UV Curable Solution Acrylic PSA with Optical Clarity

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Presentation Outline

- Introduction
  - Applications of optically clear PSA
  - Adhesion and optical clarity requirements
- Design of Optically Clear PSA
  - Adhesive composition and adhesion properties
  - Optical properties
- Optically Clear PSA Products
  - Window and safety film PSA
  - PSA for electronic displays
- Summary

Applications of Optically Clear PSA

Graphics, Films and Labels

- Window and safety film
- Overlaminating
- Clear labels (clear on clear)
- Window advertising (clear vinyl)

Electronics Displays

- TFT-LCD
- Touch screen
- e-Book

Adhesion and Optical Clarity
General Requirements

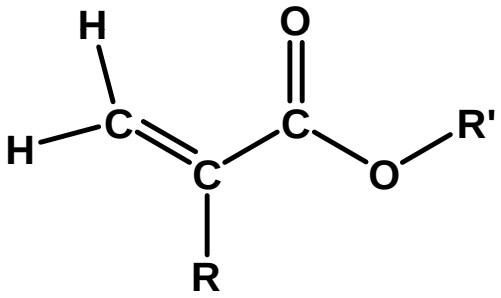
- High cohesion and peel strength for bonding transparent substrates
- High heat and humidity resistance
- Light transmission >99% when corrected for reflection losses
- Refractive index match for bonding substrate (Glass, PC, PET, etc)
- Long term durability without yellowing, delaminating or degrading
- Coating quality to reduce the bubbles, dirt, and various optical distortions
- Application specific performance requirements

Factors that Influence Optical Properties of Adhesives

- Chemical structure of polymers
  - Transmission
  - Refractive Index
  - Resistance to discoloration
    - Chemical
    - Moisture
    - Heat
    - UV radiation
- Morphology of polymers
  - Phase separation
  - Crystallinity
- Coating quality
  - Surface roughness
  - Dirt
  - Bubbles
  - Optical defects, etc.

Acrylic PSA Polymers

Various Acrylic Monomers and Functionalities for Adhesion and Optical Property Control



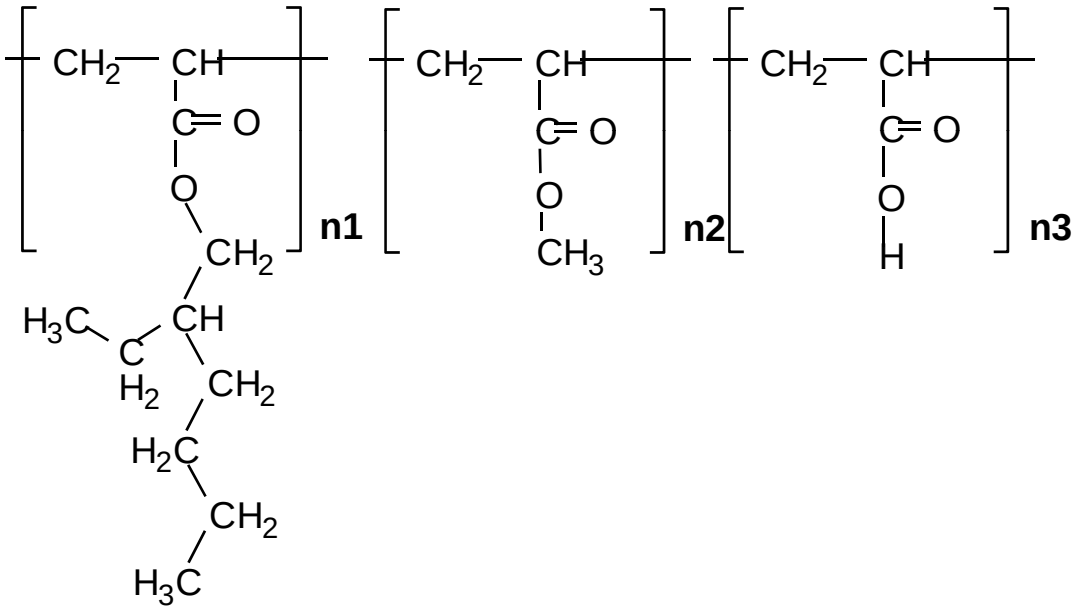
R = H, acrylate
R = CH_3, methacrylate
R’ = H, acrylic acid
R’ = C1 – Cn

