

Seal Through Contamination Performance of Metallocene Plastomers

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ABSTRACT

Metallocene plastomers are well known for providing superior toughness and excellent heat sealing performance in many high performance flexible packaging films. In a great many form-fill-seal applications it is also required that sealant remain functional even when the film surface is contaminated with product.

This paper presents further technical evidence of the excellent sealing performance of plastomers, in particular of their performance when sealing through contaminants. Both laboratory sealing experiments and actual VFFS packaging data are described.

KEYWORDS

Polyethylene, Flexible Packaging, Plastomers, mPE, Metallocene Polymers, Heat Sealing

INTRODUCTION

The flexible packaging industry continues to challenge film producers to provide cost effective improvements in packaging speed, consistent performance on packaging equipment, durable package integrity and aesthetics. Since all of these attributes are directly impacted by the quality and performance of the seal layer, the selection of the sealing polymer has become a critical parameter in the design of multilayer film structures. It is well documented that metallocene catalyzed plastomers offer the sealing characteristics to meet the current design requirements [1,2,3]. Plastomers provide a unique combination of low seal initiation temperatures, a high hot-tack and good seal strength over a broad temperature window.

This paper provides further technical evidence of the excellent sealing performance of plastomers, in particular of their performance when sealing through contaminants. In many packaging operations, such as the packaging of foodstuffs on form-fill-seal (FFS) equipment, the product packed inevitably contaminates the seal area. The ability to provide a high performance seal in the presence of contaminants therefore is an important attribute. This study presents the results of comparative testing of plastomers versus conventional sealing polymers using various contaminants. Ionomers, historically used for sealing through contaminants [4,5], have been selected as a reference polymer. The experiments have been designed to provide a systematic progression from basic measurements on monolayer, coextruded and laminated films to the evaluation of representative barrier structures on vertical form-fill-seal equipment. The contaminants studied were chosen to be relevant in practice.

EXPERIMENTAL

Film Structures:

The structures used for this program are described in table 1. The various sealing polymers included in this study are shown in table 2.

Table 1: Film Structures

N°	Structure Type	Film Composition	Thickness	Process
1	Barrier Film	PA / ctr1 / EXACT 0201HS	15 / 10 / 25 μm	P1
2	Barrier Film	PA / ctr1 / Stamylex 09-016F	15 / 10 / 25 μm	P1
5	Barrier Film	PA / ctr1 / ESCORENE FL00209	15 / 10 / 25 μm	P1
6	Barrier Film	PA / ctr2 / Surlyn 1601	15 / 10 / 25 μm	P1
11	Laminated Film	PET / adh / EXACT 0202	12 / - / 50 μm	P2 / P3
13	Laminated Film	PET / adh / Surlyn 1650 E	12 / - / 50 μm	P2 / P3
15	Coex Film	LDPE / MAA / Surlyn 1601	12 / 8 / 8 μm	
16	Coex Film	LDPE / LDPE / 80 % Exact 0201-LDPE	20 / 20 / 10 μm	P4
17	Mono Film	Iotek 3110	50 μm	P5
18	Mono Film	Iotek 4200	50 μm	P5
19	Mono Film	EXACT 0201HS	50 μm	P6

Table 2: Compared Polymers

Polymer	Polymer Name	MI	Density	Polymer type	Supplier
m-Plastomer 1	EXACT 0201HS	1.1	0.902	Plastomer - C8 copolymer	DEX Plastomers
m-Plastomer 2	EXACT 0202	2.0	0.902	Plastomer - C8 copolymer	DEX Plastomers
EVA	ESCORENE FL00209	2.10	0.929	EVA-9.4% VA copolymer	ExxonMobil Chemical
Ionomer 3	IOTEK 3110	1.3	0.939	Sodium Ionomer	ExxonMobil Chemical
Ionomer 4	IOTEK 4200	3.0	0.946	Zinc Ionomer	ExxonMobil Chemical
Ionomer 1	SURLYN 1601	1.3	0.940	Sodium Ionomer	DuPont
Ionomer 2	SURLYN 1650E	1.5		Zinc Ionomer	DuPont
VLDPE	STAMYLEX 09-016F	1.13	0.914	vLLDPE – C8 copolymer	DEX Plastomers

To simplify the discussion of the results, the four following generic names are employed in this paper: Plastomers, VLDPE, EVA and Na/Zn Ionomers. The other materials used in the film constructions are shown in table 3.

Table 3: Other materials used

Reference	Product type	Product name	Supplier
Ctrl	Tie resin	Yparex 8104E	DSM
Ctrl	Tie resin	Admer NF528	Mitsui
LDPE	Polyethylene	LD185BW	ExxonMobil
Adh	Adhesive	Adcote 301A/ 350 A	Morton
PA	Polyamide	CoPA Ultramid C35	BASF

Film Fabrication:

Films # 1 to 6 (Process P1): Coextruded blown films of 50 μm (#1-6) were produced on a 3 layer coex Barmag line.

Films #11 to 13 (Process P2 and P3): Monolayer blown films of 50 μm (#8-12) were produced on a Kiefel Complex SA 70 pilot line. The three films were laminated to a 12 μm PET film using a lab scale laminator.

Film #16 (Process P4): A 3 layer coextruded blown film of 50 μm (#16) was produced on an Alpine line.

Film #17 to 18 (Process P5): The monolayer blown films of 50 μm (#17-18) were produced on a Dolci line.

Film #19 (Process P6): The monolayer blown film of 50 μm (#19) was produced on an Alpine line.

Film #15: The coextruded Surlyn based film was produced on a commercial extrusion line.

Appropriate additives were added to all of the structures to avoid any blocking problems when performing the VFFS evaluation. Except the structure #15, all the films were produced at ExxonMobil or DSM facilities, using commercial scale production equipment.

Film Testing:

Seal strength (Method 1): The sealing samples were 24 mm wide specimens cut from the original films. A Brugger HSG/ETK apparatus was used to make the seals using a 10 mm seal beam, a seal bar pressure of 3 bar and a dwell time of 1.0 sec. After 16 hours conditioning at 23 °C the seal strength was determined using a Zwick 1425 tensile tester. The clamp distance was 50 mm and the clamp speed was 200 mm/min.

Seal strength (Method 2): The sealing samples were 15 mm wide specimens cut from original films. A J&B Hot Tack tester was used to make the seals, using a seal bar pressure of 0.5 MPa and a seal time of 0.5 sec. After 24 hours conditioning at 23°C, the seal strength was determined based on ASTM method D882 using a Zwick tensile meter. The test speed was 500 mm/min.

Hot-Tack: Hot-Tack was used to describe the strength of heat seals immediately after the sealing operation, in contrast to "seal strength " which applies to the strength of the seal after it had cooled. The hot tack samples were 30 mm wide specimens cut from original films. These samples were then back-taped (laminated) with PET to avoid (for thin films) rupture at the transition of the seal and elongation or sticking to the seal bars. A Hot Tack Tester 3000, from J&B, was employed to make the seal, using a seal bar pressure of 0.5 MPa, and a seal time of 0.5 sec. The hot tack was then determined, after a cooling time of 0.4 sec and at a peel speed of 200 mm/min.

Contamination of the sealing area (laboratory): The contaminants (detailed description given in table 4) were conditioned at room temperature before they were applied to the seal area (room temperature). The liquid and paste-like contaminants were applied to the seal area by using a small paintbrush (care was taken to apply the contamination “homogeneously” to the seal area). Immediately after the contamination step the seal was formed. The cheese contamination was done by dipping the films into the “sticky” cheese strands. Because the coffee powder adhesion to the films was poor, a damp sponge was used to obtain a moist film. These films were dipped in the coffee powder and a contaminated seal area resulted. The meat juice has been used to simulate blood.

Table 4: Specification of the contaminants used

#	Products	Origin
1	Coffee powder	Douwe Egberts ground coffee, Desert quality
2	Cheese	Molenland grinded old cheese 48 ⁺
3	Milk powder	Complete coffee creamer, Friesland Dairy foods
4	Olive Oil	Carbonell olive oil, Aceites Carbonell
5	Mayonnaise	Calvé mayonnaise, Van den Bergh Nederland
6	Ketchup	Heinz tomato ketchup
7	Meat juice	juice squeezed out of a raw steak

Sealing Comparison Methods: Because the comparison of the full seal curves is rather complex, only the following sealing parameters are reported. The Seal Initiation Temperature (SIT) is defined as the temperature at which a given seal strength (5N/24mm using method 1, 4N/15mm using method 2) is attained. In general, there was a 3°C difference between these results. The Plateau Seal Strength is the constant seal strength that was reached. Figure 1 shows a typical determination of the SIT and plateau seal strength for the seal test of film # 19. To simplify the comparison of the hot-tack data, the following definitions were used. The maximum Hot-tack force is the maximum value reached over the tested temperatures. The Hot-tack window at a certain hot-tack force corresponds to the width of the hot-tack curve.

