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COORDINATING PSA AND LINER SELECTION FOR OPTIMIZATION OF RELEASE PERFORMANCE

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Since 2011, Kara Smith has been a Technical Service Scientist in Henkel's Pressure Sensitive Adhesives group, helping to support tapes, labels, and graphics customers with a variety of pressure sensitive technologies. Kara received her Ph.D. in Chemical Engineering from the University of Illinois at Urbana Champaign and her BS in Polymer Science and Engineering from Case Western Reserve University.

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Abstract

Rubber-based hot melt pressure sensitive adhesives (HMPSAs) are used in a wide array of tape and label applications. As with all PSAs, an HMPSA's rheological features directly impact not only processing conditions and end-use properties but also the release behavior on siliconized liner. It is therefore critical to consider the combined performance of release liner and HMPSA when selecting materials for a new pressure sensitive construction. In this paper we have characterized release behavior of a variety of HMPSA/liner combinations in order to enhance material selection capabilities.

Introduction

Multiple factors influence the choice of adhesive and release liner when designing a pressure sensitive construction. First and foremost are the performance requirements, including temperature, bond strength, application surface, and product longevity. Coating and converting processes must also be considered, as well as any application or treatment procedures utilized by the end user. Finally, the material characteristics of both adhesive and liner components must be compatible with one another. Collectively, these factors ensure that the construction will meet the end user's performance and dispensing requirements.

In 2012, P. Walter et al investigated how the formulation of a hot melt pressure sensitive adhesive (HMPSA) influences release performance [1]. HMPSAs generally consist of rubber elastomers, tackifying resins, antioxidants, and process (plasticizing) oils. Components are varied by percentage and type to meet end user coating, converting, and application requirements. Such formula variation will influence how the adhesive releases from the silicone liner; it was the goal of this prior study to examine the contributions of both adhesive rheology and chemistry on release performance. A series of commercially available HMPSAs were chosen to represent a range of viscoelastic properties and chemical compositions, while the siliconized release liner chemistry was held constant. High-speed release data gathered on this sample set suggested a strong inverse correlation between release force and adhesive loss modulus (G''), while the adhesives' elastomer and/or tackifier chemistry appeared not to impact release performance.

The objective of the current paper is to expand upon previous work by examining release performance over a broader array of liners as a function of adhesive loss modulus. We have included release liners with a variety of surface energies and have deliberately chosen HMPSAs at both the high and low G'' extremes ("hard" and "soft" respectively) in order to capture the widest range of release performance. We have also investigated adhesive coating weight as an additional variable potentially affecting release force.

Experimental Setup

Release Liners

In the 2012 study, a single UV cured silicone release formulation was used to evaluate release performance of HMPSAs. All factors relating to the silicone were held as constant as possible to isolate the influence of adhesive. Silicone was coated at 1 lb/ 3000 ft^2 ream. In the current study, we utilized a series of commercially-available 100% solids Pt-cured silicone liners with different amounts of controlled release additive to vary the surface energy. Four release liners were used in total, which we refer to here as Liners 1-4 in order of increasing additive amount/decreasing surface energy.

Hot Melt PSAs

In the previous study, ten different HMPSAs were coated to the prepared single formula release liner at 0.8 mil coating weight using a ChemInstruments H-100 lab coater. The facestock was 20 # DP bond, data processing grade paper laminated in line. The ten hotmelt PSAs, along with their recommended end-use applications, are listed in Table 1 in order of increasing G″ at 25°C. The relative G″ values of each grade are visualized in Figure 1, which shows the overlaid rheology temperature sweep data for all adhesives (Rheometrics RDAIII) with the respective ordering plot from A-J.

