THE RELEASE COAT SYSTEM

Release coatings are an integral, indispensable tape construction component. All self-wound pressure sensitive tapes require some sort of release mechanism. My many years' experience in the tape industry has led me to believe that an increased emphasis on the total release coat system would benefit many practitioners. Tape products can suffer from the following release related problems:

- Inconsistent, unreliable, unwind performance
- High processing, product waste
- Excessive release coating material costs
- Over engineered, "too easy" unwind tape products

Inconsistent unwind performance is common; high unwind, low unwind and my favorite, no unwind situations can and do happen. When release coatings are outside of targeted specification ranges, costs go up, material waste increases, tape jumbos freeze and finished product is rejected due to quality issues.

Of course, companies react when these problems manifest. Commonly, management resorts to "too easy release". Then of course, customers and marketing personnel complain. Sometimes, the technician answers back, "that's the nature of the Beast". Well, it does not need to be this way, if one understands the complete RELEASE COAT SYSTEM.

RELEASE COAT SYSTEM COMPONENTS

RELEASE COAT SYSTEM components are:

1. Release coat chemistry:
   a. Chemical - molecular structure
   b. Melt point value and melt point range
   c. Film - forming temperature (glass transition temperature)
   d. Anchorage mechanism and relative anchorage capabilities
   e. Solubility (cloud point) with various solvents, solids and temperatures

2. Processing equipment constraints:
   a. Release coat applying equipment type
   b. Oven drying capabilities
   c. Recirculation equipment
   d. Release coating detection abilities
   e. Tension control

3. Tape construction materials:
   a. Tape backing (film type)
   b. Adhesive Type
      1. Hot Melt
      2. Acrylates
      3. Natural rubber

4. Tape performance requirements:
   a. Temperature range requirements
   b. Chemical resistance targets
   c. FDA requirements

5. Cost constraints:
   a. Material costs
   b. Coating weights
   c. Processing speeds

PROPERTIES OF RELEASE COAT MATERIALS

This presentation will examine CHEMISTRY / PHYSICAL properties of the release coat materials. Specifically, I will delve into the key characteristics of CARBAMATE type release coatings. Carbamate release coatings are commonly employed on film-backed tapes. The largest use being the ubiquitous OPP-HM carton sealing tapes.

Carbamates are the result of the combination of polyvinyl alcohol and a long chained isocyanate polymer. These molecules combine forming a rather high molecular weight polymer containing slightly negatively charged OH and COOH groups. [see Fig. 1]

Other major release coatings commonly used are Silicones and Acrylate based. My expertise is not with these release coatings; however I feel certain that the principles of the RELEASE COAT SYSTEM apply as well.

Release molecules have a polar end and a long chain wax-like main body: [see Fig. 2]

The release coat's polar, molecular ends are usually composed of hydroxyl and carboxyl groups. These polar ends provide anchorage and solubility properties.
The remainder of the molecule is a long aliphatic chain, possessing C16, C17 or C18 hydrocarbon chains. It is the long waxy-like aliphatic chain that produces the release properties.

Negatively charged polar groups attach to the charged or polarized tape - film surface. The long waxy ends then horizontally position themselves on the tape surface.
[see Fig. 3]

Ideally, the Carbamate long end chains are positioned side by side forming a perfectly layered molecular film. This long-chained aliphatic hydrocarbon molecular layer produces a very effective release surface.

Now that we understand release coating mechanisms, let's look closely at the chemistry/physical characteristics of Carbamates:

The two combining polymers, polyvinyl alcohol and isocyanate, provide certain processing, performance properties. Polyvinyl alcohols are available in many variations of molecular weight and purity levels. IT is very important to understand that the PVA used will significantly influence the RELEASE SYSTEM. Solubility, melt point, and film-forming temperatures are effected. For example, PVA, with a wide molecular weight distribution will in turn yield a release coating with a wide melt point range. A wide melt point can lead to inconsistent solubility, poor heat resistance, coater transfer problems and uneven film forming experience. The chemist must be aware of the performance altering possibilities attributed to differing polyvinyl alcohols.

Isocyanates provide other interesting properties. The two commonly used isocyanates are octadecyl and stearyl; the differences being the presence of a pure c18 aliphatic hydrocarbon chain (octadecyl) and/or a combination of c16 and c17 molecular chains (stearyl). The resulting release coatings are known as PVODC and PVSC, respectively. This apparently small difference in carbon chain length produces important differences in solubility and film-forming behavior.

