



Western Michigan University
ScholarWorks at WMU

Paper Engineering Senior Theses

Chemical and Paper Engineering

4-1983

Permeability of Silicone Release Coatings

Jeffrey G. Carlsen
Western Michigan University

Follow this and additional works at: <https://scholarworks.wmich.edu/engineer-senior-theses>



Part of the Wood Science and Pulp, Paper Technology Commons

Recommended Citation

Carlsen, Jeffrey G., "Permeability of Silicone Release Coatings" (1983). *Paper Engineering Senior Theses*. 31.

<https://scholarworks.wmich.edu/engineer-senior-theses/31>

This Dissertation/Thesis is brought to you for free and open access by the Chemical and Paper Engineering at ScholarWorks at WMU. It has been accepted for inclusion in Paper Engineering Senior Theses by an authorized administrator of ScholarWorks at WMU. For more information, please contact wmu-scholarworks@wmich.edu.



PERMEABILITY OF
SILICONE RELEASE COATINGS

By
Jeffrey G. Carlsen

A Thesis submitted
in partial fulfillment of
the course requirements for
The Bachelor of Science Degree

Western Michigan University

Kalamazoo, Michigan

April 22, 1983

ABSTRACT

The permeability of silicone release coatings is a function of the silicone polymer, catalyst, coat weight, and film former. Experimental results showed that increasing the amount of silicone and the coat weight of the release coating will decrease the coatings permeability. No difference in permeability was noted by changing silicone polymer or catalyst amount. Using a low molecular weight CMC (as a film former) has ^d no ^e effect on the permeability of the release coating. A high molecular weight CMC will reduce ^d the permeability ^{probably due to} by ^{diffusion of} interference of ~~the~~ dye molecules ^{through the film formed by the high molecular weight} with the large CMC molecules.

^{as of} The adhesive release, measured by 180° peel adhesion test, ~~is~~ is a function of the type and amount of silicone used, viscosity, film formers, and coat weight. Experimental work showed that as the amount of silicone increases; the adhesion of the pressure sensitive adhesive decreases. A film former (low molecular weight CMC), increased coat weight, and increased silicone content will decrease the adhesion of the adhesive. Increasing viscosity with high molecular weight CMC shows a tremendous decrease in the adhesion of the adhesive. Changing the silicone polymer showed no change in the adhesion of the adhesive. The study shows that creation of a tamper proof label is feasible concerning the permeability of the silicone release coating.

TABLE OF CONTENTS

INTRODUCTION	1
KEYWORDS	2
LITERATURE REVIEW	3
Microencapsulation	3
Silicone Release Coatings	6
Pressure Sensitive Adhesives	7
EXPERIMENTAL	12
Experimental Design	12
Experimental Procedure	12
Experimental Testing	13
Analysis of Data	14
CONCLUSIONS	15
APPENDIX A	16
APPENDIX B	17
APPENDIX C	18
APPENDIX D	19
APPENDIX E	20
APPENDIX F	21
APPENDIX G	22
TABLE 1	23
TABLE 2	24
FOOTNOTES	25
LITERATURE CITED	27

INTRODUCTION

To undertake the development of a new idea one must first understand the components of the system being analyzed. The components for creation of a tamper proof label are: microencapsulation of dyes, silicone release coatings, and pressure sensitive adhesives. In the first segment microencapsulation, color formers, color precursors, and color reactions are examined. The second part deals with silicone release coatings: formulations, variables, properties, and the factors that affect permeability. The third part, pressure sensitive adhesives, examines the types, properties, and the factors that affect the use of pressure sensitive adhesives. With a clear understanding of the components of the system an experimental plan can be devised for the creation of a tamper proof label.

KEYWORDS

Polyphenolics

Polysilicones

Release Coatings

No Carbon Papers

Encapsulation

Pressure Sensitive Adhesives

LITERATURE REVIEW

MICROENCAPSULATION

The aim of microencapsulation is to enclose gases, liquids, or solids within a shell material that can be a wax, resin, or a number of synthetic polymers. The reasons for microencapsulation are to protect the contents from air, microorganisms, chemicals, and other contaminants. Shelf life is increased and spoilage is reduced. Wall materials can be designed to allow passage of some materials while selectivity blocking others.