Table 1. HMPSAs from 2012 study

ADHESIVE	APPLICATION
A	low temp, milk jug
B	low temp, logisitics labels
C	general purpose, tyvek
D	general purpose
E	general purpose
F	general purpose
G	high temp, instructional labels, tapes
H	general purpose paper and film label
I	laser labels
J	high temp, instructional labels, tapes

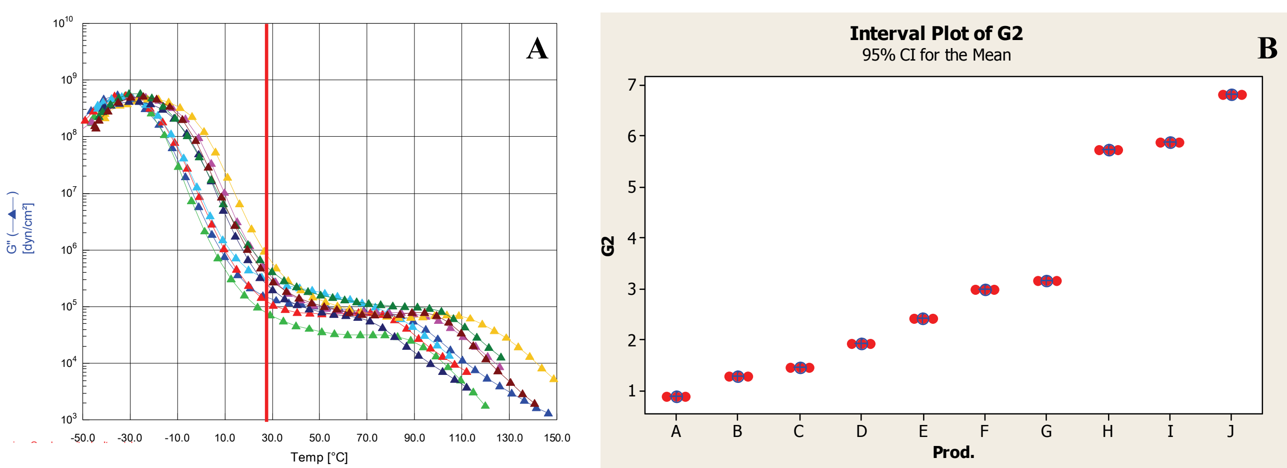


Figure 1. (a) Rheology temperature sweep overlay of ten adhesives from prior work; (b) Ordering plot based on rheology results

In our more recent work, we explored varying the release liner formulation as well as adhesive thickness). Four adhesives were selected, three with high G″ values and one with a low G″ value. The low G″ adhesive is a very soft freezer-grade label product designed to wet out in cold and/or moist environments. All three higher G″ PSAs have significantly better cohesive strength and are designed for a variety of tape applications; their G″ values at 25°C are greater than or equal to adhesive J from Figure 1. Figure 2 displays a rheology overlay of the low G″ PSA ("K") and a representative from the higher-G″sample set ("M"). All grades were coated to liners 1-4 at both 1 and 2 mil coating weights using a ChemInstruments H-100 lab coater. Two mil Mylar facestock was laminated to the adhesives in line.

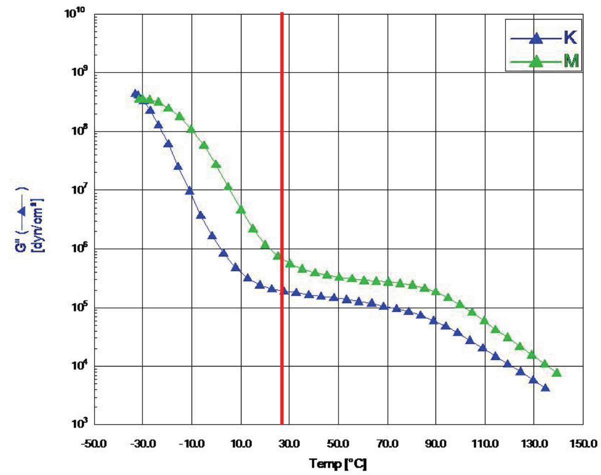


Figure 2. Rheology temperature sweep overlay of freezer grade HMPSA (K) and a high-strength tape HMPSA (M)

Release Testing
All release testing was done using a IMASS ZPE 1100W high/variable speed release tester. Coated samples were tested using a ramped velocity of 0-2 m/s with a reference release force read at 1200 ipm (0.508 m/s). A ramped speed profile provides a dynamic response characteristic indicative of dispensing performance. An example of the charted data appears in Figure 3.