Acrylic PSAs are typically composed of:

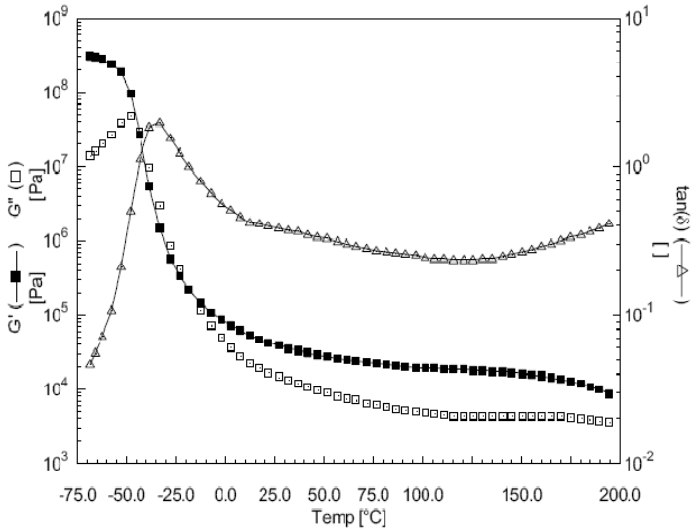
70	- 90	%	Soft monomers
10	- 30	%	Hard monomers
3	- 6	%	Functional monomers