A third type of octadecyl Carbamate release coating is available; this is PEI-ODC or polyethyleneimine octadecyl carbamate. The presence of polyethyleneimine versus polyvinyl alcohol produces quite different release characteristics. In summary, the three major carbamate release coat types are:

PVODC - Polyvinyl octadecyl carbamate
PVSC - Polyvinyl stearyl carbamate
PEI-ODC - Polyethyleneimine octadecyl carbamate

Major performance differences are exhibited by these three types. They are:

1. Solubility
2. Melt Point
3. Surface Anchorage Ability
4. Film-forming Temperature

[see Fig. 4]

Solubility:

Completely understanding and controlling solution parameters achieve good solubility. For example, Carbamates seem to be completely and easily soluble in polar solvents such as toluene and xylene. They are less soluble in aliphatic solvents such as heptane and hexane. The easy answer would be to use only toluene. However, toluene is comparatively expensive and a bad environmental health chemical. Frequently, companies must resort to a combination of solvents such as toluene and heptane or toluene and hexane. The aliphatic solvents may solve some regulatory issues, but they present other problems.

Knowing the potential for solubility problems, the chemist must analyze his constraints. First a complete cloud point evaluation is required. Cloud point analysis would demonstrate varying solubility values at different combinations of solvents. Release solids concentration levels also effect cloud points. Cloud points are very much affected by solution temperature. And finally, the release coat solubility will be effected by manufacturer created impurities. Experience has shown that impurities can and do vary by release coating. These factors that affect cloud point must be monitored and controlled during the release coating process. These factors are:

1. Solvent or combination of solvents
2. Release solids concentration percentage
3. Solution temperature
4. Presence of impurities

[see Fig. 5]

Once the solubility/cloud point system has been analyzed and determined, process parameters can be defined and implemented as a comprehensive control system. Temperature control at the coater is crucial. The chemist now knows his temperature targets. Further, a chemist can add additional process controls by incorporating a Release Recirculation System. A recirculation system is really a must.

Additionally, through cloud point analysis, the chemist is now aware of the effects of solids concentration. Incorporating systematic, routine monitoring of composition solids should then be recommended.

Why Is Solubility Control So Important?

When one controls solubility, partial gelation and/or partial crystallization is avoided.

Gelation is a simple term to describe the phasing or settling out of the solid materials. Gelation is easily detected and obvious. Gelation reduces solids, causes uneven coating and will reduce equipment accuracy and effectiveness.

Partial crystallization is a phenomenon that is more difficult to detect; release material appears quite clear and a solids test may not reveal the problem. However, the potential for partial crystallization exists when the cloud point is approached. Partial crystallization significantly effects release-coating performance. To understand this situation, picture the partial crystallization as several release molecules join to form a crystal.

As discussed before, proper film-forming requires individual lay-down of the aliphatic chain: [see Fig. 6]

For these reasons, constant solids control and the elimination of any type of gelation or partial crystallization are a must. By exceeding the cloud point temperature, both gelation and partial crystallization will be avoided.

Melt Point:

Melt point of the incorporated release coating material must be completely understood. Melt point is particularly important when release coating HOT MELT adhesive tapes.

If the melt point is relatively low, release will transfer from the tape backing. The lower the melt point, the more difficult to control coater transfer problems. This can be avoided by insisting on a very tightly controlled melt point and the highest practical melt point.

I have also found that the higher molecular weight Carbamates (higher melt point) are more stable when subjected to chemicals and ambient temperatures. Narrowly defined and controlled melt point materials allow the converter to more closely control the release properties. This is very important when engineers desire to "tighten" the release coating. Also, higher melt point usually means higher molecular weight polymers and better aging performance. Therefore, the chemist, when considering various release coating, should evaluate their differing melt points as it effects the product and coating process.

Anchorage/Adhesive System Relationship

Anchorage is effected by molecular chemistry of the release coating and of the tape backing materials. Anchoring ability and strength, in turn, dictates effectiveness with different adhesive systems.

PVODC and PVSC utilize OH and COOH polar groups to facilitate anchorage to the tape surface. The performance varies according to the polyvinyl alcohol used and the degree of purity.

Polyethyleneimine Carbamates have stronger, more polar ends (NH2) and thus anchorage is increased. This performance characteristic proves effective when releasing against soft high tack adhesive systems. For example:

Hot Melt adhesives which are plastic - like having high cohesiveness - and fairly "hard" surfaces will release easier than natural rubber type adhesive system. PVODC and PVSC release coatings perform quite effectively. This is because Hot Melt adhesives do not strain the release coat anchorage bond to failure. However, these same release coatings fail with some other adhesive systems.

Natural rubber systems, for example, exhibit higher tack, lower cohesive strength and more quick-grab. This type of adhesive requires a relatively better anchored release coat. The chemist understanding this would know that a PEI-ODC type release is more effective on natural rubber adhesive tapes. [see Fig. 7]

Tape Surface:

Better anchorage is facilitated by consideration of the film type. Films such as polypropylene, polyester and polyethylene behave differently when one wishes to release coat. Polypropylene film, for example, requires surface treatment.