In carbonless copying systems the microcapsule is ruptured by pressure and transmitted to the image forming coating. The image forming coating can also be enclosed in microcapsules to protect from contamination. To prevent smudging of the system by premature rupture of the microcapsules, due to stacking and converting operations, loadbearing agents are employed. Loadbearing agents have an average diameter (15 to 30 microns) which is greater than that of the image forming microcapsules (5 to 25 microns) and is at least as great as the thickness of the coating (10 to 30 microns) that contains the image forming microcapsules. Thus, the loadbearing capsules will protrude through the surface of the image containing coating. The loadbearing agents are preferably of the same polymer as the shell of the image containing capsules so a separate binder material is not required for the loadbearing agents and the image forming microcapsules. Some loadbearing agents and their resistance to smudge are reported

in Appendix A.¹ In simple terms there are three methods for micro-encapsulation.² One method of wall formation, known as Complex Coacervation, involves the separation of a liquid "colloid complex" out of the aqueous phase and its deposition around the color former solution droplets. The liquid walls, in which a common factor is gelatin, are gelled by cooling and then permanently hardened by reaction with a material such as formaldehyde.

The second method of encapsulation, known as Interface Polycondensation, involves the inclusion of a special reactive chemical in the color former solution droplets. This chemical must be capable of reacting with another chemical in liquid phase, so that around the droplets - where the two chemicals come together - a wall is formed consisting of the reaction product of these chemicals. An example would be the reaction of terephthalic acid chloride and an amine, the result is walls being chemically similar to the plastic Terylene.

The third method, Resin Condensation, uses preformed polymeric resins. The formation of the walls is accomplished by transfer of the polymer out of the phase in which it is initially dissolved by changing the balance of solvents in the system. All three methods of encapsulation involve complex chemical reactions and require a high degree of control.

No discussion of microencapsulation would be complete without discussing the chemical reactions involved between the dye and color formers. The most important imaging systems today are those based on the reactions of certain chromogenic materials

such as the lactone phthalides, the lactone xanthenes, and the N-acryllercmethylenes blues. These reactants are electron donors when brought into reactive contact with Lewis acids (electron acceptors) such as acidified clays, polymeric phenols, and organic acids.³

The chromogenic donor - acceptor reactions in current use are essentially acid - base reactions. The main reaction involves a fundamental change at an important site in the donor molecule. For example, the reaction of Crystal Violet Lactone, CVL, involves the cleavage of a covalent bond with the removal of a pair of electrons from a key carbon in the color precursor molecule, thereby forming an intensely colored carbonium ion dye in resonance with ammonium extremes. The hetro-bond cleavage is effected by means of the electron acceptor (acid), such as the proton of a phenolic resin or a metallic ion of a Lewis acid.⁴ Example of reaction of CVL is shown in Appendix B.

A second type of color forming reaction includes donor-acceptor reactions of a different type; molecular complexation reactions. When donor and acceptor molecules of sufficiently different electronegativities are brought together, an intermolecular association may occur, yielding a C-T complex capable of detection. The exact nature of the bond that holds the co-reactants of the complex together is not yet fully understood. The basic concern is with the molecular complexations taking place between what are known as π - or n , and π molecules with other π molecules.⁵ At the present time no systems have been

reported using molecular charge-transfer reactions for encapsulation systems. It is an important concept because of the cost reducing ability that these chemical reactants have.

SILICONE RELEASE COATINGS

Silicone release coatings are a mixture of a vinyl-containing polyorganosiloxane, a catalyst, a hydride polysiloxane crosslinking agent, water, and emulsifying agents (ie. PV alcohol). Coating catalysts include zinc, tin, and platinum. Different release properties can be obtained with the use of different vinyl-containing polysiloxanes, catalysts, crosslinking agents, and amount of emulsifying agent. Crosslinking, in most cases, takes place only very slowly at room temperature. Heating the film to approx. 120°C for one to two minutes will promote crosslinking. The coating must usually be aged for one to twenty days for complete maturing of the release coating.⁶

Many factors affect the properties of the release coating. The properties of a release coating are: incompatibility with organic polymers, high free volume of silicone polymers, and high mobility of the silicone polymer chains. These make it difficult for the organic adhesive to get completely enmeshed in the silicone release coating. Other properties; the low energy of activation for viscous flow and a low surface energy allow for the silicone to "wet out" for good coverage.⁷ Physical properties of the base sheet are also extremely important. Increasing the smoothness and decreasing the absorptivity of the base paper will reduce the amount of silicone needed to obtain certain adhesive release properties.

