The slow and winding road to "ZERO" VOC

Werner J. Blank
King Industries
Norwalk, CT 06852

wblank@kingindustries.com

WHAT IS VOC (VOLATILE ORGANIC CONTENT)

USA

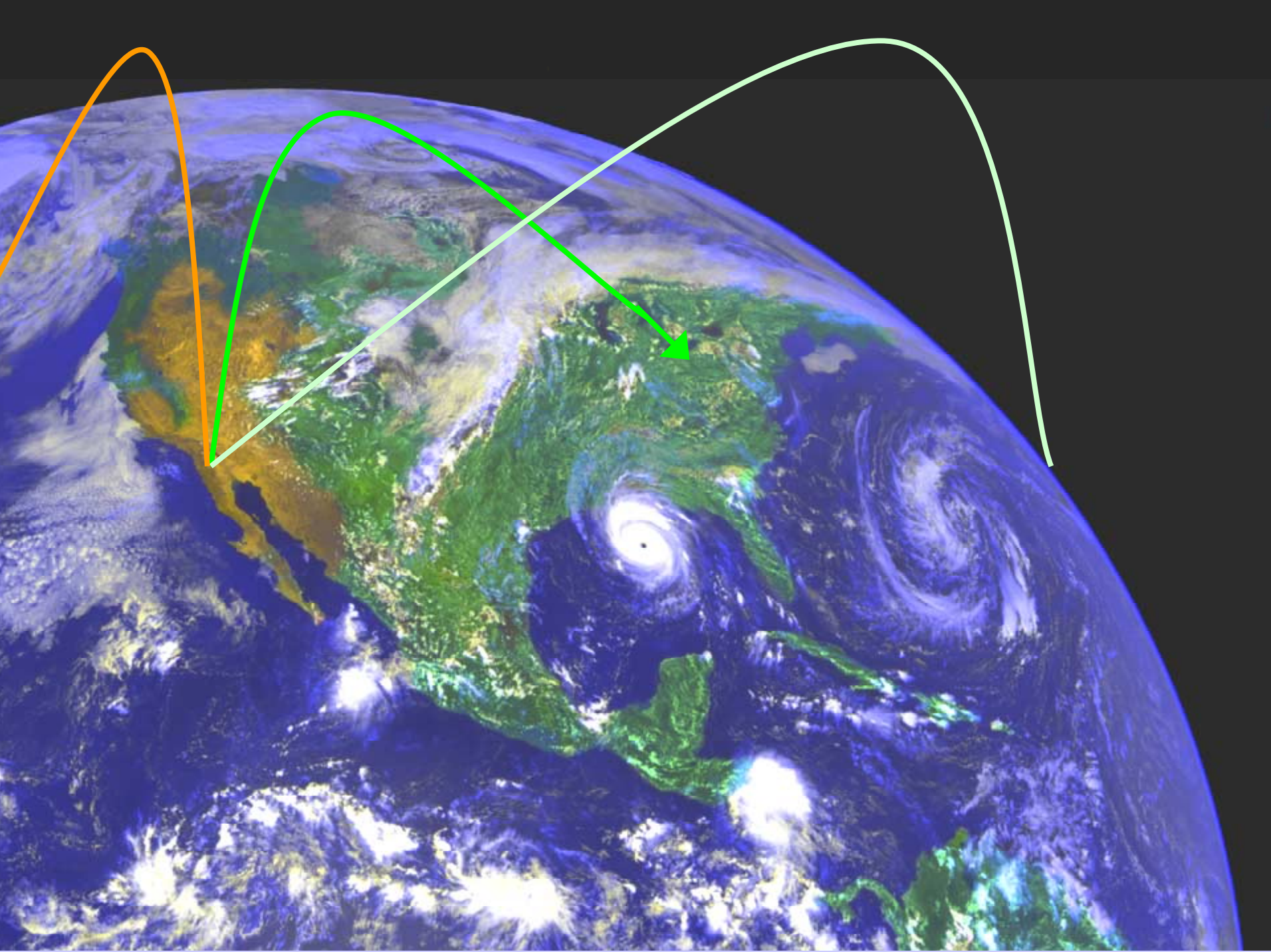
"any organic compound that participates in atmospheric photochemical reactions except those designated by EPA as having negligible photochemical reactivity"

AUSTRALIA

organic compounds with a vapour pressure of more than 0.01 mm Hg at 21°C, and with a boiling point of less than 250°C.