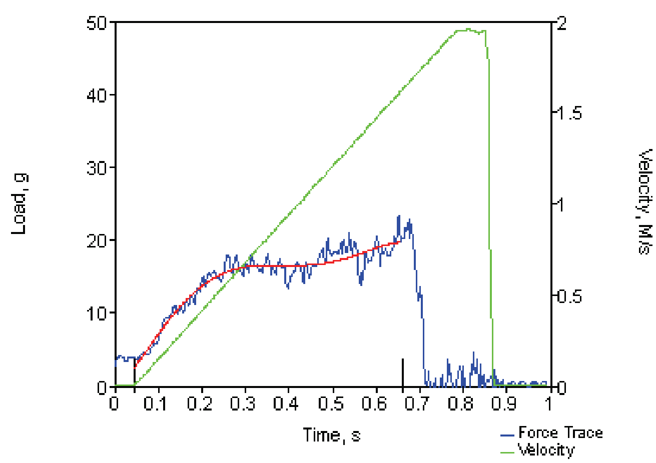
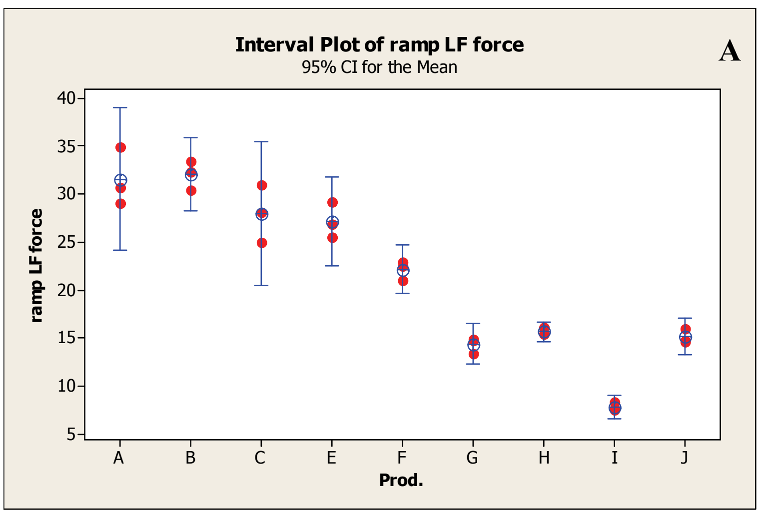


Figure 3. Typical ramped speed released profile

Results and Discussion

PSA Characteristics Affecting Release Performance

Figure 4 summarizes the findings from the 2012 study. Release force values (grams force) at a speed of 1200 inches per minute (0.508 m/s) are displayed for each of the ten adhesives. The red dots indicate measured values, blue dots average values, and the blue bars the 95 % confidence interval. This data indicates a significant inverse correlation of G″ and release force; stiffer adhesives (higher G″ values) release more easily than lower modulus adhesives. Samples A, B, and C are all lower shear strength adhesives designed for lower temperature label applications and exhibit more flow characteristics to wet out at lower temperatures. On the other extreme, samples I and J are targeted at higher temperature tape and label applications and thus must exhibit higher rigidity at room temperature. It should be noted that no correlation was observed between the adhesives' tackifier or rubber chemistry and release response. Furthermore, relative adhesive component levels, rubber molecular weight, and styrenic content were not inherently linked to release performance trends beyond their impact on a given formula's rheology. The findings of this study have already been used to optimize a specific HMPSA formula with high release force; loss modulus at room temperature was slightly increased without significant impact on end-use performance.