Surface sizing of the base paper can lower the silicone coating demand to a third or a fifth of a sheet without surface sizing.⁸ Thickeners (ie. CMC) are used in silicone release coatings to increase viscosity and film forming capabilities. Appendix E shows the relationship between silicone release and viscosity.⁹

One of the important questions for this study is whether the silicone release coatings are permeable to the dye base molecules. According to some work done at Dow Corning Corporation with silicone and organic solvents, silicone films are permeable.¹⁰ The proportion of crystallinity in the polymers and polymer orientation in the absence of crystallization have considerable influence on permeation. The degree of cross-linking and filler content are also factors as is the rigidity of the polymer backbone. The concentration of the permeant can have considerable effect. Temperature and membrane thickness (why sizing is so important) must also be considered.¹¹

A comparison of Dow Corning release coatings and catalysts is shown in Appendix C. Also included are release characteristics with SBR and acrylic pressure sensitive adhesives.¹²

PRESSURE SENSITIVE ADHESIVES

Pressure sensitive adhesives are among the fastest growing classes of adhesives in current use. Their unique ability to form useful bonds without the use of heat, pressure, and time consuming clamping along with their versatility of form (emulsions, hot melts, and solutions) lead to many end uses. The pressure sensitive industry has undergone tremendous change in the past de-

cade due to two factors: the escalating cost of energy requirements and the new stringent government regulations concerned with solvent emissions.

The important requirements of pressure sensitive adhesives are: thorough and rapid wetting, tack (quick bond), adhesive strength, cohesive strength, and creep resistance. Each of these properties are a function of polymer base, tackifier, plasticizer, antioxidants, and UV stabilizers. The dependence of properties on components is detailed in Appendix E.¹³ The adhesive properties are also dependent upon the temperature of the system. Also oxidation and UV radiation are important factors that must be considered when evaluating properties of pressure sensitive adhesives; these are detailed in Appendix F.¹⁴

There are currently three major types of pressure sensitive adhesives in use commercially: solutions, emulsions, and hot melts. Solutions can consist of SBR and acrylic polymers while hot melts are usually SBR polymers. Emulsions are generally acrylic polymers; but SBR is also moving into this area due to lower cost. Emulsion type pressure sensitive adhesives may be carboxylated. Presence of carboxyl groups on the chain contributes to self cure properties, excellent mechanical stability at low surfactant levels, and increased formulating latitude. When carboxyl groups are not present on the polymer chain, SBR latexes are usually stabilized with about one to four percent of a surfactant.¹⁵

Solutions, the first form to be considered, are systems in which the adhesive mass is dissolved in an organic solvent, or

more common in a mixture of organic solvents. Both rubber/resin and acrylic polymers are available in this form. The adhesive segments are partially separated by the solvent vehicle, reducing viscosity. Viscosity increases with increased solids content or higher molecular weight. Solutions release the solvent vehicle by a diffusion process in which the solvent molecules must uniformly move through the adhesive mass. As drying proceeds, the viscosity increases making the diffusion rate decrease and the solvent more difficult to remove. In addition, solvent-adhesive interactions (hydrogen bonding) frequently occur adding to the problem.¹⁶

Emulsions, the second form of pressure sensitive adhesive, consist of discrete particles of adhesive suspended in a water vehicle. Viscosity is essentially independent of both solids content and molecular weight. Emulsions dry by an entirely different method than solution adhesives. The water molecules move freely around the adhesive particles rather than through the adhesive mass. As a critical amount of water is removed the particles start to coalesce, causing flow to stop. Unlike solutions, there is very little water-adhesive interaction, with drying proceeding as if only water were present. Premature coalescence in the liquid stage (when drying) is avoided by incorporation of surfactants into the system. At high depositions, skinning may occur in inefficient dryer configurations but, overall, emulsions dry more readily than solutions.¹⁷ Any degradation of the color devolping properties by the pressure sensitive adhesive (SBR systems) can be prevented by the addition of an organic acid such as

diethyl succinate.