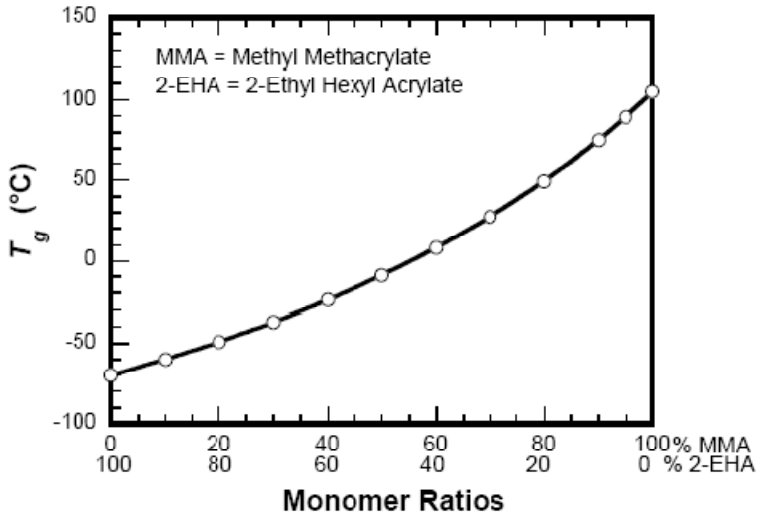
Acrylic PSA Property Control

Soft Monomer Hard Monomer Functional Group



PSA Property Design via Monomer Selection



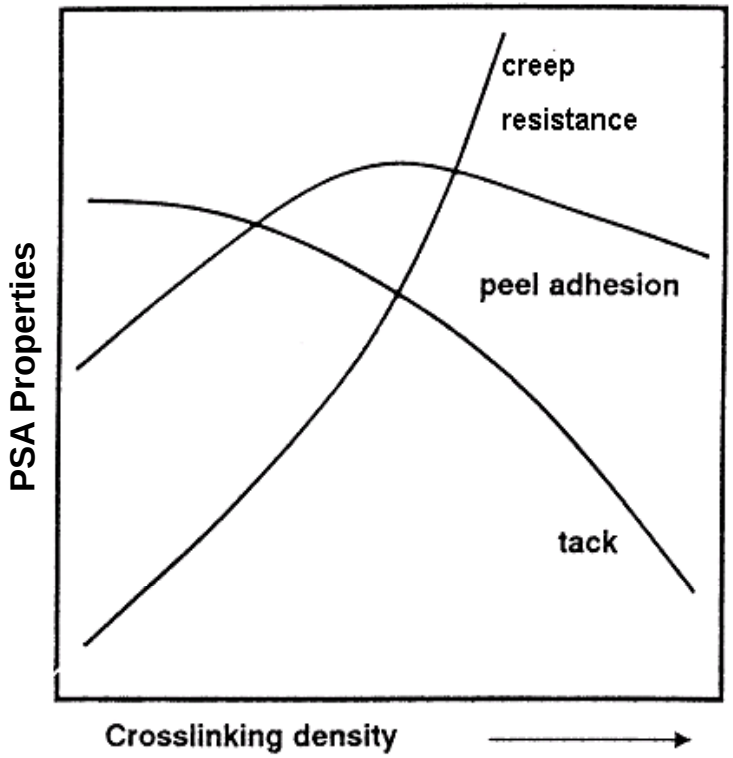


Control of Acrylic PSA Adhesion
A Variety of Methods, e.g., Crosslinking

One-part
- Metals – Al, Ti, Zn
- Self-crosslinking monomers
- Polymeric epoxies
- Blocked isocyanates
- Carbodiimides

Two-part
- Isocyanates
- Aziridines

Radiation Curing
- UV
- EB



from Advances in Pressure Sensitive Adhesive Technology, Don Satas, p. 3, © 1989, Satas & Associates, RI.

PSA for Window and Safety Films

Optically Clear PSA for Window and Safety Film Applications

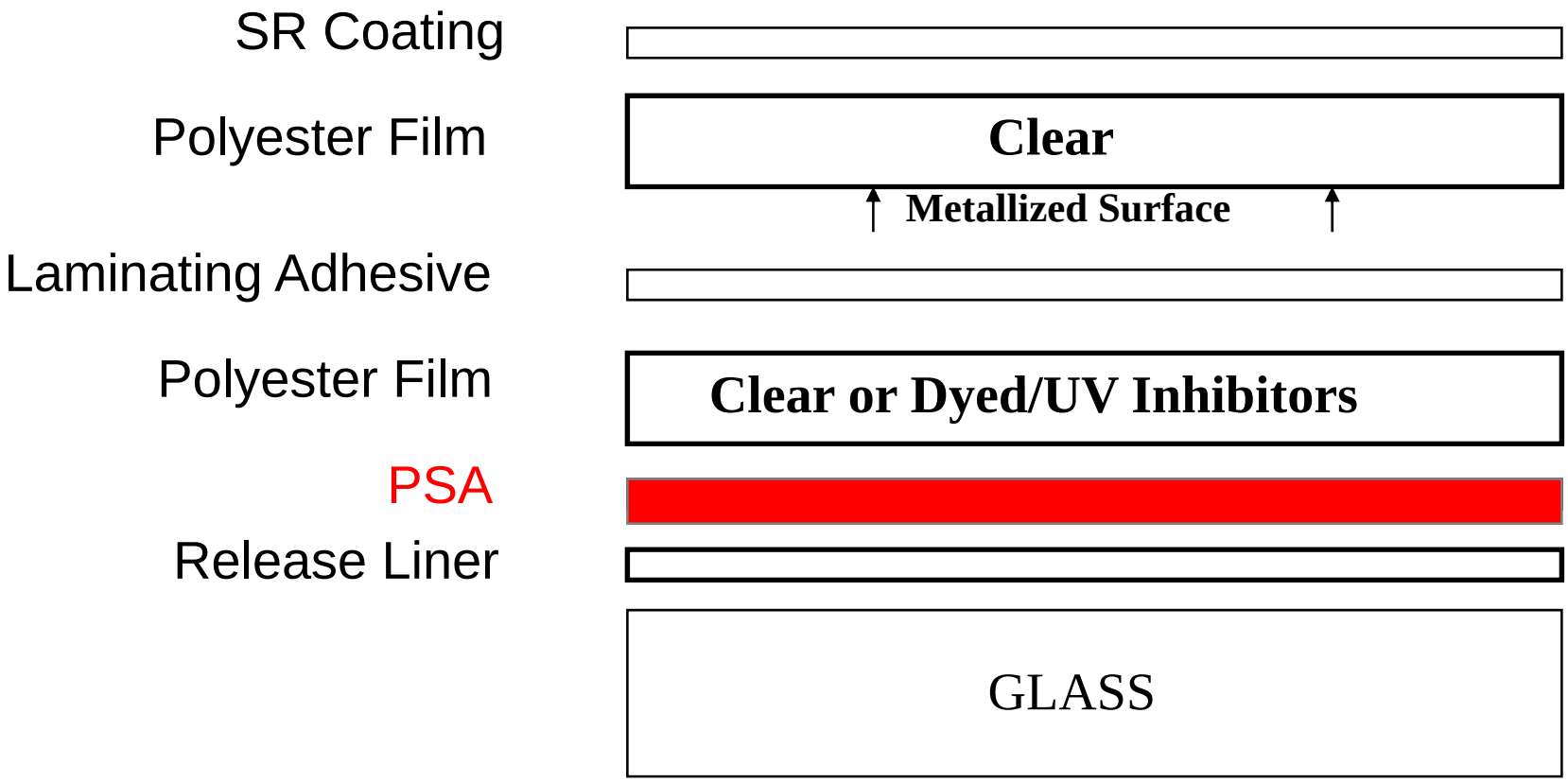
Window & Safety films: Polyester film, Dyed, Metallized