Microscopic analyses of contaminated seals: To get an illustrative picture and to qualitatively determine why some seals perform better than others, a microscopic image was obtained by making a perpendicular cut of the contaminated seal area is made at low temperature (cooled with liquid nitrogen).

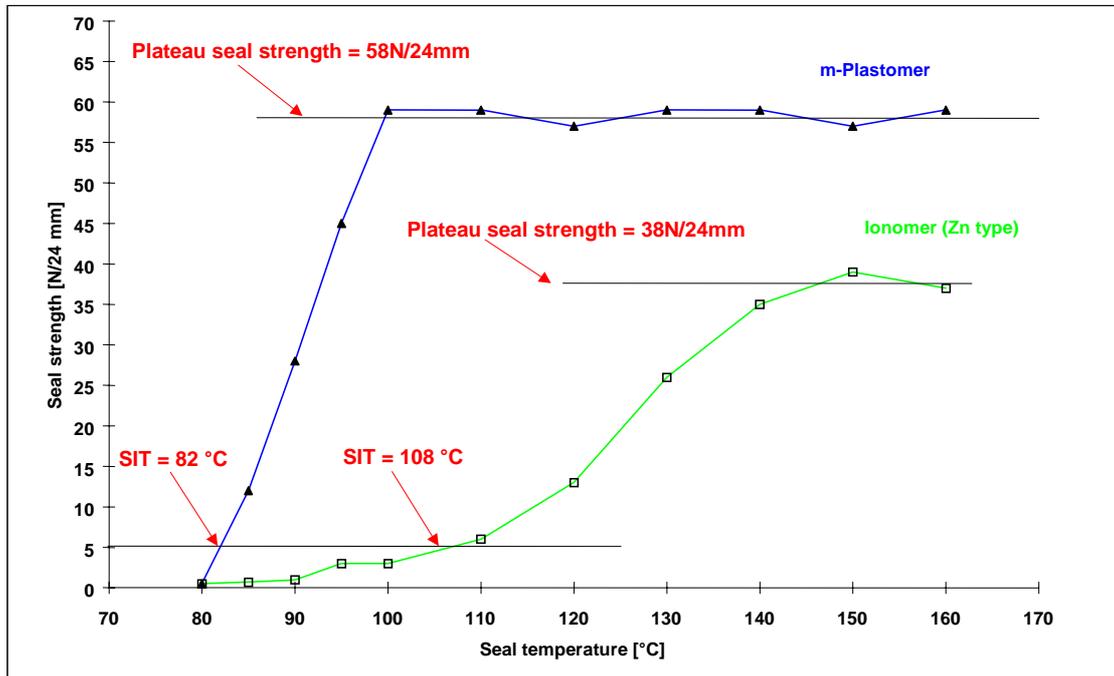


Figure 1: Comparison of seal strength curves

VFFS ROVEMA tests

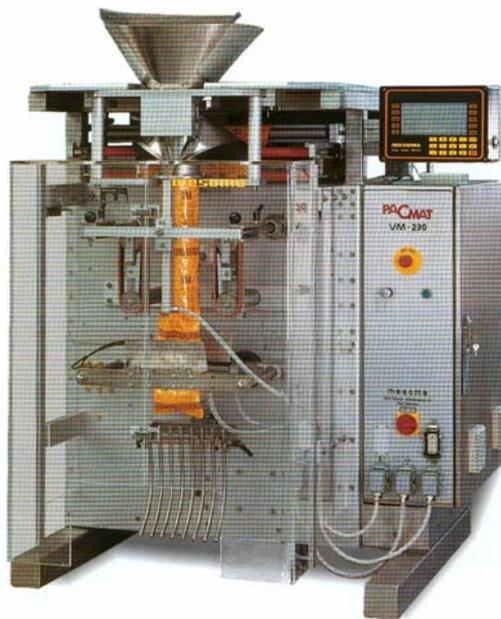


Figure 2: Vertical Form Fill and Seal machine

Machine principle: The term form/fill/seal means producing a bag or pouch from a flexible packaging material, inserting a measured amount of product and closing the bag top. The configuration of a Vertical Form, Fill and Seal machine is shown in Figure 2 and illustrated in Figure 3. Coming from the roll and passing through a series of rollers to a bag-forming collar, the film is wrapped around a metallic tube that gives it a cylindrical form. The two

edges of the film are sealed as they pass along the metal tube. A first transverse seal forms the bottom of the bag that is then able to be filled through the hollow tube. The packaging film then advances a predetermined distance that equals the desired bag length. The cylindrical film gets another transverse seal to close the filled bag. As the product comes in direct contact with the bottom seal when it is still hot, the hot-tack capability of the film is extremely important. The hot-tack force of the seal determines the quality of the closed bag and the machine speed.

Figure 3: VFFS machine principle

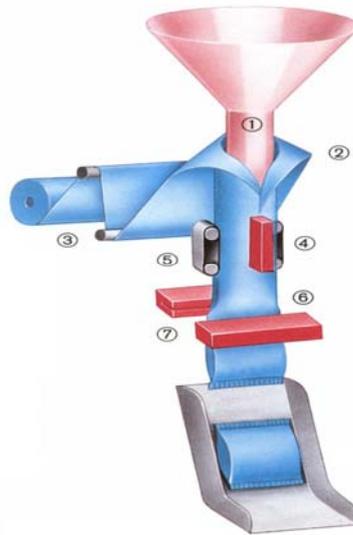


Table 5: VFFS machine main characteristics

Piece #	DESCRIPTION
1	Filling tube
2	Forming shoulder
3	Packaging structure
4	Vertical seal tool
5	Transfer belts
6&7	Horizontal seal tool

Machine Setting: On a ROVEMA VFFS machine, empty bags were made with a length of 180 mm while the bag width, based on the chosen filling tube was 160 mm. The ranges of ROVEMA settings for these experiments were seal temperatures: 90-140°C (interval of 10°C), seal times: 150-500 msec (interval of 50 msec), seal pressure: 0.73 N/mm². Since all the structures were quite flexible, the reel tension was kept low. The top and the bottom seal profile were horizontal serrated while the vertical seal had no profile. For the vertical seal, a conventional fin seal was used, as PA cannot be sealed to a PE. All seal tools were covered with a Teflon sheet to avoid sticking.

Contamination of the sealing area (ROVEMA): For the contamination in the ROVEMA tests, the liquid contaminants indicated in Table 6 were used. As this system only allows for liquid contamination, no powder was used.

Table 6: Specification of the used contaminants

	Products	Origin	Characteristic
#1	Water	Chaufontaine	Neutral liquid
#2	Milk	Stabilac – fatty	Animal fat
#3	Tomato juice	MinuteMaid – filtered	Polar liquid
#4	Olive Oil	Carapelli – virgin	Nonpolar liquid

To obtain uniform distribution of the contaminant on the sealing layer, a Norgren liquid spraying system was installed on the Rovema as follows: A tube (see Figure 4) was inserted into the filling pipe. The end of this tube reaches to the bottom end of the formed film tube and allows the contaminant to be sprayed onto the sealing area of the structure immediately before the bottom seal of the formed bag is made (see Figure 5 and 6).