In conclusion, anchorage is a function of the release material individual chemistry and the film backing used. Anchorage requirements for optimal performance is related to adhesive type.

Film-Forming Temperature

All release coatings have an ideal FF temperature. Carbamates are no exception. The chemist should fully investigate FF temperature differences before selecting a release coating. Film-forming temperature very closely correlates melt point; but is in fact the actual glass transition temperature. Without achieving the proper film-forming temperature, incomplete and mis-applied release coating will occur. [see Fig. 8]

It is very important to understand this phenomenon. Many companies continually apply release coating at below the FF temperature level without recognizing the ramifications. A study of various RC coat concentrations demonstrates this point. [see Fig. 9]

If according to this analysis, an increase in RC concentration yields little or no improvement, then why have I found people using relatively large amounts of release coat concentrations? The system is not achieving the FF temperature. This may be due to the coating equipment's inability to efficiently reach the proper tape surface temperature. The ovens themselves may not be capable. Poor tension control and/or heat control can contribute to the equipment's inability to reach the appropriate FF temperature. Sometimes, the tape backing material itself is just too heat sensitive.

If a chemist knows the proper FF temperature, then he can detect if good film forming is being achieved. If the FF temperature is not being reached, the chemist will consult the process control experts. Should the equipment be unable to respond, the chemist could select release coat product with a lower FF temperature.

SUMMARY:

A complete understanding of the RELEASE COAT SYSTEM will allow the tape product to be refined. Release, unwind values will be contained. Tape coating and converting will benefit. Consistent unwind products slitter converting efficiency. Web brakes are decreased and productivity is maximized. Jumbo roll waste at the coater and slitter is reduced.

Controlled release coating reduces release material costs. The "overuse" of release can be minimized.

Tight unwind products can be produced; yo-yo tape is not necessary. Customers that prefer other tapes because of unwind can be appeased. The product itself elevates to a higher utility and performance level.

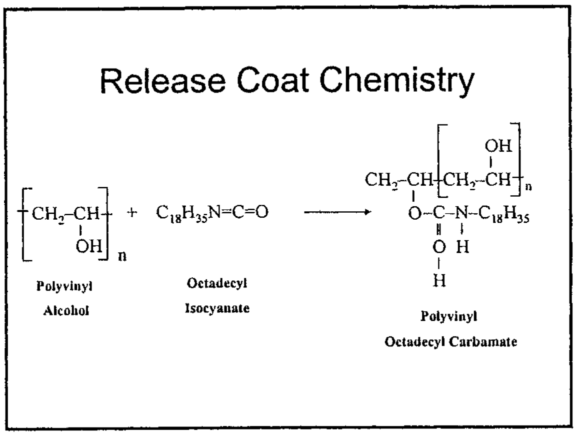
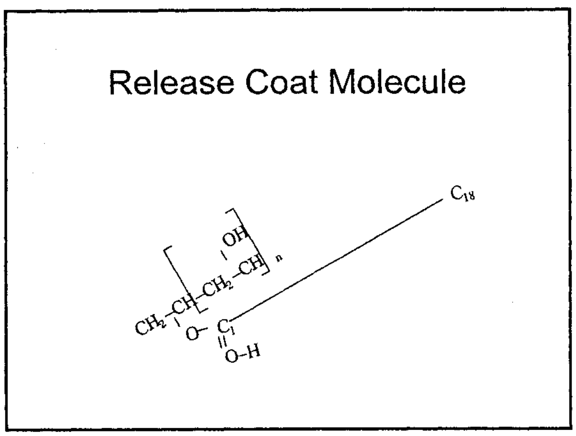


Figure 1



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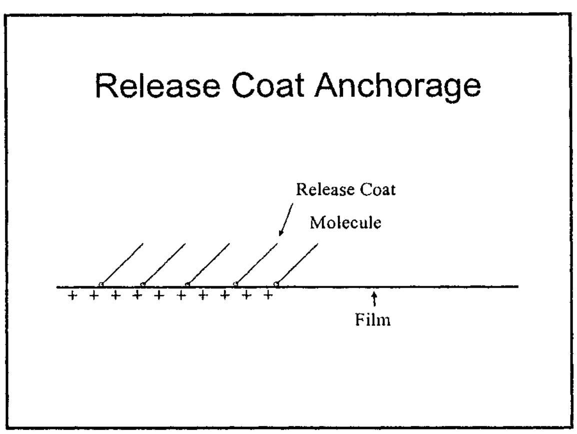