B

	Rubber	Tackifier
A	SIS/SBS	Hydrocarbon/ Rosin Ester
B	SIS	Rosin Ester/ Hydrocarbon
C	SIS	Rosin Ester
D		Hydrocarbon
E	SBS	Rosin Ester
F	SBS	Rosin Ester/ Hydrocarbon
G	SIS	Hydrocarbon/Rosin Ester
H	SIS	Hydrocarbon/ Rosin Ester
I	SIS	Hydrocarbon/ Terpene
J	SIS	Hydrocarbon/ Rosin Ester

Figure 4. (a) Release force at 0.508 m/s for the ten HMPSAs in the previous study; (b) compositional summary of the selected HMPSAs

Impact of PSA G″ on Different Liner Types

In the current study, recall that liners 1-4 represent increasing "tightness" (or decreasing surface energy) based on release coating formulation. We would expect to see a corresponding increase in responding PSA release force over this range of liners. Understanding how a given HMPSA's loss modulus impacts this differentiation in release properties could be useful in release liner selection and the overall design of the finished tape or label construction.

In Figure 5, the release force (grams) at 0.508 m/s for liners 1-4 is plotted for adhesives M and K at both (a) 1 mil and (b) 2 mil coating weight. Red/black solid data points are mean values, blue points are individual values, and the blue bars represent 95% confidence intervals. Adhesive M represents the "higher G″" sample set; the other two grades in this set have remarkably similar release response and were eliminated from this display for the sake of clarity. As expected, the release force of both M and K increases over liners 1-4 at both coating weights. However, this increase occurs to a much higher degree in the low G″ adhesive than the stiffer product. At 1 mil coating weight, adhesive K increases from approximately 13 to 55 gf (315%) from liner 1 to liner 4, while adhesive M only shows an increase from 11 to 18 gf (64%). At 2 mil coating weight, these differences between liners are even more significant, approximately 20-135 gf (560%) for adhesive K and 15-27 gf (80%) for adhesive M. The softer HMPSA (K) is clearly more sensitive to release liner tightness and tends towards very high initiation peaks on the tighter release liners. Another interpretation here is that release response differentiation between low and high G″ HMPSAs increases with liner tightness.

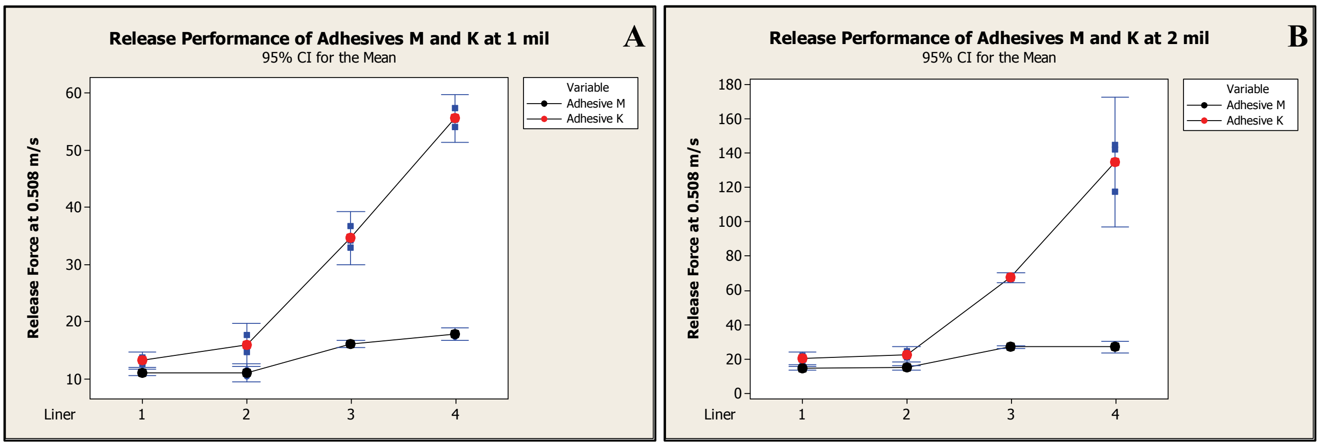


Figure 5. Release performance of adhesives M and K on liners 1-4 at 1 mil (a) and 2 mil (b)