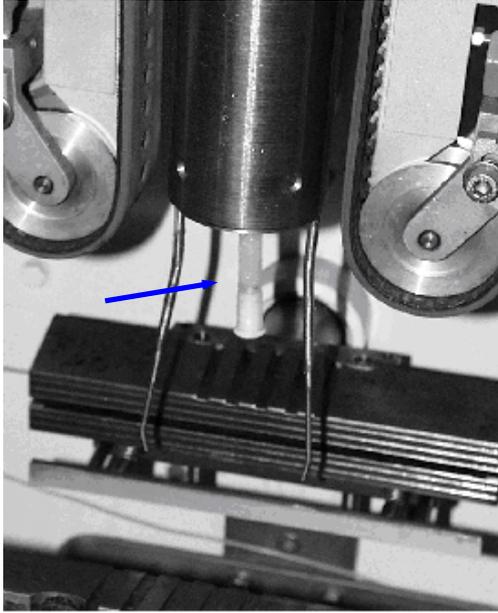


Figure 4: Spraying tube

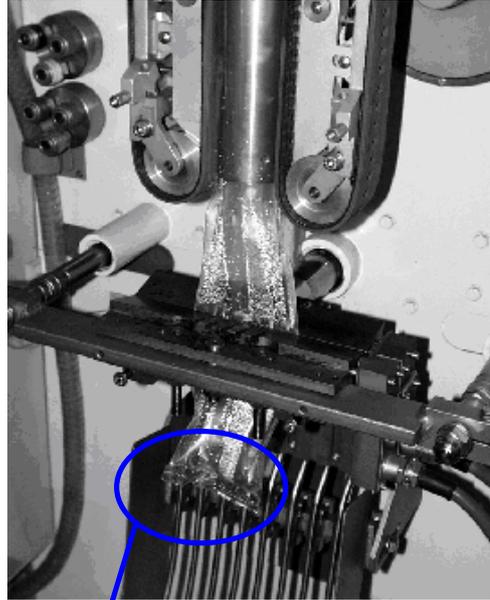


Figure 5: Contaminant spray at the seal

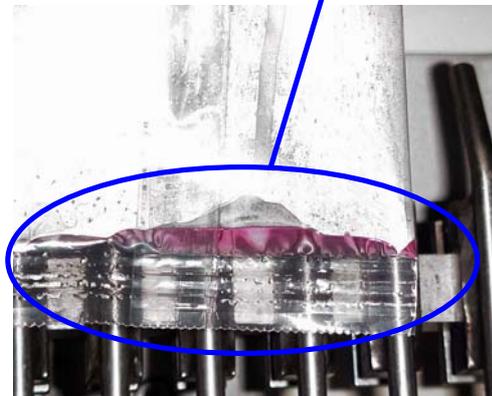
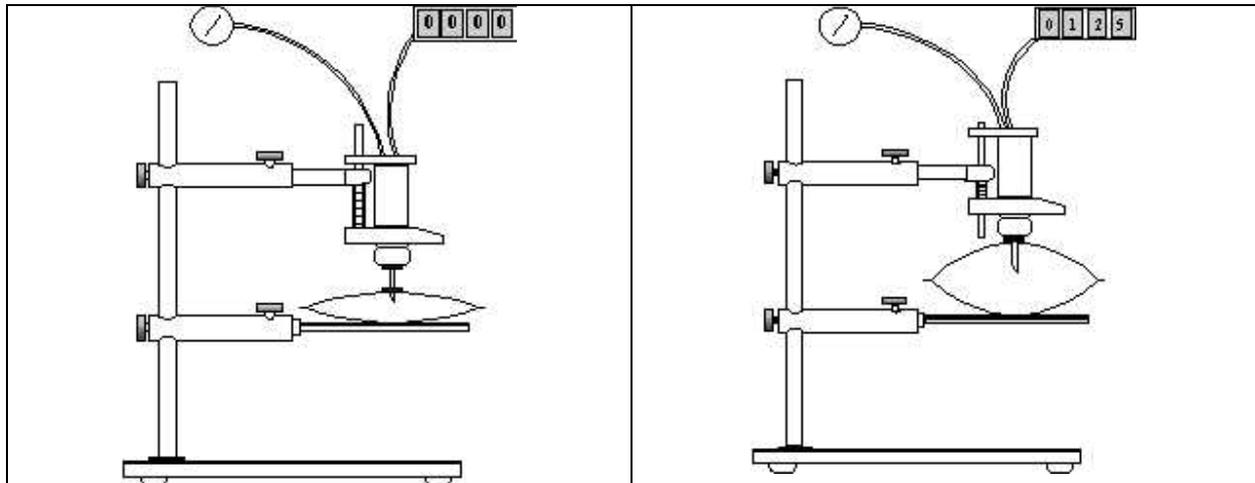


Figure 6: Contaminated seal area - detail

Rupture strength: Empty bags made on the Rovema at particular set of sealing conditions and sampled at random were inflated with compressed air at a constant pressure increase of 5mbar/sec (Figures 7a & 7b). The pressure at which sealing and/or structure break occurred was noted. Four out of six measurements (minimum and maximum values were discarded) were averaged and reported as the *rupture strength* value.

To get an estimate of the structure performance, the minimum conditions (sealing temperature – sealing time) to reach rupture strength of 100mbar without contaminants, considered as acceptable for this type of barrier structure, was determined and an estimation of the packaging line speed is performed. This estimation is done considering that the entire cycle time on the Rovema is (750 msec + seal time).

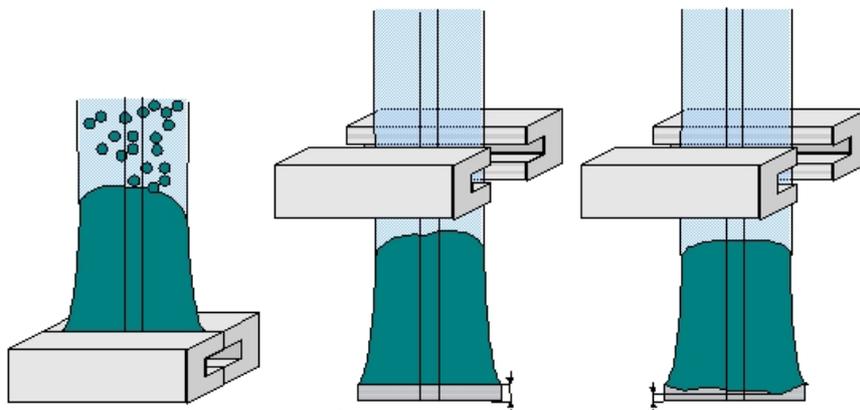
Figures 7a & b: SKYE rupture strength tester



From this experiment, it was determined that operating conditions of 120°C sealing temperature and 250msec sealing time resulted in a rupture strength measurement above 120mbar for all the structures. At these conditions, the contaminants were introduced and the influence on rupture strength was evaluated, by comparing the rupture strength of the bags made in the presence of contaminant to the rupture strength on “clean” bags.

In-Line Hot-Tack: In this study, in-line hot-tack was determined as the percentage of peeling (or deformation, see Figures 8a, b, c) of the bottom seal after filling the bags on the VFFS with 0.5kg of LDPE pellets and reopening of the sealing bars.

Figure 8a: In-line Hot-tack determination



To simulate in-line hot-tack through contamination, a liquid has been added, using the liquid spraying system, while filling the bags with a load of 0.5 kg LDPE pellets. To get an idea of the impact on Hot-tack performance, the level of peeling of the seals after the filling step was observed and compared with the rupture strength of the clean structure tests. Again, to make the comparison simpler, we have determined the minimum conditions at which the bags do not show any hot tack deformation and estimated the difference in machine speed of the studied barrier structures.

Figure 8b: No deformation of the sealing area



Figure 8c: Strong deformation of the sealing area



RESULTS AND DISCUSSION

Laboratory Evaluation

Comparison of monolayer films- m-Plastomer 1 vs Ionomers (structures 17-19): The results from the seal strength measurements through contamination of monolayer film containing m-Plastomer 1 and Ionomer are presented in Figures 9 and 10. Plastomer 1 shows no change in SIT under meat juice or tomato ketchup, while the Zinc Ionomer shows a good behavior with tomato ketchup, but a strong deterioration in SIT under meat juice. Sodium Ionomer performed even worse with both contaminants. Regarding the plateau seal force change with contamination, Plastomer 1 shows a decrease of 15% and 30% with ketchup and meat juice, while both Ionomers show a significant reduction (of up to almost 90%) with both contaminants.

