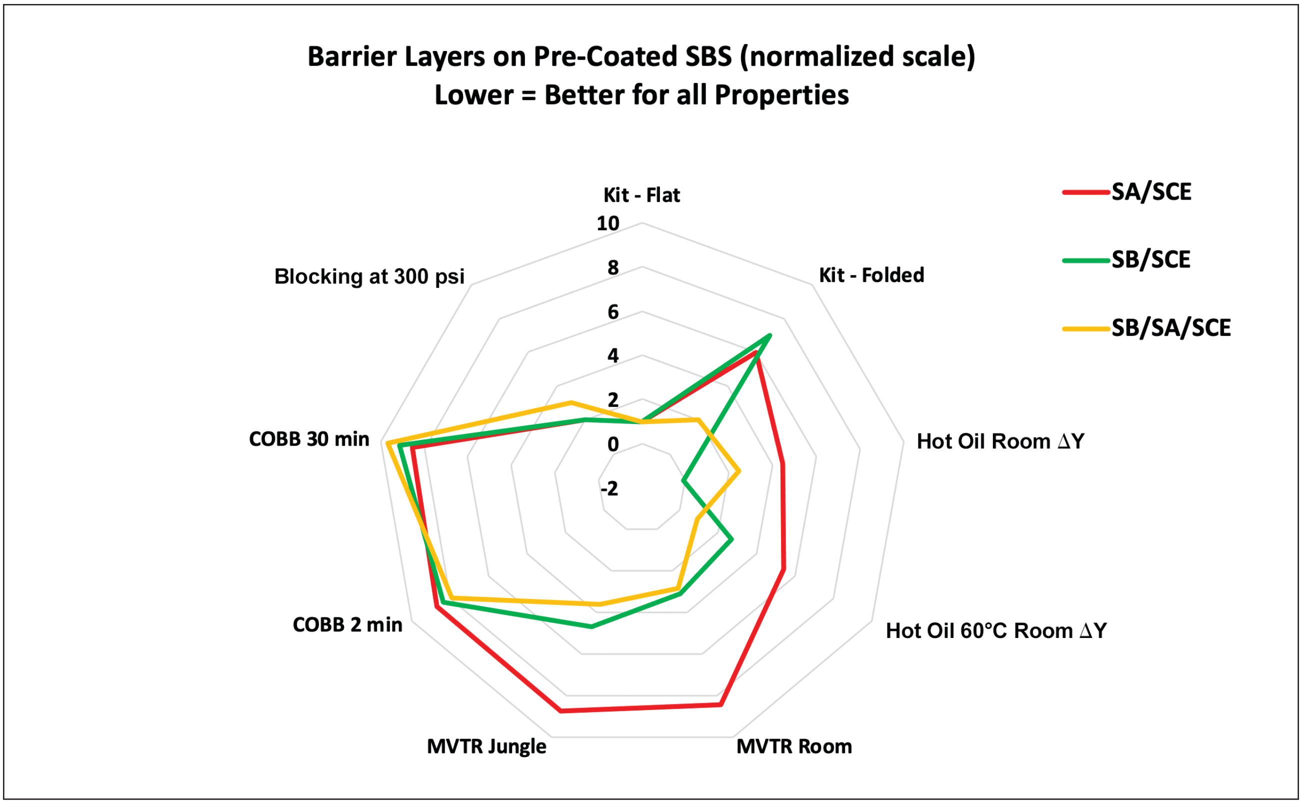
- This paper shows that MLCC can be used to achieve barrier coating systems that could not be accomplished with a series of conventional coaters.
- For the barrier coated samples, the general trend is increased blocking with increased pressure.
- On both the uncoated and coated paper, the barrier



17. Comparison of barriers on 40 g/m² uncoated paper (U-CP).



18. Comparison of barrier on 40 g/m² pre-coated paper (C-P).



19. Comparison of barrier on coated solid bleached suflate (SBS).

systems with only the single layer of SA, SB, or VA coatings have significant blocking.

- With the SCE coating in the top layer, the blocking is reduced significantly.
- The data shows that the barrier layers coated on the pre-coated paper substrate have better MVTR than the similar barriers coated on uncoated paper. This indicates that the pre-coat allows the laydown of a more consistent thickness barrier coating layer.
- The best MVTR at room and jungle conditions is with the SB and the SB/SCE systems. Also, the SB/SA/SCE and the SB/VA/SCE also have low MVTR. On the SBS substrate, the best systems are the SB/SCE and SB/SA/SCE.
- For the Cobb test, we also see an improvement in water absorption for the barrier systems on the pre-coated paper substrate. The best barrier system for water absorption is the SB coating. The systems with the SCE top layer have worse water absorption on both the paper and SBS substrates.
- All of the multilayer barrier systems have a flat Kit test between 11 and 12 on the pre-coated paper and SBS systems. In the folded sample Kit testing, the SA system is significantly higher than the SB and VA systems on the uncoated paper, but with the pre-coated paper, these 3 systems are fairly similar. Most of the multilayer barrier systems have folded Kit tests between 11 and 12, except for the VA/SCE system, which may have experienced cracking. On the SBS substrate, the SB/SA/SCE system had the highest Kit.
- Of the single layer barrier systems, the SA system had the best oil resistance on uncoated and coated paper substrates, both at room temperature and 60°C. At room temperature, the pre-coated single layer barrier systems had better oil resistance. The multilayer barrier systems had the best oil resistance, most likely due to the thicker overall barrier coating thickness and the contribution to oil resistance from the SCE coating. **TJ**

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ABOUT THIS PAPER

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About this journal

ABOUT THE AUTHORS

There is a high demand and urgency from paper and paperboard producers to find water-based barrier coatings to replace fluorochemicals and extruded plastic laminates due to regulatory issues. The purpose of this research was to develop coated substrates with multipurpose barrier properties using water-based coatings and using the most cost-efficient coating application method. The goal was to find barrier solutions for the current regulatory issues using water-based coatings.

Most research presented so far concentrates on the single layer application of a water-based barrier coating. Our research is different from previous research and current practice in that we are applying multiple barrier layers with a single pass using multilayer curtain coater (MLCC) technology, thus achieving multiple barrier properties. This is also impossible to accomplish with sequential conventional coaters.

The most difficult aspect of the research was to optimize the rheology and extensional viscosity of the coating formulations to process on a curtain coater at speeds typically run in mills. This was accomplished with a series of preliminary studies. Without the optimized rheology and extensional viscosity, we would have experienced an unstable curtain and defects such as holes and skips, producing a very poor barrier.

Our research confirmed the enormous advantage of curtain coaters over conventional coaters. Curtain coaters give such uniform coating thickness that they allow for a possible reduction in coat weights. Also, the application of wet coatings, each with different barrier properties, in one pass results in no loss of performance with any of the layers.

The most interesting finding was that despite the perfect contour coating produced by MLCC technology, it is still advantageous to apply these coatings onto a pre-coated substrate. The pre-coated substrate improves barrier performance, not because the precoat is a barrier, but because it allows for the laydown of a smoother and more consistent coating thickness.

Ventresca

With the information from this research, mills contemplating a new coater should strongly consider the installation of an MLCC coater due to the flexibility it gives in developing barrier structures. For mills who currently have MLCC coaters, we hope this research will help them develop new barrier coating solutions fairly quickly.

Welsch

Our next step is to explore different barrier options with the MLCC coater. This includes developing structures with four or five layers of water-based coatings, including coatings for excellent oxygen barrier, water barrier, and oil and grease barrier performance. This would create the optimum food packaging barrier grade.

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