Hot melts are supplied at 100% solids with the adhesive ingredients melted together during manufacture to form a homogeneous mixture. Temperature controlled viscosity is the only variable. The solid mass is liquidified for coating by raising the temperature, generally between 250-350°F. The coating is applied and the temperature is then dropped as quickly as possible, usually by means of a chill roll. Viscosity tends to increase very rapidly as the temperature decreases and the deposited adhesive tends to set without any flow. Since there is no vehicle to remove, blistering and other surface distortions are not a problem.¹⁸

The permeability and properties of pressure sensitive adhesives is highly dependent upon the amount of tackifier, plasticizer, and viscosity control additive that are put into the system. Pressure sensitive applications require some compromise among the following characteristics: shear or creep (measured by Williams plasticity), pressure sensitivity (measured by Polyken probe tack, rolling ball, and quick tack tests), load bearing strength (measured by static shear), and adhesive strength (measured by 180° peel adhesion). Because specific conditions as substrate type and coating weight vary, pressure sensitive adhesives are frequently custom designed. Out of the developing art of pressure sensitive polymer design has come a convenient equation to aid in predicting effects of several variables on 180° peel adhesion performance.

$$180^\circ \text{ Peel Strength} = \frac{\sigma_{ab}^2}{E_t}$$

where σ^2 = Cleavage stress (area under tensile curve)

a = Thickness of glueline

b = Width of glueline

E_t = Tensile modulus

The equation predicts an increase in peel strength with increase in thickness or width of the glue line, variables that can be easily controlled. Tensile modulus and cleavage can be modified slightly by compounding, but these factors are governed largely by characteristics inherent in the polymer and must be controlled by polymer selection.¹⁹ Low temperatures decrease the bonding and flexibility of pressure sensitive adhesives. Oxidation and ultraviolet radiation also decrease the effectiveness of the adhesives. These properties are outlined in Appendix F.²⁰

Because of the different properties of the three types of pressure sensitive adhesives; coating methods differ for each type of adhesive. Appendix G gives a rundown of solids for each type of pressure sensitive adhesive along with viscosities and coating machines for each adhesive.²¹

EXPERIMENTAL

The experiment is based on the factors affecting the permeability of the silicone release coating. It is proposed that the film thickness, catalyst concentration, silicone polymer, and viscosity will affect the permeability of the release coating.

EXPERIMENTAL DESIGN

Silicone release coatings will be made using two Dow Corning release coatings (1171 and 22). The silicones will be added in two amounts: 20 pph and 14 pph. Dow Corning catalyst 164 will be added in two ratio levels (1:4 and 1:6) based on the amount of silicone in the formulation. Low molecular weight CMC will be used as a film former and adhesive (CMC has some adhesive properties). A high molecular weight CMC is used to produce an increased viscosity. The coating mixture will be applied with a drawdown blade on a presized base paper. The coating will be dried to promote crosslinking of the silicone polymer (Table 1).

EXPERIMENTAL PROCEDURE

The release coating formulation is made by "folding" the silicone into the predissolved water-CMC mixture. The catalyst is added after thorough mixing and "folded" into the silicone-water-CMC mixture. Mixing is done by hand to prevent air from being entrapped in the coating. The coating formulation is applied by use of a drawdown blade. Two pressures were used (A and D - marked on blade) to produce two coat weights (1.1 #/ream and 1.5 #/ream - 3300ft²). The coated sheet is put into a forced

draft oven at 105°C and dried for approximately five minutes to promote silicone crosslinking.

The pressure sensitive adhesive coating (for the 180° peel adhesion test) was premixed by the supplier. The adhesive is a solvent based screenable acrylic adhesive (#205-4714) made by General Formulations Inc. This pressure sensitive adhesive is used for all testing. The adhesive is applied with a #26 wound wire rod and dried in a forced draft oven at 105°C for approximately five minutes. The dried coating is approximately .7 to .8 mils thick when measured between two mylar sheets. The pressure sensitive adhesives are coated on paper and mylar.