Figure 9: SIT through contamination for monolayer film m-Plastomer 1 vs Ionomers

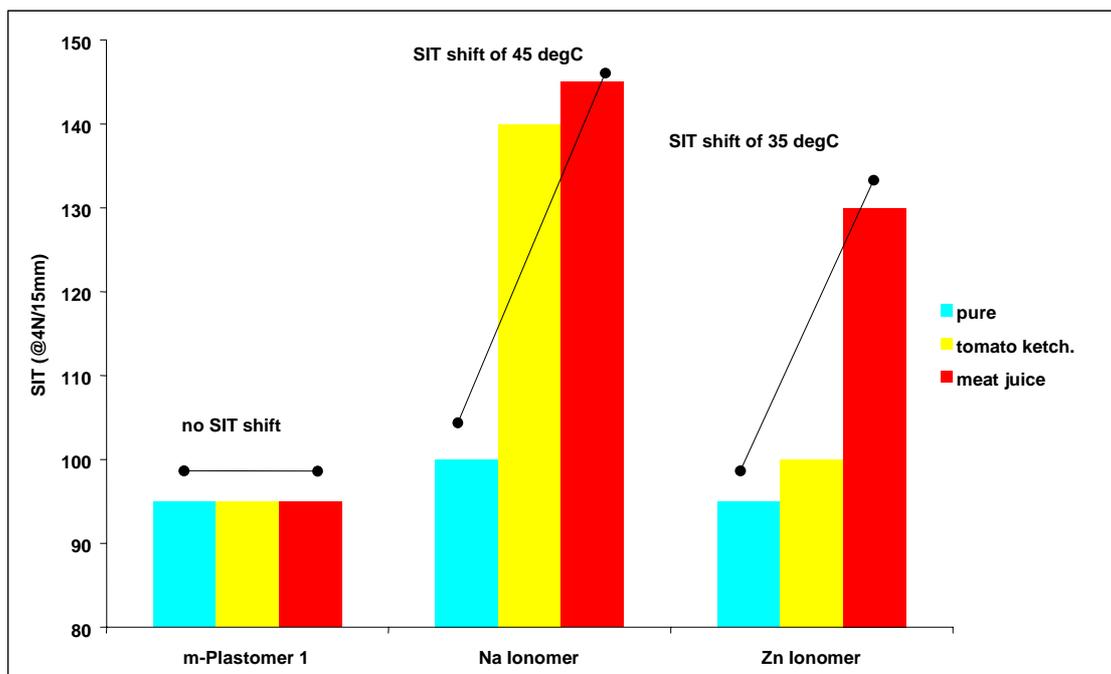
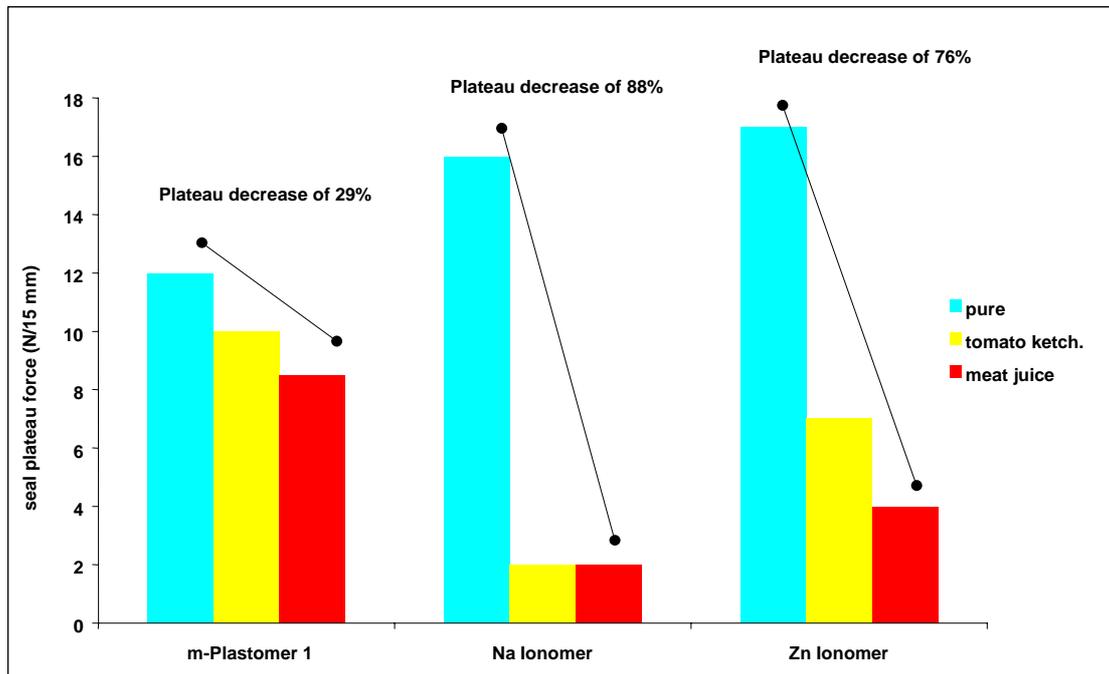


Figure 10: Plateau seal strength through contamination – monolayer film m-Plastomer 1 vs Ionomer



From these results we can conclude that while Zinc Ionomer performs better than Sodium Ionomer, it is clear that m-Plastomer 1 outperforms both types of Ionomer, for sealing through meat juice and tomato ketchup.

Comparison of coex film m-Plastomer 1 vs Na Ionomer 1 (samples 15-16): The results from the seal strength measurements through contamination of coex films containing m-Plastomer 1 and Ionomer 1 are presented in Figures 11 and 12. While the m-Plastomer 1 shows essentially no SIT shift with contamination, the Na Ionomer 1 shows, as with the monolayer structure, a shift in SIT of about 40°C with ketchup and meat juice. Olive oil has no influence on the SIT of any of these structures. We also get a confirmation of the monolayer film data; with a maximum decrease in m-Plastomer 1 plateau seal strength of about 30% with meat juice and ketchup, while the decrease in Ionomer 1 plateau seal force is about 60%. Additionally, the Ionomer shows a “peeling behavior” over the whole tested temperature range. Olive oil does not influence the plateau seal strength of m-Plastomer 1 or Ionomer, but causes a “peeling behavior” at temperatures below 120°C. Note that in this example, we can not directly compare the absolute plateau seal strength values of m-Plastomer 1 and Ionomer 1, as the structures are not equivalent (see Table 1). The shift in plateau seal strength is, however, indicative of performance in use and shows that the plastomer seals are much less affected by contaminants than the ionomer seals.

Seal through contamination laboratory tests for the laminated structures (samples 11 and 13): In Figures 13a-b and 14a-b, the SIT and the plateau seal strength of the tested laminated films are summarized. In all cases, the SIT is the lowest for m-Plastomer 2 compared to Zn Ionomer 2. Starting from the pure non-contaminated seals with a difference of 25°C, this difference becomes larger on sealing through the contaminants. The maximum increase in SIT is about 10°C for m-Plastomer 2 while for the worst contaminants (meat juice and ketchup) an increase of 50°C in SIT is noticed for Zn Ionomer 2. Also the effect of coffee and cheese on the SIT is more pronounced for Zn Ionomer 2 than for the m-Plastomer 2. The plateau seal strength of the two sealant starts at a different level: the m-Plastomer 2 shows a substantially higher seal strength than the Zn Ionomer 2. The seal strength of the laminates is acceptable with most of the contaminants tested. Only the meat juice reduces the seal strength significantly. The Zn Ionomer 2 shows relatively good seal strength only for the olive oil and mayonnaise contaminants. All the other used foods reduce the seal strength of Zn Ionomer 2 significantly. Summarizing the results one can say that the m-plastomers will seal well through contamination except for the meat juice while the Zn Ionomer results in poor seal for a large number of tested contaminants which were significant different in nature (meat juice, ketchup, cheese, milk-powder and coffee).