EU

any organic compound having at 293.15K a vapour pressure of 0.01kPa or more, or having a corresponding volatility under the particular conditions of use



German Legislation Concerning the Environment

- 1970 basically 2 laws: Abfallbeseitigungsgesetz, Bundesimmisionschutzgesetz
- 1996 Alltogether approx. 2000 laws, edicts, regulations and recommendations by the authorities

WHY REDUCE VOC ?

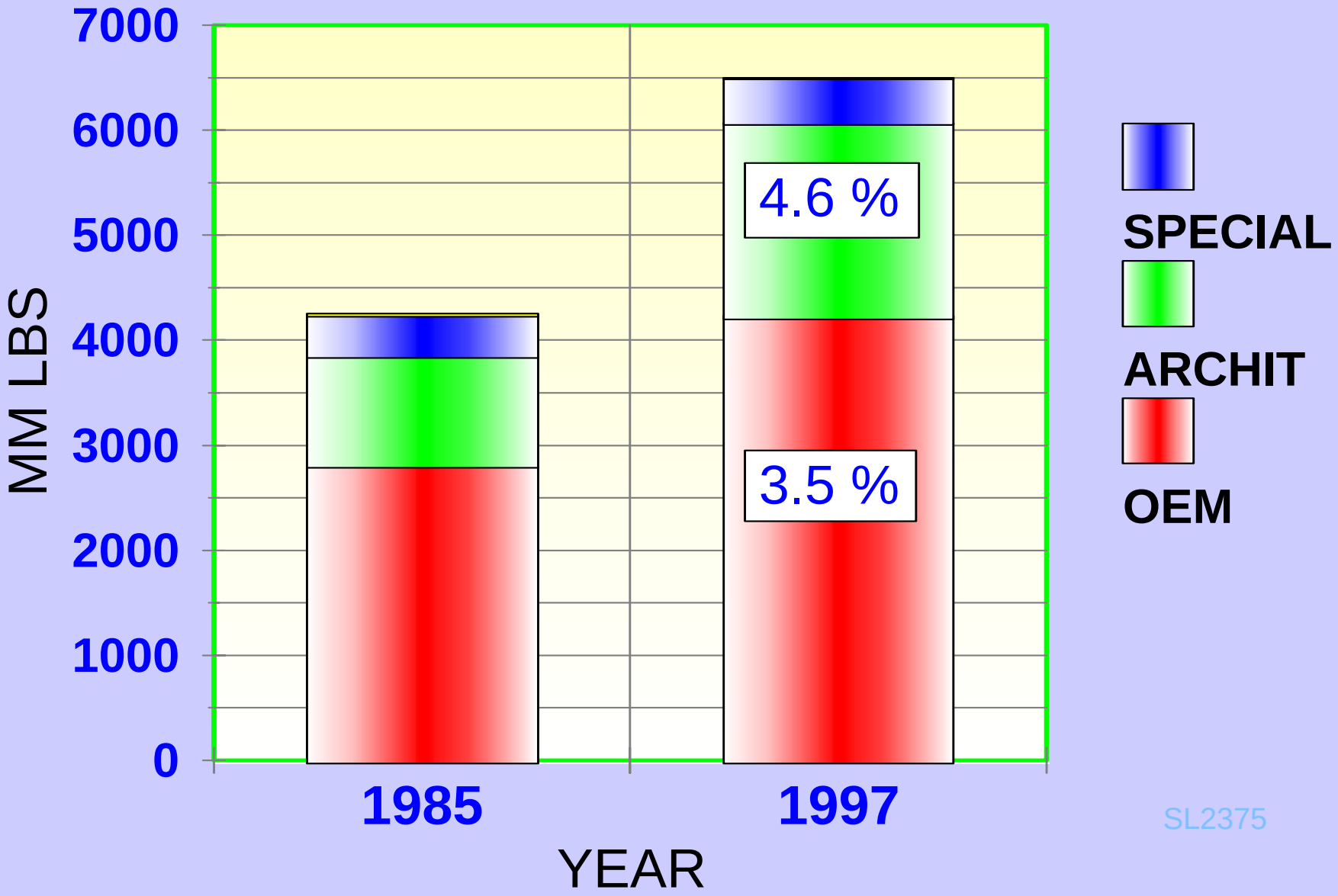
ELIMINATION OF SOLVENT POLLUTION
REDUCTION IN OZONE FORMATION
SAFETY IN WORK PLACE
HEALTH OF WORKER
ENERGY USE FOR CURE