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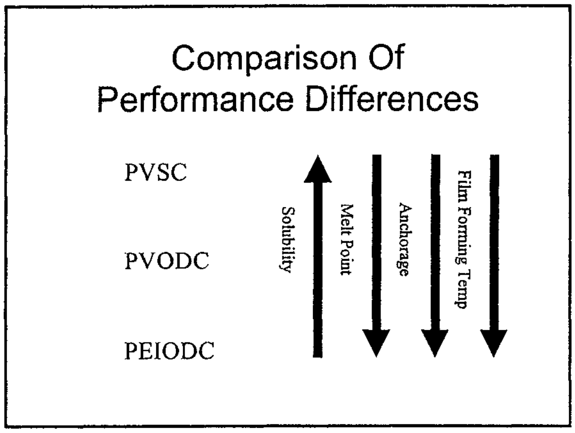

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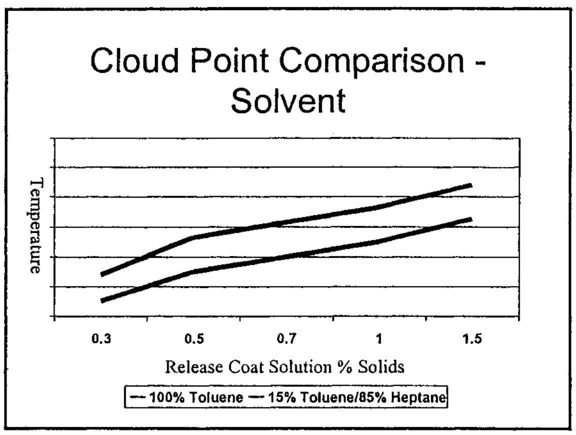

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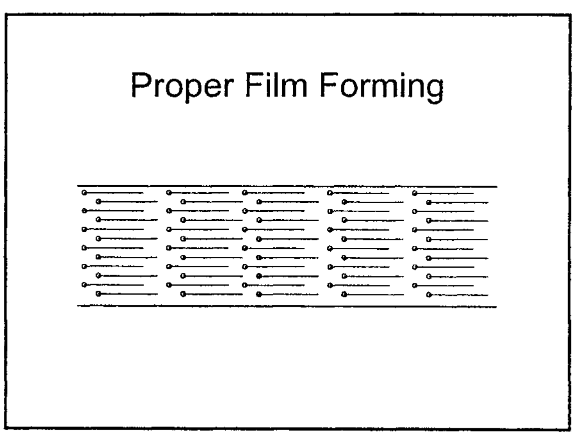

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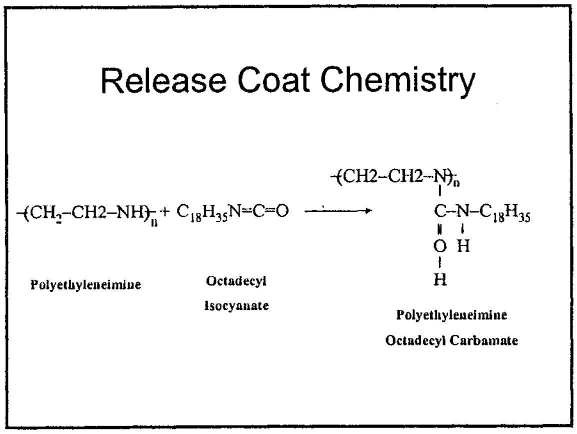

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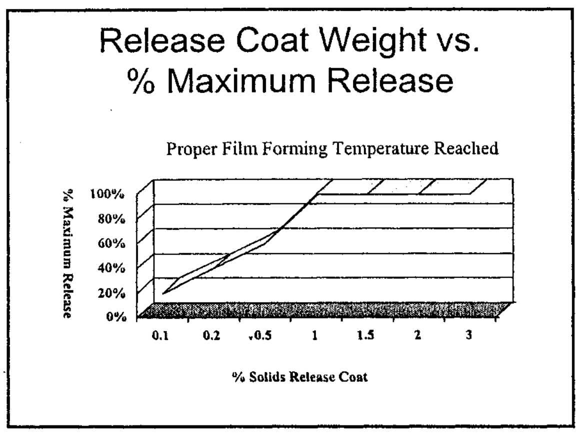

Figure 8

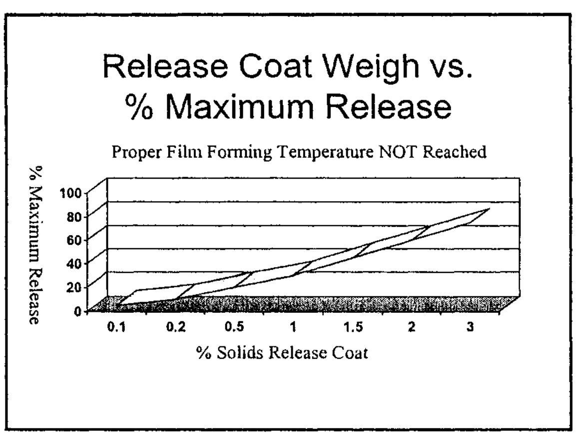

Figure 9