Figure 11: SIT through contamination on coex structures

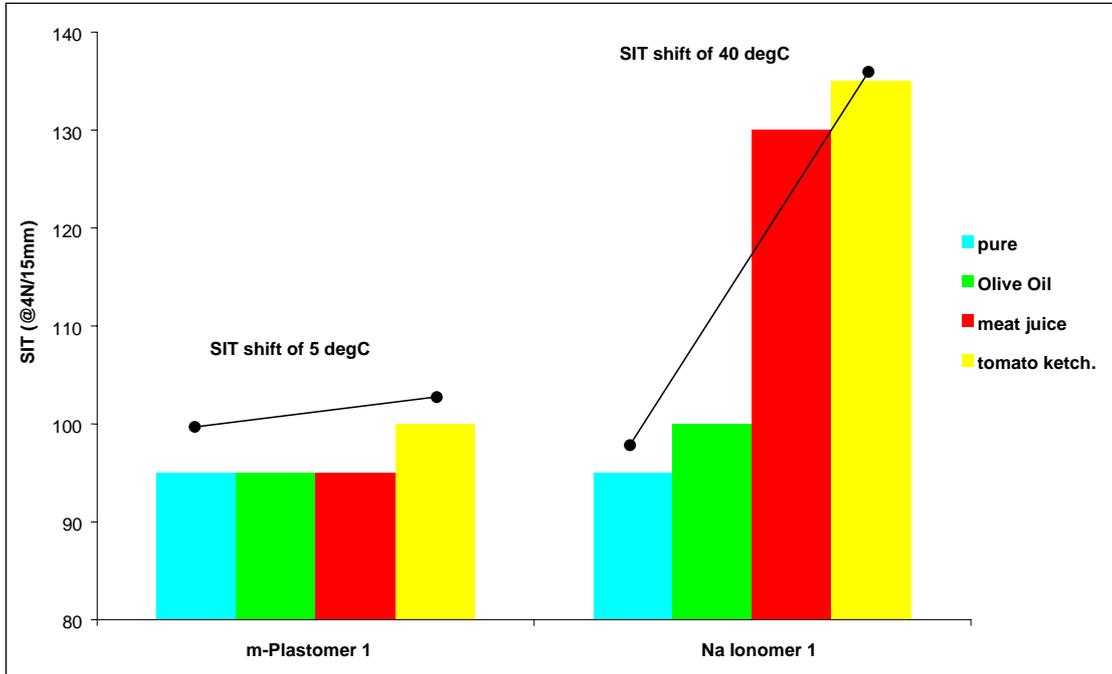


Figure 12: Plateau seal strength through contamination on coex structures

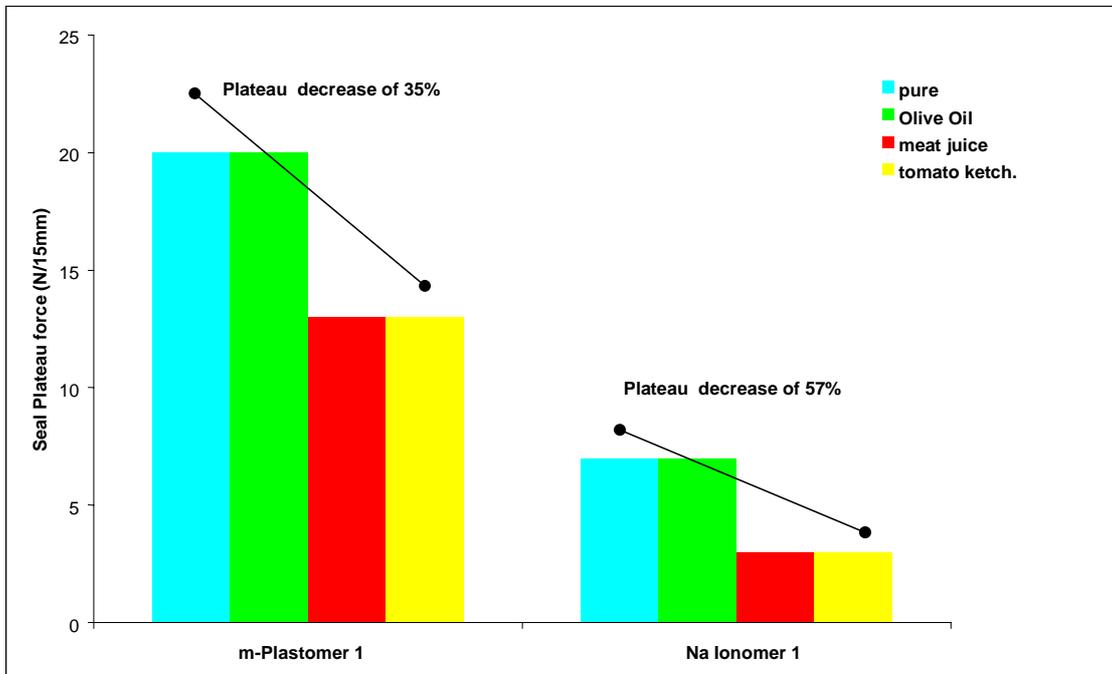


Figure 13a: SIT through (powder) contamination for laminated structures

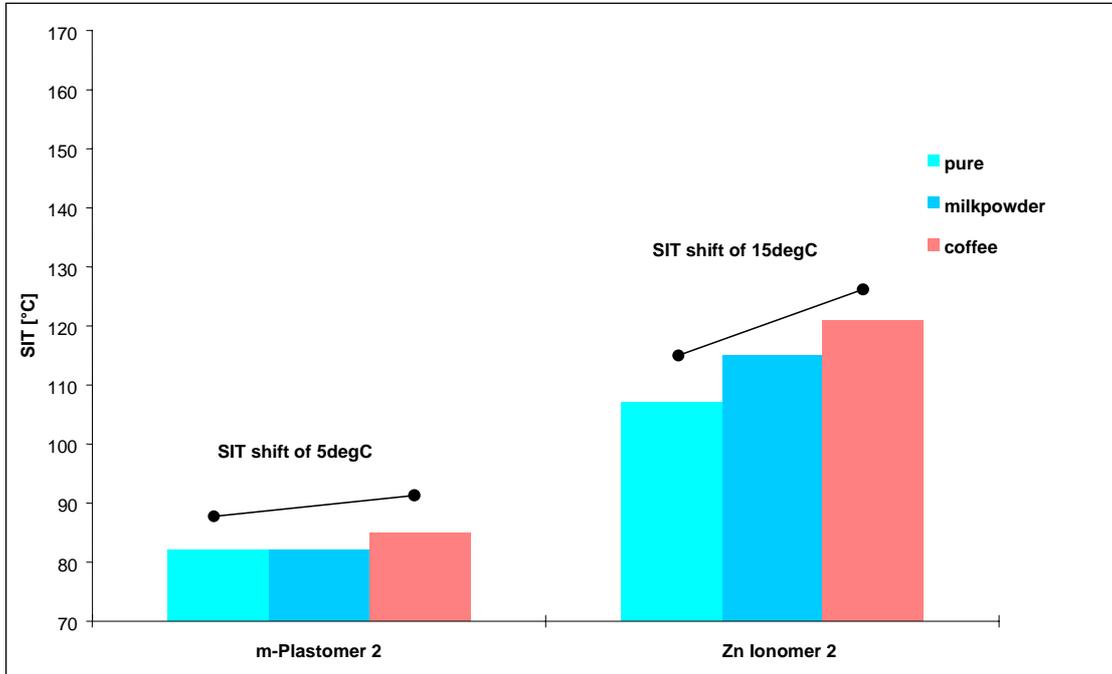


Figure 13b: SIT through (liquid) contamination for laminated structures

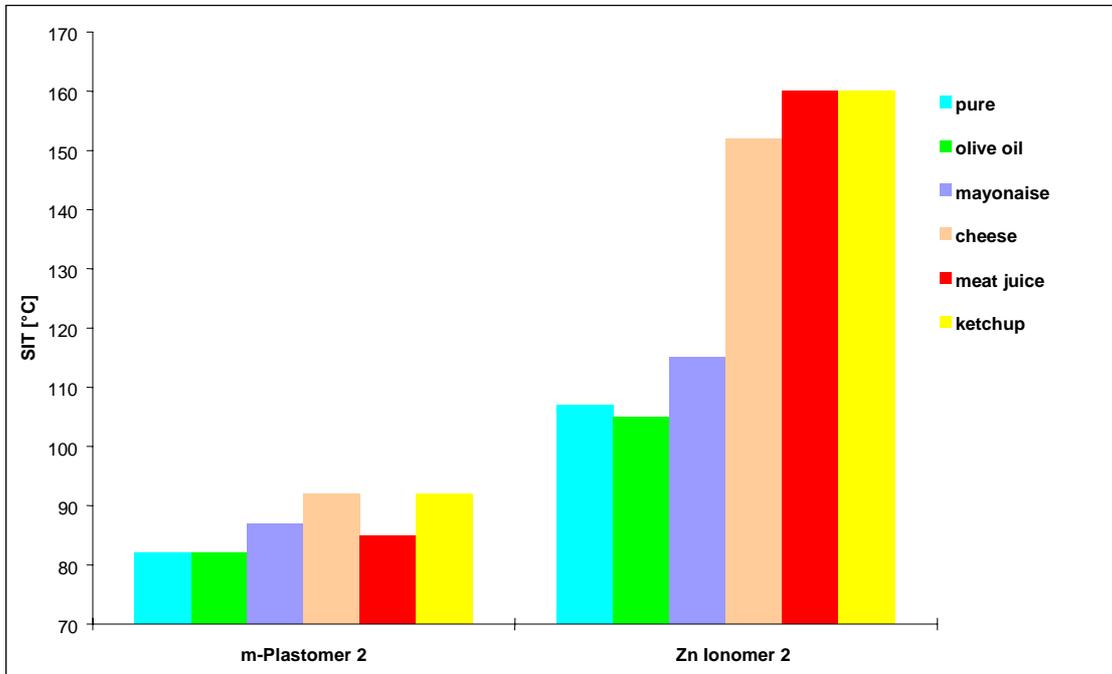


Figure 14a: Plateau seal strength through (powder) contamination for laminated structures