EXPERIMENTAL TESTING

The permeability of the release coating is tested by mating it with a color former sheet and typing of the front side of the silicone release coated (back side coated) paper. An electric typewriter (Royal Medallion II) is used to type on the mated carbonless paper to keep the pressure constant. The image formed on the color former sheet is then objectively analyzed by magnifying glass and rated on a 1 to 5 (poor to excellent) basis. The results are recorded in Table 2.

To evaluate the release coating, the 180° peel adhesion test is used. This test uses the Instron tensile tester. The release coating is mated with a pressure sensitive adhesive that has been coated on either paper or mylar. After the two sheets are put together the "sandwich" is pressed using the roller for the British Handsheet mold to control the uniformity of the 180° peel adhesion

test. The samples are cut into 1" strips and the peel adhesion is measured in grams. Three strips were used for each sample and the average is reported in Table 2.

ANALYSIS OF DATA

Only two factors affect the dye transmittance through the silicone release coating. The factors are: an increase in coat weight (1.1 #/ream to 1.5 #/ream) and the use of high molecular weight CMC (runs 5 and 20). The high molecular weight CMC's larger molecular structure creates a barrier for the microencapsulated dye.

Five factors affect the 180° peel adhesion test. They include: coat weight, viscosity, silicone concentration, film former, and substrate. Increasing coat weight (1.1 #/ream to 1.5 #/ream), using film formers (runs 1 to 3), and increasing silicone concentration (runs 3 and 6) will decrease the adhesive adhesion. The paper substrate has a slightly higher adhesive adhesion than the mylar substrate due to better interaction between the adhesive and silicone release coating. The increase in viscosity (runs 4 to 6 and 20 to 22) greatly reduces the adhesion of the adhesive due to the excellent film forming of the CMC.

CONCLUSIONS

Silicone release coatings are permeable! The degree of permeability is related to the silicone polymer, silicone content, viscosity, coat weight, and catalyst concentration. An increase in viscosity, coat weight, and silicone polymer reduce the permeability of the release coating. It was found that the silicone polymer and catalyst concentration had no affect on the permeability of the release coating. High molecular weight CMC decreased permeability due to interference by the size of the CMC molecules.

The adhesion of pressure sensitive adhesives to the silicone release coatings is related to: silicone polymers, silicone content, viscosity, coat weight, film formers, and catalyst concentration. Increases in silicone content and coat weight decrease the adhesion of the adhesive to silicone release coating. The silicone polymer and catalyst concentration had no affect on the adhesive adhesion. Film formers (ie. low molecular weight CMC) tend to decrease the adhesion of the adhesive to the release coating. High molecular weight CMC increases the viscosity and greatly decreases the adhesion of the adhesive to the silicone release coating.