- Reduce radiant heat loss
- Control light transmission
- Provide shatter resistance
- Ensure privacy

Key requirements for the window film PSA

- Optically clear and long term optical stability
- Strong adhesion on glass substrates
- High temperature / humidity performance

Window Film Construction



Historical Window Film PSA Product Features

- Several products for window/safety film in the market

- Performance Features
  - Optically clear and colorless
  - Long term optical stability
  - Strong adhesion on glass substrates
  - Strong cohesion and shear strength
  - High temperature / humidity performance
  - Excellent coatability
  - Repositionability

Continuous Product Development

Further Product Improvement

- Optical clarity of formulation and coatings
- Shear adhesion performance

Polymer composition
Improve PSA properties, solubility & optical clarity

Solvent selection
Match solubility parameters

Crosslinking upgrade
Higher crosslinking density
Different mechanisms

Solubility Parameter of Solvent Mixture

$$\delta = \sum_{i=1}^{n} \delta_i v_i$$

where δ_i is solubility parameter and v_i the volume fraction of individual solvent

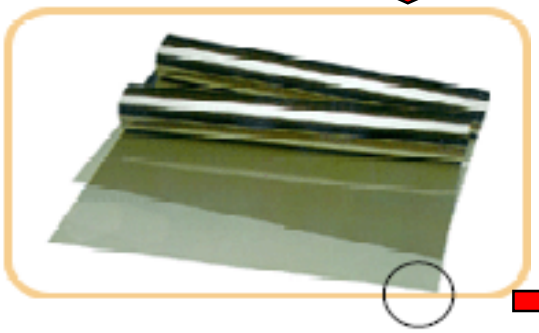
New Development of Window Film PSA

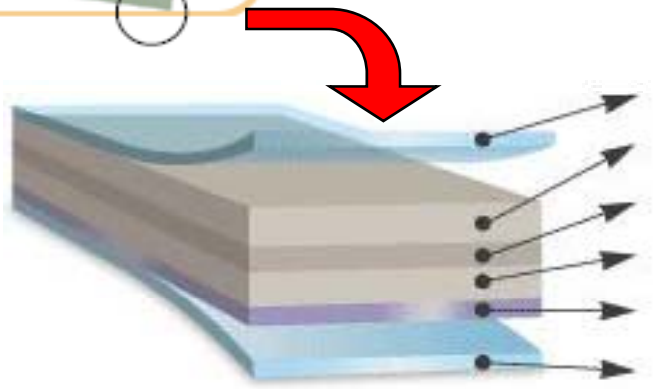
Properties/Adhesion	Commercial Products		Newly Developed Products	
	Product A	Product B	Product C	Product C + tackifier
Total Solid (%)	40.5	35	43	----
Viscosity (mPa·sec)	1000	2700	1200	----
Peel, 24hr (N/25mm)	20.8	17.8	14.4 →	18.7
Shear, hr (1" x 0.5" x 2kg)	8	0.4	**74**	**80**
Solution Clarity	Excellent	Excellent	**Superior**	**Superior**
Coating Clarity	Excellent	Excellent	**Superior**	**Superior**