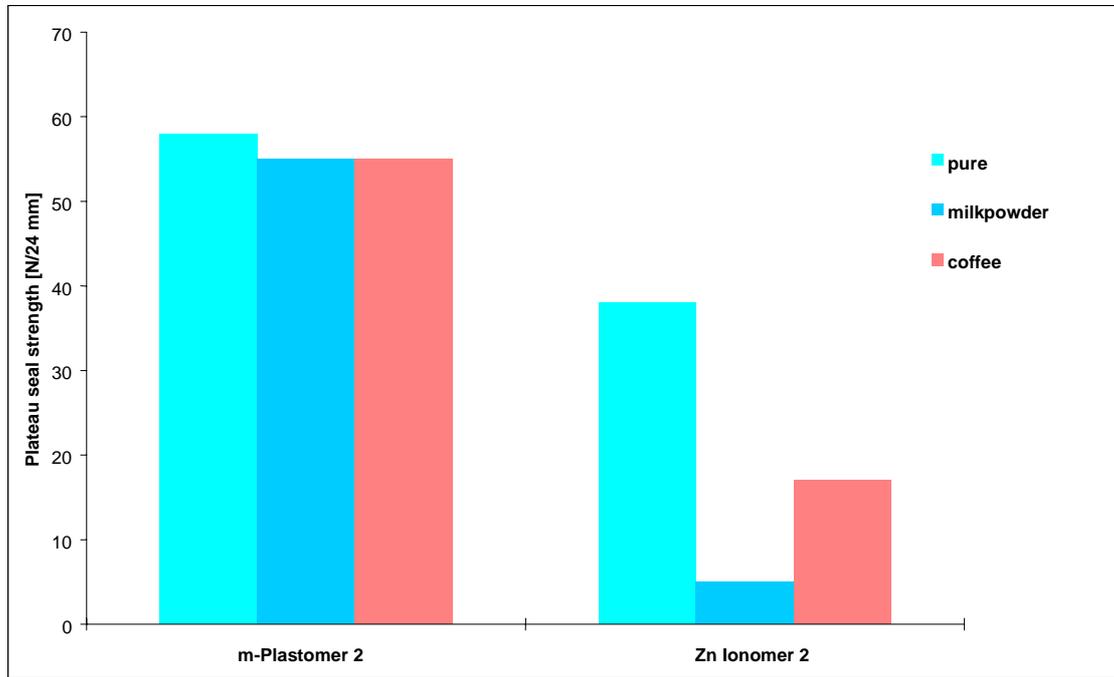
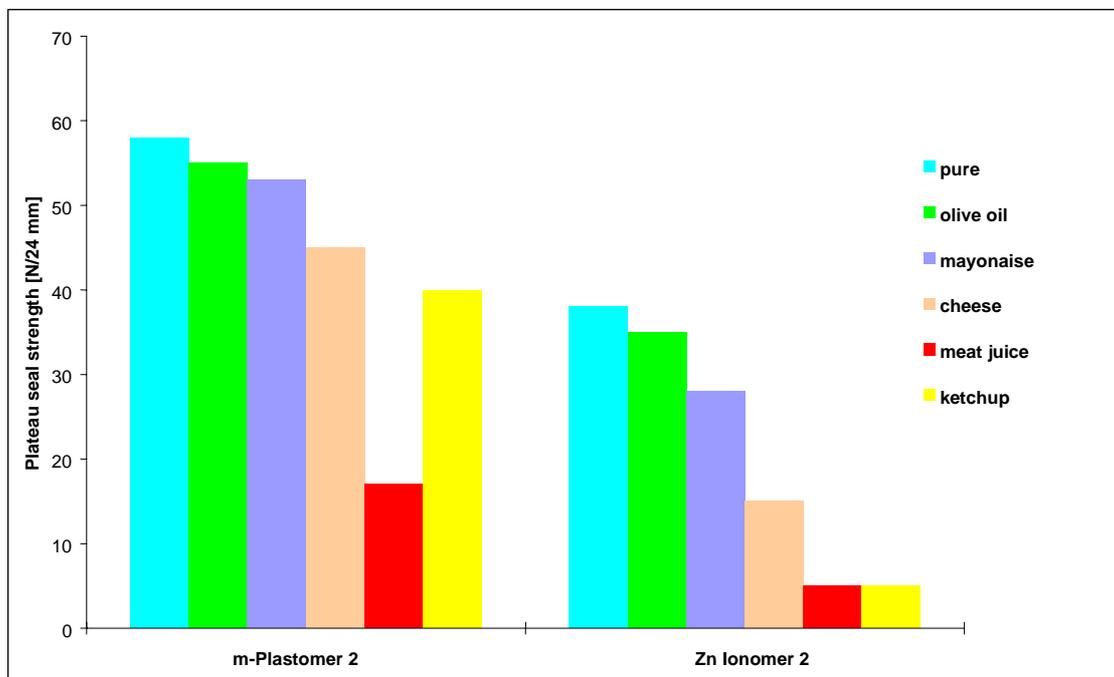
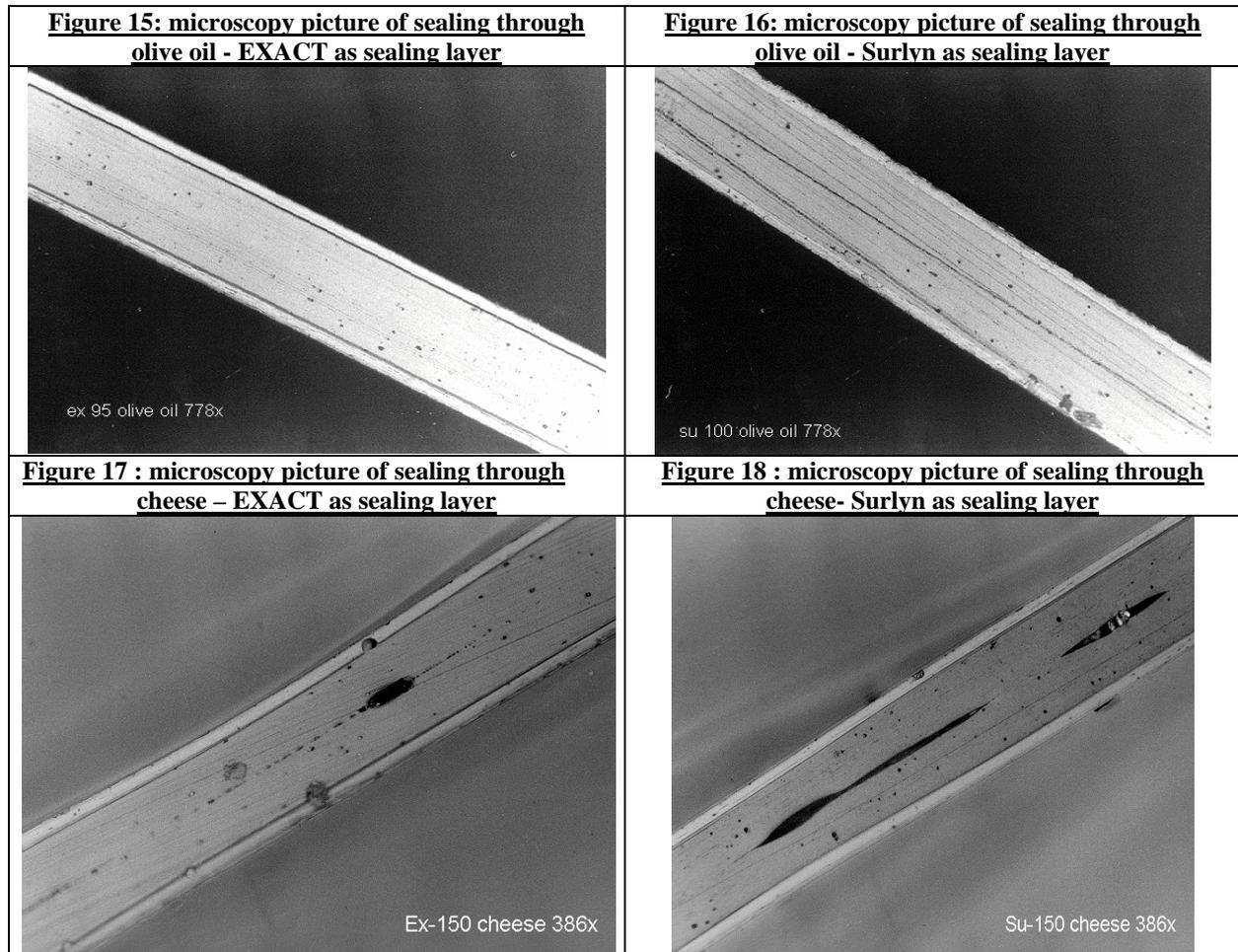


Figure 14b: Plateau seal strength through (liquid) contamination for laminated structures



Microscopic analyses of the contaminated seal area's: To get an idea of the mechanisms which can influence the sealing through contamination behavior of our tested sealing polymers, a microscopic pictures of the cross-cut contaminated seals (for the laminated structures) were taken. As can be seen in Figure 15 (sealing temperature 100°C, olive oil) the evidence of olive oil contamination for the m-Plastomer is practically invisible in the seal that is formed. There is no difference noticeable versus a picture of a clean seal. The crosscut for the olive oil contaminated seal for the Zn Ionomer does not show any significant difference versus a clean seal. The very thin lines (black line on the Figure 16) on the picture are probably related to sample preparation. On sealing through cheese (Figure 17, 150°C) the seal of the m-Plastomer shows a well-wetted cheese particle on the seal surface and a lot of finely dispersed cheese droplets. One can also see that there is a very smooth, almost diffuse transition from sealing polymer to the contamination particle and in between. Some larger cheese droplets can still be observed (one in the case of this picture). The Zn Ionomer seal (Figure 18) shows larger, elongated cheese particles that are much less dispersed than with the m-Plastomer. The transition from the cheese particle to Ionomer, partially sharp and distinct, indicates the poor adhesion.



Summary of Laboratory evaluations: The laboratory results of the seal through contamination which are described above were comparable to earlier published data by M. Simpson et al [4]. For a significant number of contaminants such as cheese, ketchup and milk powder, plastomers clearly outperform ionomers. For other tested contaminants, plastomers provided comparable seal through contamination, but with lower SIT and higher plateau seal strength. The results are similar for monolayer, coex or laminated structures and are summarized in Table 7. The rating is expressed by comparing the relative performance of contaminated versus clean bags. A rating of “++” means a loss of less than 10% of plateau seal strength after contamination, “+” means less than 30%, “-” means a loss of about 50% of initial seal strength, “--” indicates more than 70% loss.

Table 7: Polymer evaluation under seal through various contaminants

	Olive Oil	Coffee	Milk powder	Mayonnaise	Cheese	Tomato ketchup	Meat juice
Plastomer	++	++	++	++	+	+	-
Ionomer	++	-	---	+	--	--	--

The microscopic pictures of the contaminated seal areas show trends consistent with the SIT and plateau seal strength measurements. A good and stable seal is nearly invisible in the microscopic picture (well inter-diffused polymer chains). The best way to cope with contaminants is the dispersion in finer droplets or the good wetting of the contaminant with the sealing polymer (or perfectly sealed regions in between the contaminated seal areas). Bad seals are formed when the contaminant is not well wetted and not dispersed into smaller parts.