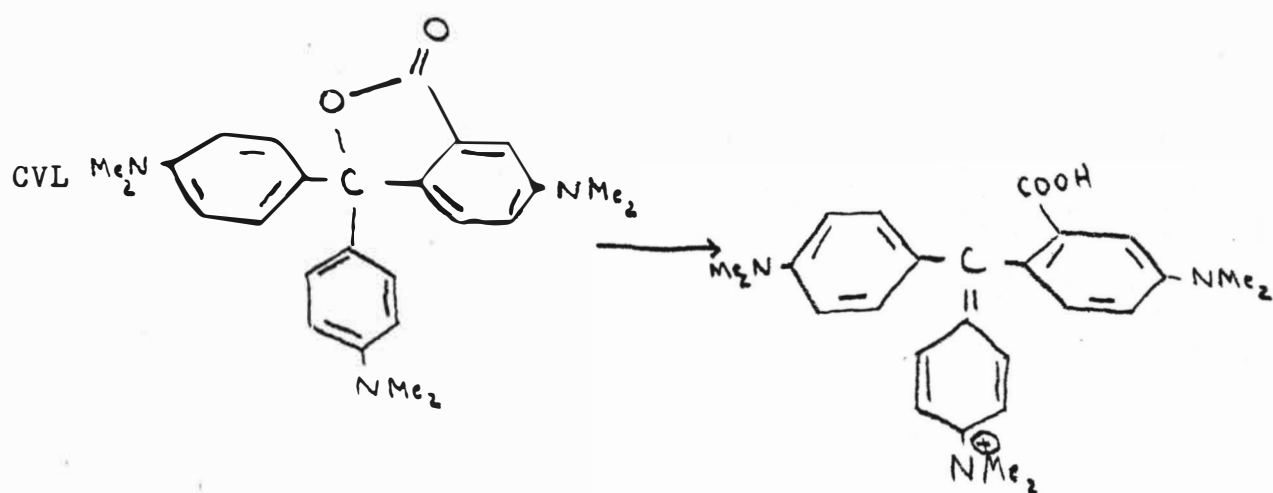
APPENDIX A

<u>Load-Bearing Agent</u>	<u>Amount Grams*</u>	<u>Impact Intensity</u>	<u>Smudge</u>
None	---	Very High	Very High
Cellulose	2.0	High	High
Cellulose	6.0	Moderate	High
Cellulose	10.0	Low	Moderate
Polystyrene/starch	8.3	High	Moderate
Polystyrene/starch	25.0	High	Low
Polystyrene/starch	41.5	Moderate	None
Polystyrene/polyvinyl alcohol	9.7	High	Moderate
Polystyrene/polyvinyl alcohol	29.2	High	Low
Polystyrene/polyvinyl alcohol	48.5	Moderate	None

*Weight admixed based upon dry cellulose and aqueous suspension of microcapsular load-bearing agents.

APPENDIX B
Color Formers

Colorless ----- Colored



APPENDIX C

<u>Emulsion Systems</u>	<u>Cure Comparison</u>	<u>Release Comparison</u>	<u>General</u>
SYL-OFF 1107/EY-142	4	3	Requires several days at RT to post cure
SYL-OFF 22/22A	3	2	Requires 2-24 hour post cure
SYL-OFF 1171/1171A	1	1	Requires no post cure
SYL-OFF 1171/EY164	2	1	275° Min. cure temp.

Cure Comparison

1 = Fastest

4 = Slowest

Release Comparison

1 = Lowest Release Force

4 = Highest Release Force

<u>Emulsion Coating</u>	<u>SBR Adhesive</u>	<u>Acrylic Adhesive</u>
SYL-OFF 22	45	50
SYL-OFF 1171	45	30

APPENDIX D

<u>Solution</u>	<u>Viscosity (cps)</u>	<u>Release (g/in)*</u>	<u>Release (g/in)**</u>
1***	500	30	170
2***	4400	30	100
3***	60,000	12	35
1****	500	45	150
2****	4400	30	85
3****	60,000	20	30

*No Amino Compound

**Amino Compound

***Sellotape

****Takstrip

APPENDIX E

Dependence of Properties on Components

	<u>Cohesion</u>	<u>Adhesion</u>	<u>Tack</u>	<u>Creep Resistance</u>
Polymer Base	*	***	***	*
Tackifier	**	***	***	**
Plasticizer	**	**	***	**
Filler (nonreinforcing)	**	**	**	**

Property

* = Increase

** = Decrease

*** = Goes through maximum

APPENDIX F

Low Temperature Properties

% Of Room Temperature Strength Retained
When Formulated To:

	<u>Bond At 10°F</u>	<u>Remain Flexible At -40°F</u>
Rubber/Resin		
Solutions	25 - 50%	75%
Hot Melts	40 - 60%	50%
Acrylics		
Solutions	60 - 80%	100%
Emulsions	80 - 100%	100%

Oxidation and UV Resistance

	<u>Acrylic (all forms)</u>	<u>Rubber/Resin Solutions</u>	<u>Hot Melts</u>
<u>Oxidation</u>			
Resistance to change at normal or slightly elevated temperatures	Excellent	Poor-Good	Fair-Good
<u>Ultraviolet</u>			
Resistance to dis- coloration and de- gradation	Excellent	Poor	Poor

APPENDIX G

Solids Content - Viscosity

	<u>Solution</u>	<u>Emulsion</u>	<u>Hot Melt</u>
Solids Content:			
Rubber/Resin	20-60%	50-60%	100%
Acrylics	30-55%		
Viscosity:			
Rubber/Resin	20-1000 ps.	2-100 ps.	100-500 ps.
Acrylics	5-200 ps.		