- Extension of the proven product line
- Similar polymer composition and formulation approach
- **Further improvement of optical properties**
- **Substantially improved shear strength**

PSA for Electronic Displays

Optically Clear UV Curable PSA for TFT-LCD Construction





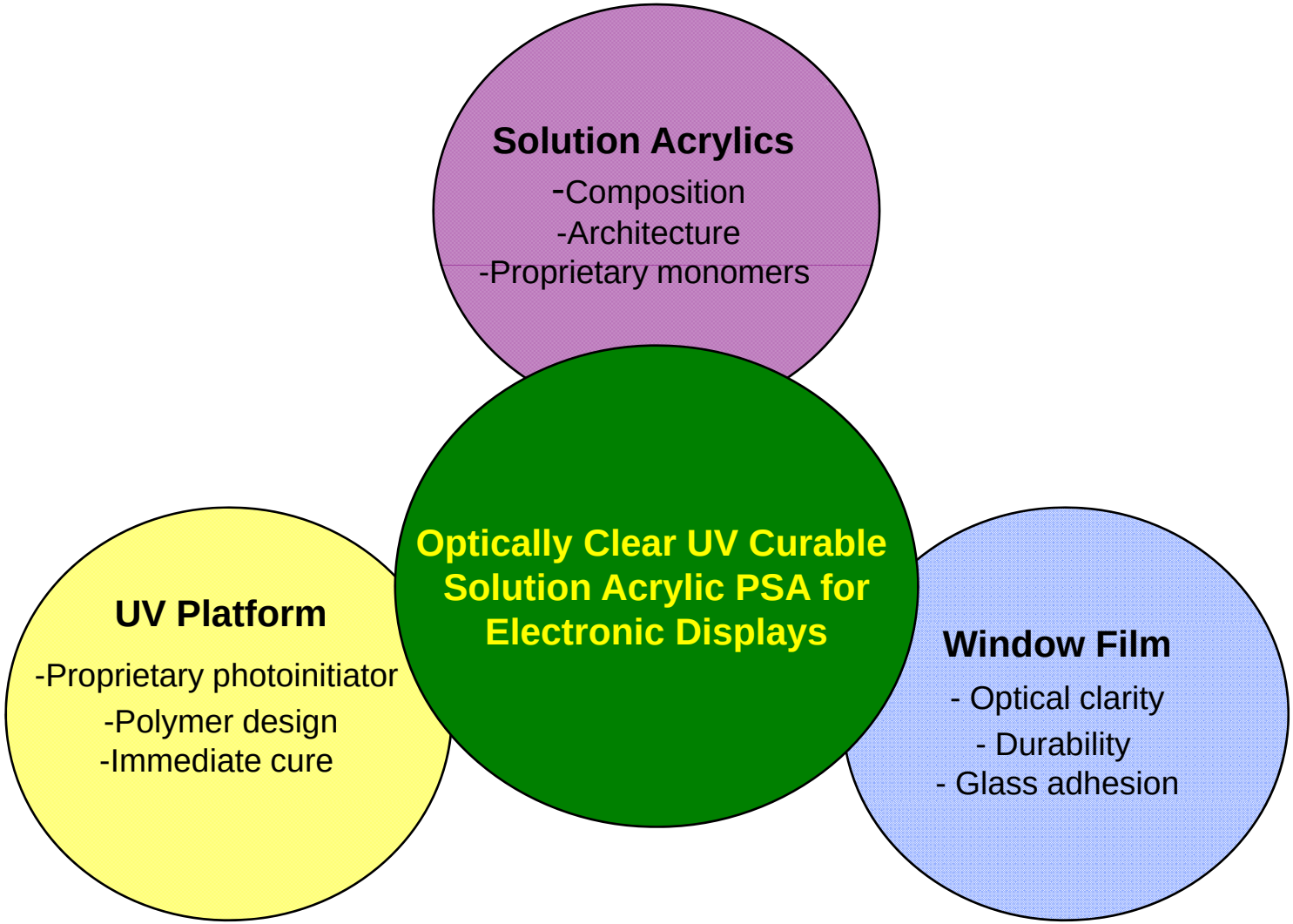
Protective film Adhesive
Protective layer (TAC)
Polarizer (PVA)
Protective layer (TAC)
Construction Adhesive
Release film

