

Radiation Polymerization

Coatings and Inks

Radiation Curing of Coatings, Inks and Adhesives

- **Electron curing or UV Curing**
 - **Only electron curing covered here**
- **Fast cure, no residual monomers**
- **Quality of the product much better (than UV or thermal cure)**
- **Environmentally friendly**
 - **Drastically reduced emissions (no solvents)**
- **Generally, cost-competitive**
 - **Energy efficiency, initial attraction**
- **Ambient temperature cure**
 - **Good for heat-sensitive materials**
- **Includes polymerization, crosslinking and grafting**

Wide Variety of Products

Coatings

- Magazines
- Record albums
- Paper currency
- Release paper
- Hardwood Floors
- Wood surfaces
- Abrasive films
- Metallized film
- Vinyl flooring
- Tapes, CD's
- Cans (soft drink, beer)

Inks

- Magazines
- Posters
- Wall coverings
- Graphics

Adhesives

- Labels, decals
- Packaging material
- Bonding of abrasives

Woods and Pikaev (1994)

Typical Formulation for Coating, Ink or Adhesive

- **Base oligomer for basic properties of cured polymer, e.g., acrylated epoxy**
- **Monofunctional monomer, diluent to control viscosity**
- **Specific application-oriented additives**
- **Appropriately coloured pigments, for inks and graphics**
- **Tailor components to give desired properties to the final product**

Relative Product Characteristics for Selected Resins

Property	Selected Resins				
	SR-399	SR-2000	SR-5000	SR-9503	SR-3000
Abrasion Resistance	X			X	X
Adhesion	X	X	X		X
Chemical Resistance	X				X
Flexibility	X	X	X	X	
Hardness	X				X
Impact Resistance		X	X		
Low Shrinkage		X	X	X	X
Water Resistance		X	X		X
Weatherability	X			X	

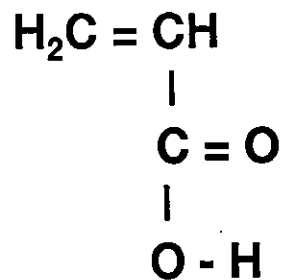
X-imparts specified property to the cured polymer

Typical Oligomers (MW 400-700)

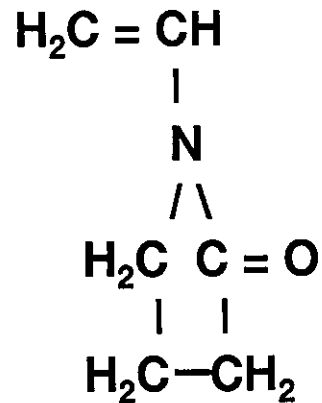
- **Acrylated urethanes**
 - Tough, flexible product with good abrasion resistance (inks, wood finish)
- **Acrylated epoxies**
 - Harder product (metal coatings, composites)
- **Acrylated polyesters**
 - Soft product (pressure-sensitive adhesives, strong adhesives)
- **Acrylated silicones**
 - Soft product (release coatings)
- All of these polymerize via free radical reactions, which are inhibited by oxygen
- Inert atmosphere required for electron or gamma curing

Diluent Monomers

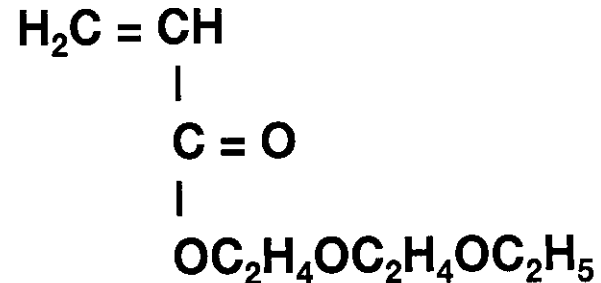
Acrylic acid
- used as an
adhesion
promoter



N-Vinyl pyrrolidone
- a relatively non-
toxic diluent



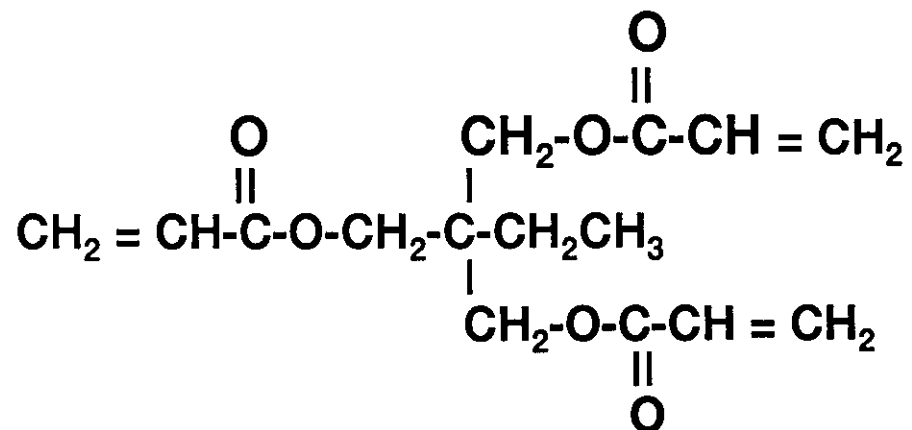
Ethoxyethoxyethyl
acrylate



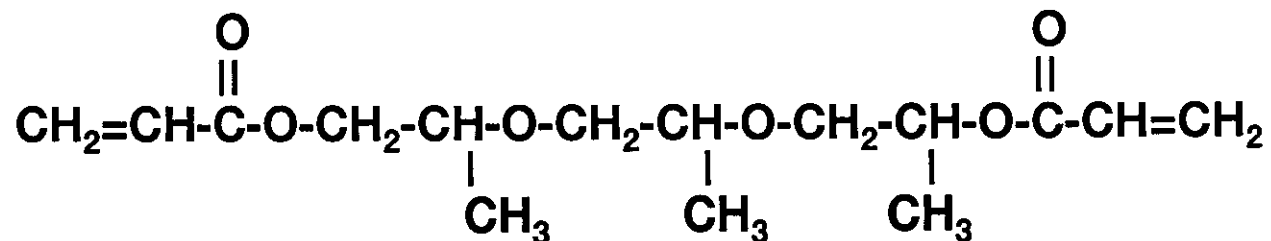
- These participate in polymerization, crosslinking and grafting reactions

Multifunctional Monomers

Trimethylolpropane triacrylate (TMPTA)



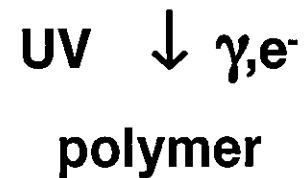
Tripropylene glycol diacrylate (TPGDA)



- These enhance crosslinking and grafting reactions

Cationic Curing

- Epoxies or vinyl ethers + arylsulfonium salts



- Epoxies and vinyl ethers are being used in coatings and adhesives, and in advanced composites
- Cationic curing is not inhibited by oxygen

Health Hazards

- **Equipment**
 - **Consult equipment supplier**
 - **Check regulations**
 - **Partly covered under equipment, earlier**
- **Chemical**
 - **Consult chemical supplier**
 - **Check regulations**
 - **Consult databases, e.g. Sax and Lewis (1989)**
 - **Primary hazard, irritation of skin and eyes**
 - **Potential for occupational dermatitis, phototoxicity, photoallergy and carcinogenicity**
 - **Important to control exposure of workers**
 - **Important to be able to deal effectively with spills and wastes**

Conclusion

- **The use of radiation processing for curing coatings and inks would continue to grow, primarily because it is cost-effective and gives very good product**
- **This is primarily an application for low energy electron accelerators (~0.3 MeV)**