How is VOC Regulated

Enduse
Regional control
Location, Amount of paint used
Per Object (surface area)

RESIN CONSUMPTION

1985 - 1997



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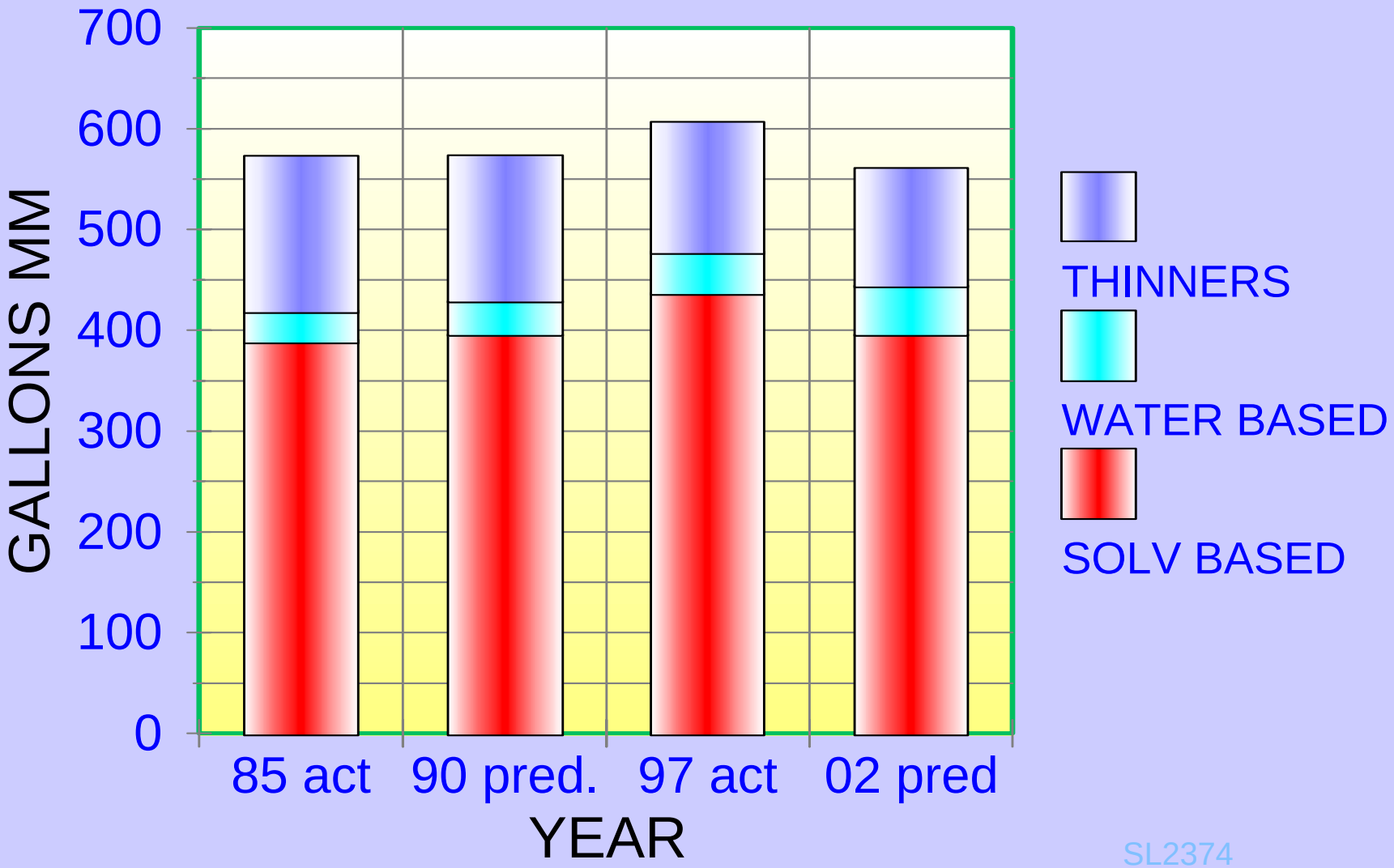
SOLVENT CONSUMPTION