Critical to the overall display performance

Key Requirements for Construction Adhesives

- Removability and Repositionability
- Optical Clarity
  - Transmission rate >98 %
  - Refractive index approaching 1.5
- No Defects upon Aging
  - 60 ^{o}C / 90% RH resistance
  - 80 ^{o}C / 95 ^{o}C temperature resistance
  - Thermal shock cycling (-40 to 85^{o}C)
- Good Mura Value
  - Very low shrinkage
  - High cohesion

Leverage of Existing Technical Capabilities

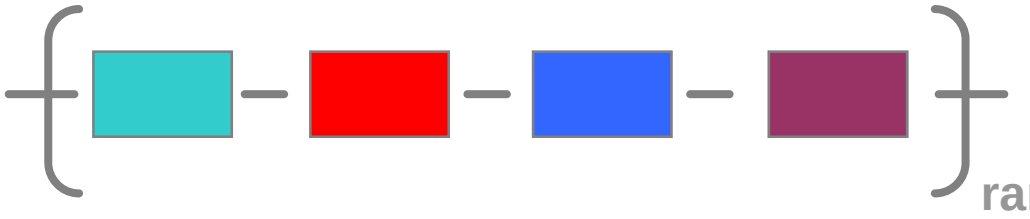


UV Curable vs. Current Technology

	UV Curable Technology	Current Technology
Product Design	UV Solution acrylic	Solution acrylic
Optical Clarity	Excellent	Excellent
Product Form	1 Part system	2 Part system
Curing Mechanism	UV Radiation	Chemical XL
Curing Rate	Fast (Instant)	Slow (Up to 7 days)
Solid Level	Medium - High (40 - 60%)	Low (20%)

UV Crosslinking Mechanism

UV Curable Acrylic Polymer Building Blocks



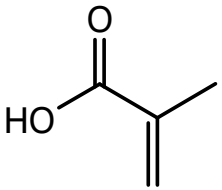
PSA backbone
Provides PSA Properties & optical clarity

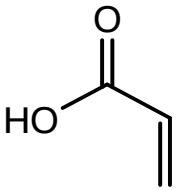
Interaction with substrate
Improves adhesion

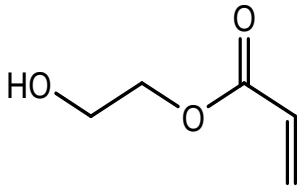
Coupling agent
Interaction with glass
Humidity resistance

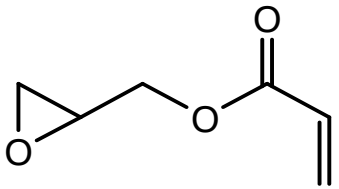
Photoinitiator: Xlinking
Improves cohesion