VFFS ROVEMA Evaluation -comparison of the Coex barrier structures (samples 1, 2, 5, 6)

In this part of the study, the seal through contamination performance of barrier structures was investigated on a VFFS ROVEMA. To obtain a first estimate of the performance, laboratory testing is done.

Seal strength (laboratory evaluation): As with the previous monolayer and laminated results, it was observed that the m-Plastomer 1 had the best SIT, at least 10°C lower than those of the more conventional structures while the final seal strength was comparable to C8-VLDPE and EVA or higher than Ionomer 1. Table 8 illustrates the differences in Seal Initiation Temperature (at 4N/15mm) and plateau seal force (N/15mm).

Table 8: Laboratory comparison of sealing performance

	m-Plastomer 1	VLDPE	EVA	Na Ionomer 1
SIT (°C @ 4N/15mm)	83	96	98	102
Plateau Seal Strength (N/15mm)	21	19	17	13

Hot-tack (laboratory evaluation): m-Plastomer 1 performs exceptionally well in terms of hot-tack: the maximum hot-tack force is approximately 25N/30mm for a corresponding temperature of about 100°C (Figure 19). A conventional VLDPE still has a reasonable max hot tack force but at a much higher temperature. Ionomer 1 and certainly EVA cannot compete with m-Plastomer 1. Table 9 compares some of the most important parameters needed for evaluating the hot-tack performance of these structures.

Table 9: Laboratory comparison of hot-tack performance

	m-Plastomer 1	VLDPE	EVA	Na Ionomer 1
Max. Hot-Tack force (N/30 mm)	26	19.5	4	16
Max. Hot-Tack temp (°C)	99	120	100	102
Hot-Tack window at 10N/30 mm	48	35	0	31
Hot-Tack window at 20N/30 mm	25	0	0	0

VFFS machine evaluation: Figure 20 shows a comparison of the packaging line speed that can be reached with the different structures evaluated, for empty bags, as a function of the sealing temperature. The m-Plastomer 1 was already performing at 80% of the machine capacity at 100°C sealing time, and outperformed conventional polymers at 110°C. Ionomer 1 started sealing properly only above 120°C. The effect of the different tested contaminants on rupture strength is reported on Figure 21 for average conditions of 120°C sealing temperature and 250msec sealing time. The m-Plastomer 1 is the most consistent over the different contaminants used, with a maximum decrease of 10% in rupture strength at these conditions. The VLDPE is also good, except with milk, when it does not seal at all. The EVA shows a decrease of 20-30% in rupture strength with nearly all the contaminants, nevertheless the packages are still strong enough because the rupture test shows a clear structure break. Again with milk this sealing material showed its weakest performance and the seal peeled. Also Na Ionomer 1 shows its weakness, with a decrease of ± 40% in rupture strength when sealing through tomato juice, and no sealing at all through milk, most likely because the ionomer chemically reacts with the calcium contained in the milk.

To evaluate the impact of sealing conditions on the sealing through milk results, some tests were done at 500msec seal time and up to 130°C sealing temperature. It was still impossible to seal with Ionomer, while the sealing with VLDPE was still weak and peelable. These results are comparable with the laboratory evaluation, where Ionomer was judged defensive versus the m-Plastomer for seal through tomato ketchup and milk powder contamination, and equivalent through olive oil.

Figure 19: Laboratory comparison of hot-tack performance

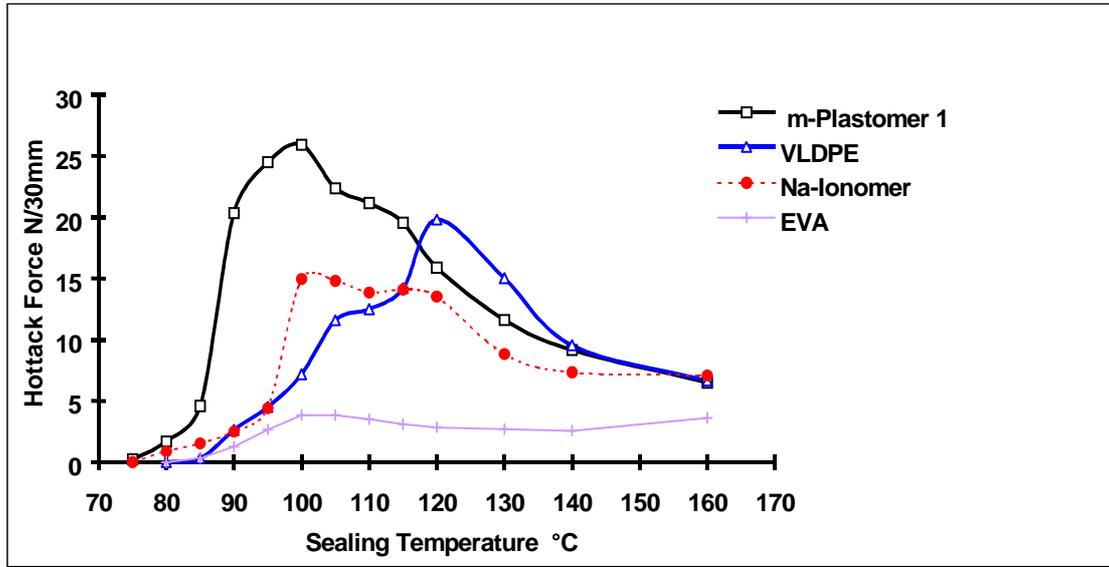


Figure 20: VFFS machine best performance - empty bags

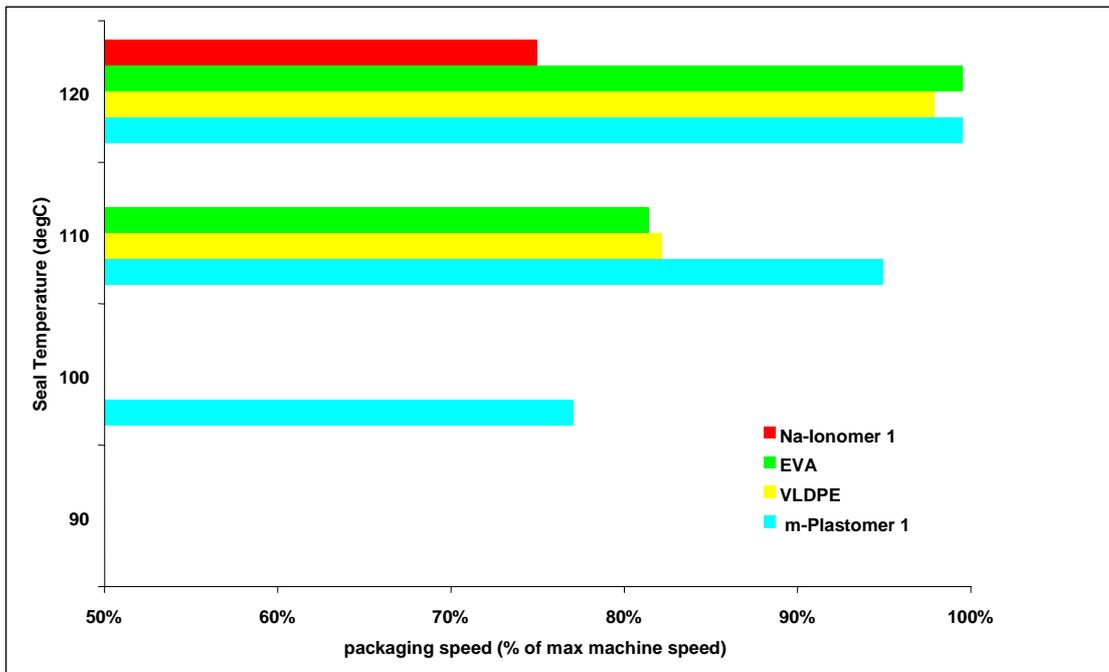
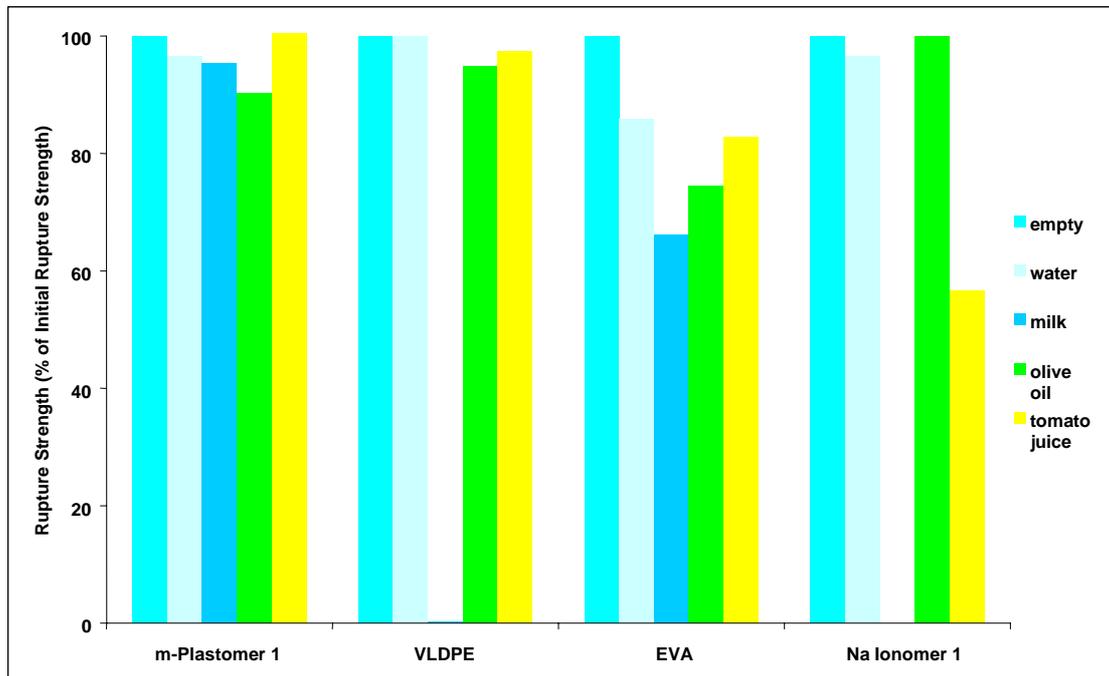