ACTUAL & PREDICTED



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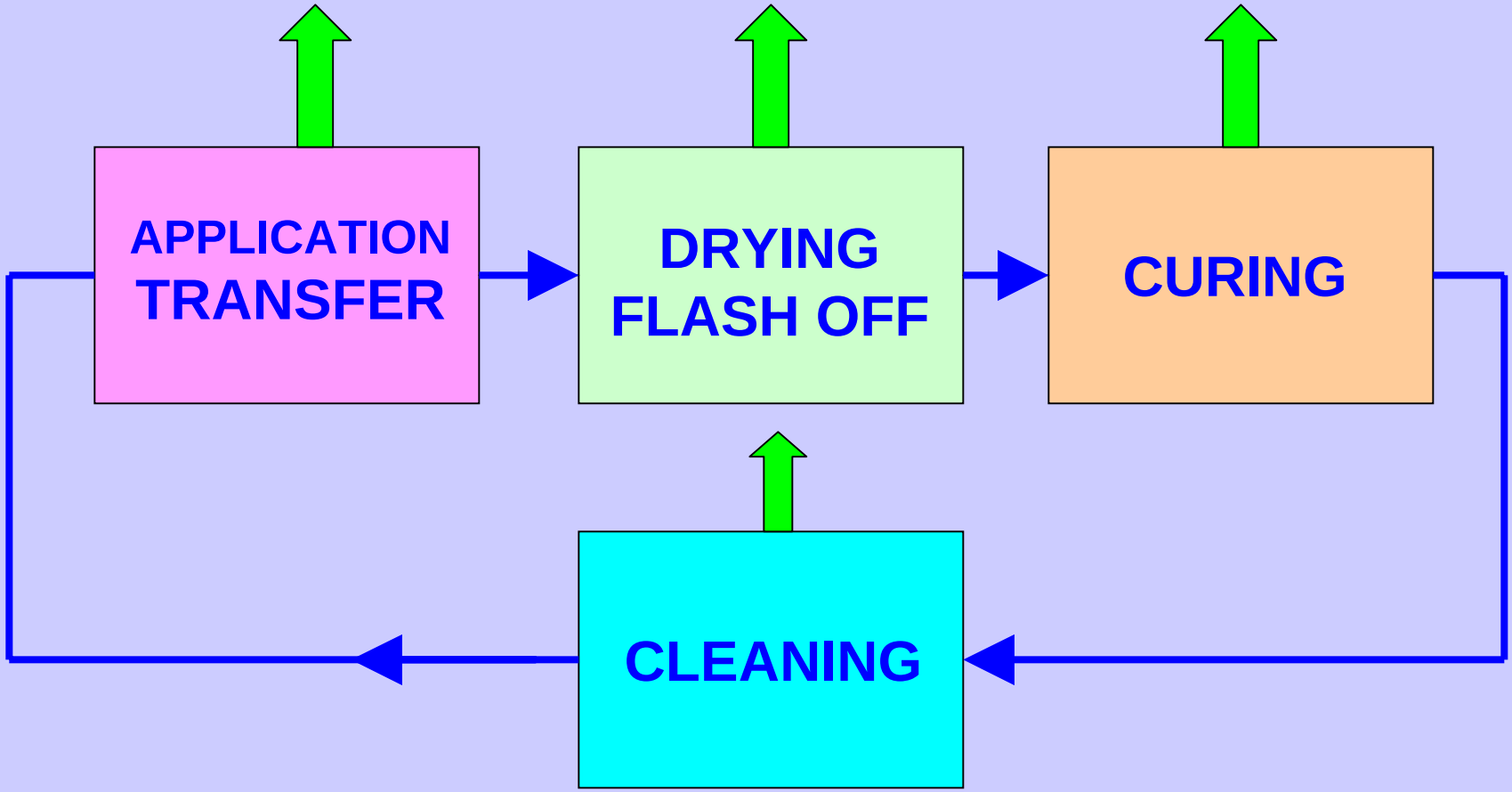
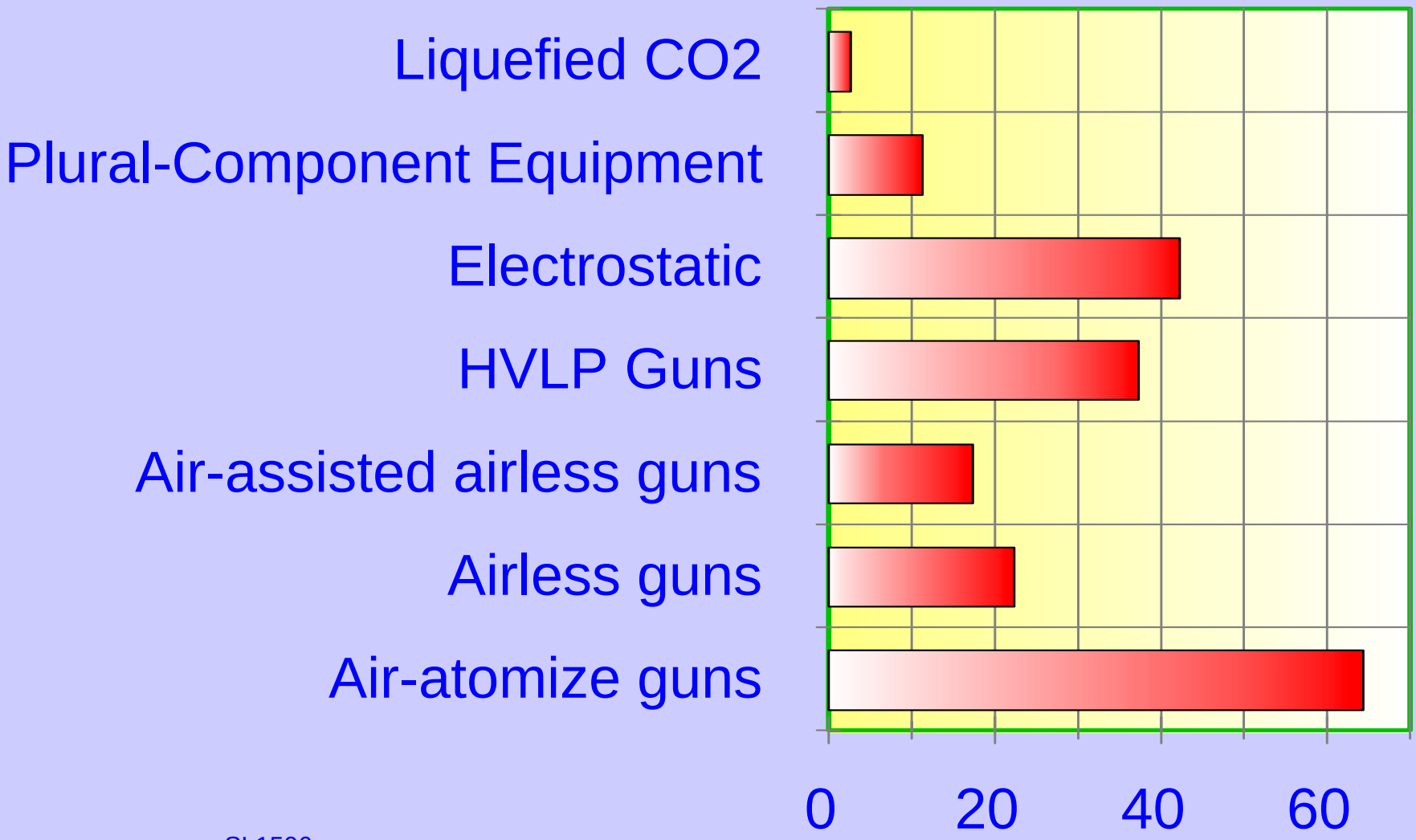
SOLVENT EMISSION