To isolate the effects of HMPSA coating weight, the release performance data from Figure 5 was grouped by adhesive grade (Figure 6). Both Adhesive M and K show higher release force at 2 mil coating weight on all four release liners. This difference between 1 and 2 mil adhesive response increases with liner tightness and once again is more significant in the softer, lower G″ adhesive (K). On liner 4, adhesive M has about 50 % higher release at 2 mil compared to 1 mil (18 gf to 27 gf), while Adhesive K is about 140% higher (55 gf to 135 gf). These results further confirm that softer, lower G″ HMPSAs trend towards more easily-manipulated release behavior than their stiffer HMPSA counterparts.

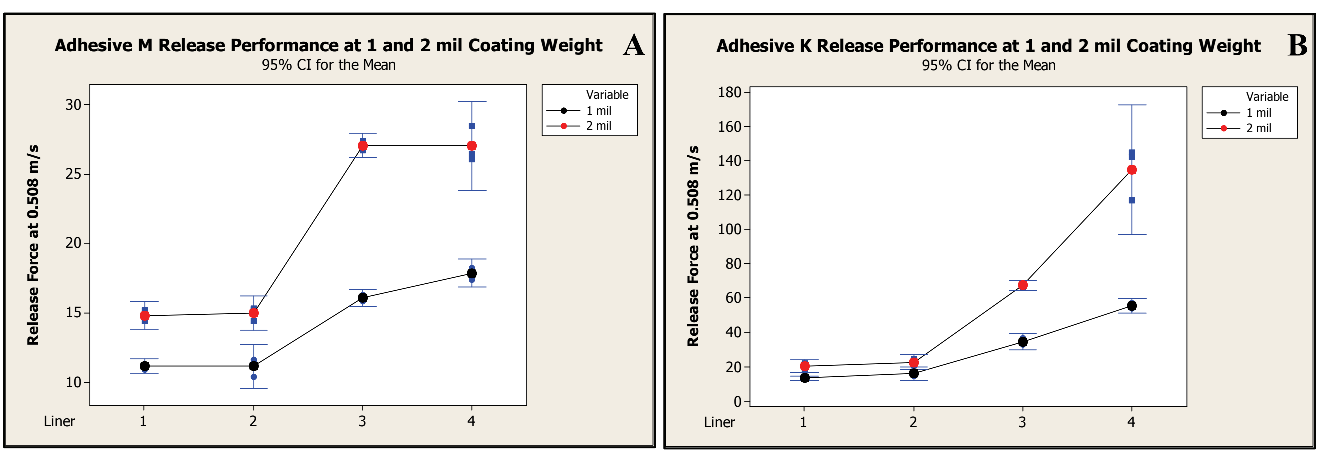


Figure 5. Release performance of (a) Adhesive M and (b) Adhesive K at 1 and 2 mil coating weight on liners 1-4

Conclusions

The loss modulus (G″) of HMPSAs is a critical parameter that impacts high-speed release performance and should be considered when designing pressure sensitive tapes and labels. The degree of this impact, however, is notably higher in softer adhesives. For stiffer, higher G″ HMPSAs- which are geared towards tape constructions- greater liner surface energy variation is needed in order to affect perceived changes in release characteristics. Thus, particular care must be taken in selecting conjunctive high-G″ HMPSA/liner combinations to achieve target release performance.

References

[1] I Brase, P. Walter, and A. Bhongir. "*How hot-melt PSA formulae influence silicone-release performance in labeling.*" Converting Quartertly, 2013 Q3, p. 36-41.

Acknowledgments

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