Viscosity Parameters

<u>Method</u>	<u>Viscosity Range</u>
Air Knife	Low: 100-1000 cps.
Wound Wire Rod	Low: 300-2000 cps.
Gravure	Low: 300-2000 cps.
Reverse Roll	Intermediate: 2000-10,000 cps.
Knife-Over-Roll	High: Over 5000 cps.
Die-extrusion	Hot Melts Only
Hot Casting Roll	Hot Melts Only

Coating Methods

<u>Method</u>	<u>Solutions</u>	<u>Emulsions</u>
Air Knife	Not Practical	Practical
Wound Wire Rod	Not Practical	Practical: may require smoothing roll
Gravure	Practical: often requires reduced solids	Practical: may require smoothing roll
Reverse Roll	Practical	Practical
Knife-Over-Roll	Practical	Practical: may require solids reduction to control deposit

TABLE 1
Experimental Runs

		<u>Silicone</u>	<u>Catylist 22</u>	<u>H₂O - CMC</u>	<u>Viscosity (cps)</u>
Syl-off 1171	1	14.0	3.5	82.5-0.0	28
	2	14.0	3.5	81.5-1.0	42
	3	14.0	3.5	80.5-2.0	96
	4	20.0	3.5	76.5-0.0	26
	5	20.0	3.5	75.5-1.0	40
	6	20.0	3.5	74.5-2.0	72
Syl-off 22	7	14.0	3.5	82.5-0.0	30
	8	14.0	3.5	81.5-1.0	42
	9	14.0	3.5	80.5-2.0	96
	10	20.0	3.5	76.5-0.0	24
	11	20.0	3.5	75.5-1.0	43
	12	20.0	3.5	74.5-2.0	70
Syl-off 1171	13	20.0	5.0	75.0-0.0	30
	14	20.0	5.0	74.0-1.0	44
	15	20.0	5.0	73.0-2.0	79
	20	20.0	3.5	75.5-1.0	50*
	21	20.0	3.5	74.5-2.0	640*
	22	20.0	3.5	73.5-3.0	2360*

*High M.W. CMC

Silicones supplied by Dow Corning Co.

CMC supplied by Hercules Inc.

TABLE 2

Experimental Data

	<u>Dye Transmittance</u>		<u>Release (Paper)</u>		<u>Release (Mylar)</u>	
	<u>A</u>	<u>D</u>	<u>A</u>	<u>D</u>	<u>A</u>	<u>D</u>
1	5	5	330	315	300	290
2	5	4	310	310	280	260
3	5	4	300	285	280	255
4	5	5	290	280	260	250
5	5+	5	270	250	245	240
6	5	4	250	245	240	240
7	5	5	300	295	320	300
8	5	5	300	300	300	295
9	5	4	280	270	260	260
10	5	4	285	280	270	270
11	5	4	280	270	280	250
12	5	5	265	250	250	240
13	5	5	285	280	260	240
14	5	4	265	250	220	230
15	5	5	260	250	240	220
20	4	4	275	275	270	260
21	4	3	240	220	200	180
22	4	3	195	170	180	160

Coat Weight A = 1.1 #/ream (25 x 38 - 500)

Coat Weight D = 1.5 #/ream (25 x 38 - 500)

Release Values for 1" wide strip - 180° peel; in grams

FOOTNOTES

¹Vassiliades, A.E. and Vincent, D.N. and Shroff, S., U.S. Patent #3,844,816; October 29, 1974.

²Collins, J.M. Converter, December 1980, 13.

³Spatz, S. and Shackle, D.R., "Charge-Transfer Complexes as Imaging Materials in Carbonless Copy Papers," Tappi, Vol. 59, No. 8, August 1976, 128.

⁴Ibid., p. 128.

⁵Ibid., p. 129.

⁶"Some Release and Water Repellent Agents," Paper, No. 9, June 1980, pp 35-37.

⁷"Recent Improvements in Solventless Silicone Paper Coatings," Dow Corning Corp.

⁸Eklund, D. and Rogaczewski, Z., "Coating of Paper with Organic Silicone Solutions," Paperi Puu, 53 No. 12, December 1971, pp. 711-13.