Figure 21: VFFS evaluation – rupture strength comparison



In-line Hot-tack through contamination tests results: In-line hot-tack has been evaluated using bags filled with dry pellets. In-line hot tack through contamination has been evaluated by addition of milk, to make it simpler, and because milk gave the largest shift in rupture strength. Data is reported in terms of VFFS packaging speed in Figures 22 and 23. The m-Plastomer 1 gave the best hot-tack performance both with and without contamination. Compared to the VLDPE, the m-Plastomer would permit operation at lower sealing temperatures and/or faster line speeds. The structure with EVA as sealing layer gave poor in-line hot-tack at all tested temperatures and time settings even in the absence of contaminant. The hot-tack performance of Ionomer 1 was worse than the VLDPE and the m-Plastomer in this temperature range. At 120°C, there was a 20% reduction in VFFS speed performance, when using Ionomer 1 versus m-Plastomer 1. Most likely, Ionomer would have to be sealed at a higher temperature to get better rupture strength as well as better in-line hot-tack. In conclusion, it is remarkable that the laboratory hot-tack evaluation (Figure 19) of these structures is so similar to the findings of the Rovema hot-tack testing.

SUMMARY AND CONCLUSIONS

A quantitative study has been performed on the seal-through-contamination performance of metallocene plastomers versus several other conventional sealing polymers.

The results of standard laboratory sealing tests confirm the basic sealing characteristics of plastomers such as low seal initiation temperatures, high hot-tack and seal strengths over a broad temperature window. Furthermore, the results of seal-through-contamination tests supported by microscopy analysis and line-speed evaluation on vertical form-fill-seal equipment demonstrate that plastomers outperform conventional sealing polymers, particularly at low sealing temperatures. When sealing through contaminants such as ground coffee, milk, ketchup and olive oil, the loss in sealing performance for plastomers are insignificant in comparison with the drastic loss in seal performance for ionomers and other conventional sealing polymers. Even for meat juice contamination, plastomers provided superior seal strength and less deterioration in performance when the seal is contaminated.

The results suggests that metallocene catalyzed plastomers provide the designer of state-of-the-art flexible packaging structures, a valuable design tool to meet the ever increasing demand for cost-effective improvements in packaging speed and durable packaging integrity.

Figure 22: VFFS machine best performance - bags filled in with 500g dry pellets

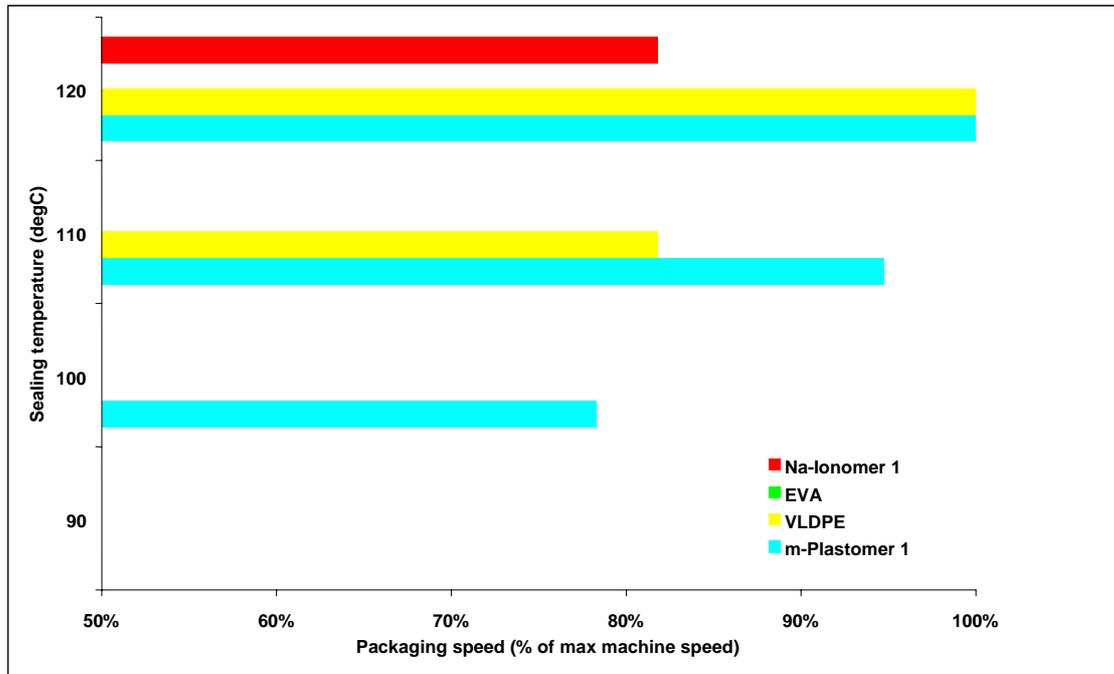
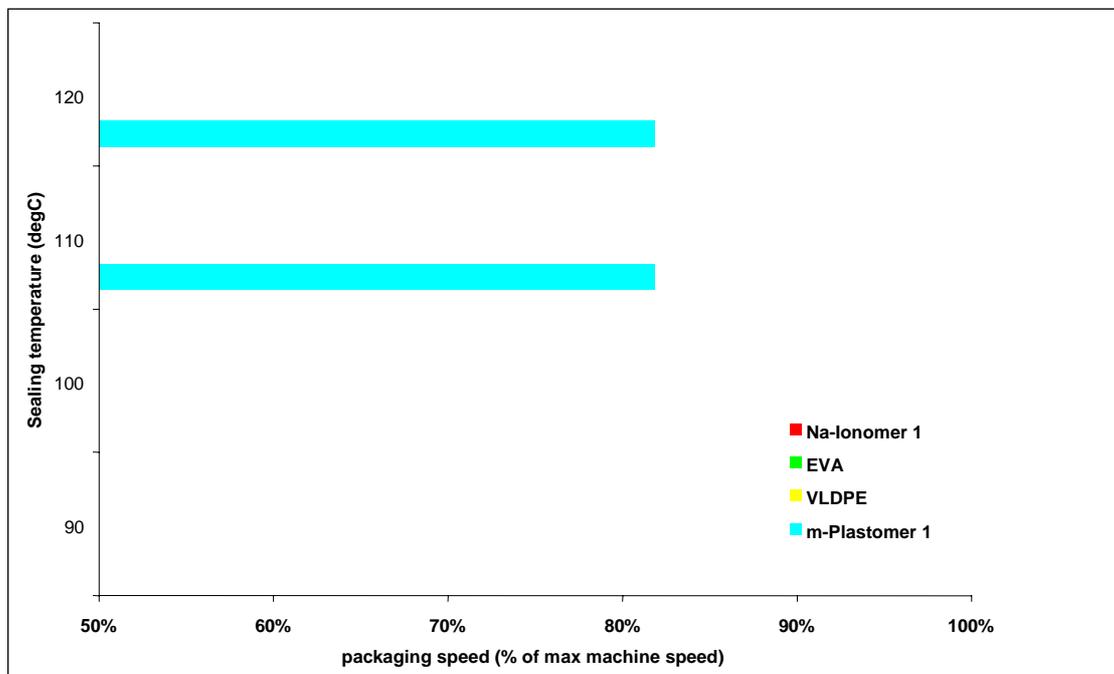


Figure 23: VFFS machine best performance - bags filled in with 500g milk contaminated pellets



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