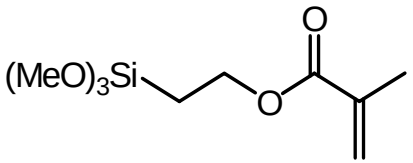
Functional Monomers





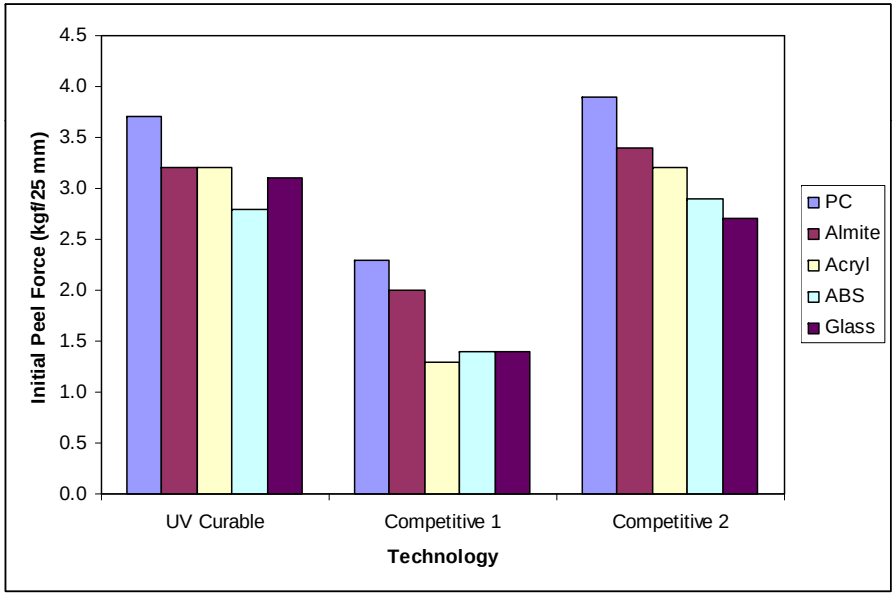




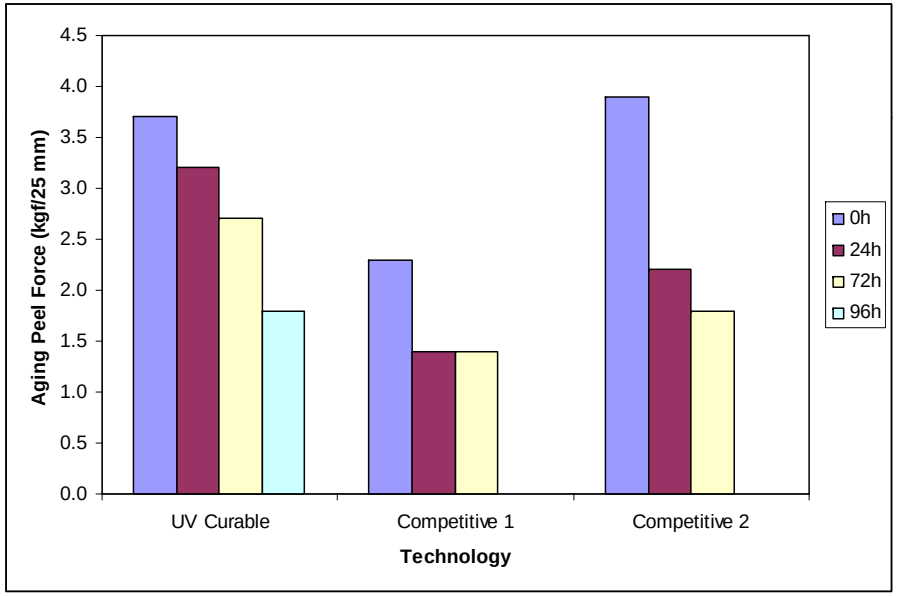


Comparison between UV and Current Technology

Peel values on different substrates



Aging Resistance at 80°C & 85% RH



Summary

- Henkel window film adhesive portfolio has thirty years of proven history.
- Further improvement has been made to the product line with better optical properties and shear performance.
- UV curable solution acrylic PSA technology is being developed for display industry by leveraging the window film PSA capability and patented UV technology.
- Free radical UV curable solution PSAs offer several benefits to chemical crosslinked adhesives: instant cure, one-part system, and efficient coating at higher solids.

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Thank you for your attention!