⁹Atkinson, H.C. and Gibbison, R.M., U.S. Patent #3,565,838; February 23, 1971.

¹⁰Dennis, William E. and Larson, Willard D., "Permeation and Silicone Elastomers," Dow Corning Corporation.

¹¹Ibid.

¹²"Emulsion Based Paper Coatings," Dow Corning Corporation.

¹³Miron, J. and Skeist, I., "Trends in Pressure Sensitive and Heat-Seal Materials," Adhesives Age, January 1978, 36.

¹⁴Fries, John H., "Pressure-Sensitive Adhesives: An Overview - Part II," Paper, Film, & Foil Converter, March 1979, 66.

¹⁵Jahn, R.G., "Styrene/butadiene Latexes of Adhesive Applications," Adhesives Age, December 1977, 35.

¹⁶Fries, John H., "Pressure-Sensitive Adhesives: An Overview - Part I," Paper, Film, & Foil Converter, February 1979, 53.

¹⁷Ibid., pp. 53-4.

¹⁸Ibid., pp. 53-4.

¹⁹"Latexes in Adhesive Systems," B.F. Goodrich Chemical Group, L-14, pp. 32-5.

²⁰Miron, op. cit., p. 36.

²¹Fries, John H., "Pressure-Sensitive Adhesives: An Overview - Part I," Paper, Film, & Foil Converter, Febuary, 1979, 52-3.

LITERATURE CITED

- Baxter, George. "Microencapsulation Technology and Modern Business Forms," Tappi, Vol. 60, No. 5 (May, 1977), 85-7.
- Collins, J.M. "Carbonless Paper," Converter, December, 1980, 12-16.
- Dennis, William E. "Permeation and Silicone Elastomers," Dow Corning Corporation.
- Dunning, Henry R. "Pressure Sensitive Adhesives," Second ed., Park Ridge, New Jersey, U.S.A., Noyes Data Corporation, 1977.
- Eklund, D. "Coating of Paper with Organic Silicone Solutions," Paperi Puu, 53, No. 12 (Dec. 1971), 711-3.
- "Emulsion Based Paper Coatings," Dow Corning Corporation.
- Fries, John A. "Pressure-Sensitive Adhesives: An Overview - Part I," Paper, Film, & Foil Converter, Feb. 1979, 50-5.
- Fries, John A. "Pressure-Sensitive Adhesives: An Overview - Part II," Paper, Film, & Foil Converter, March, 1979, 62-68.
- Jahn, Robert G. "Styrene/Butadiene Latexes for Adhesive Application," Adhesives Age, December, 1977, 35-37.
- "Latexes in Adhesive Systems," B.F. Goodrich Chemicals Group, L-14, pp. 32-5.
- Miron, Jerry and Skeist, Irving. "Trends in Pressure-Sensitive and Heat-Seal Materials," Adhesives Age, January, 1978, 35-38.
- "New Option in Solvent Adhesives," Upaco Adhesives Inc.
- Noll, W. "Chemistry and Technology of the Silicones," 3rd ed., New York and London, Academic Press, 1968.
- Peverill William J. "Carbonless Paper: Where Does It Stand Now?" Paper Trade Journal, February 28, 1972, 37-8.
- "Recent Improvements in Solventless Silicone Paper Coatings," Dow Corning Corporation.
- "Some Release and Water Repellent Agents," Paper, 193 (June, 1980), 36-37.
- Spatz, Sydney M. "Charge-Transfer Complexes as Imaging Materials in Carbonless Copy Papers," Tappi, Vol. 59, No. 8 (August, 1976), 128-32.

"Tech Notes," Mead Carbonless, Revised June, 1979.

U.S. Patent 2,550,473. Green, Barrett K. and Sandberg, Robert W. September 15, 1950.

U.S. Patent 3,565,838. Atkinson, H.C. and Gibbison, R.M., Feb. 23, 1971.

U.S. Patent 3,844,816. Vassiliades, A.E. and Shroff S. Oct. 29, 1974.

U.S. Patent 4,190,688. Traver, F.J. and cietek, T.j. Feb. 26, 1980.

U.S. Patent 4,199,169. March 23, 1978.