Product life cycle



Spray Equipment



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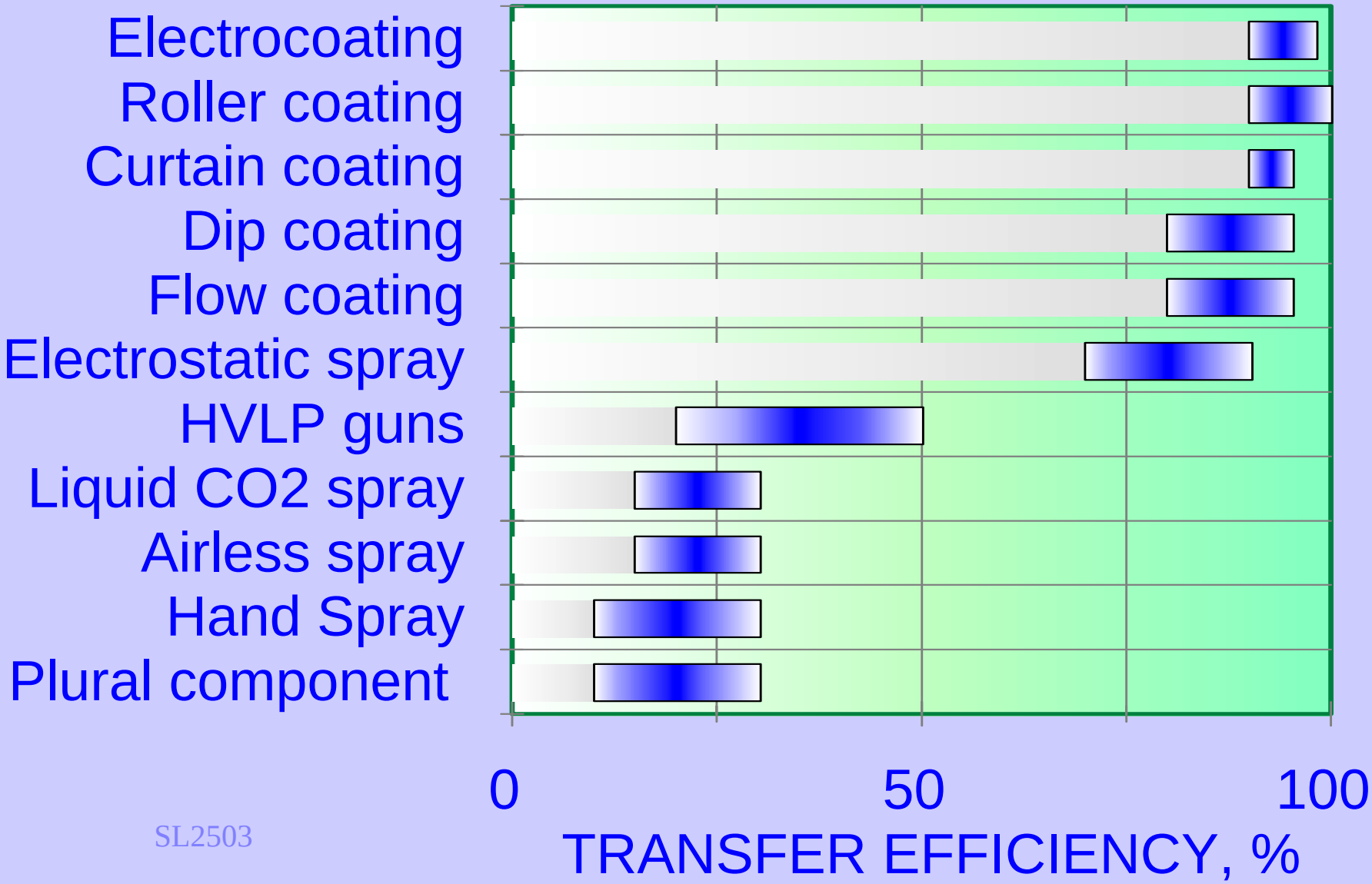
APPLICATION METHOD



COATING TECHNOLOGIES

HIGH SOLIDS - SOLVENT FREE

VISCOSITY/SOLIDS & POTLIFE/DRY TIME

WATERBORNE

COSOLVENT, APPLICATION CONDITIONS

ELECTROCOATING

DRY-TIME

PRODUCTION VOLUME, SUBSTRATE

CURE TEMPERATURE

UV/EB COATING

COMPLEX OBJECTS, PIGMENTS

POWDER COATING

LOW FILM THICKNESS, CURE TEMPERATURE

FLOW AND LEVELING

HIGH SOLIDS - SOLVENT FREE COATINGS

Advantages

Reduces VOC and HAP emissions
Reduces inventory
Reduces fire hazards
Reduces number of spray applications to achieve a given film thickness
Higher crosslink density improves abrasion and mar resistance
Compatible with conventional spray equipment
Reduces safety and odor problems
Reduced air makeup in ovens

HIGH SOLIDS - SOLVENT FREE COATINGS

Disadvantages

Generally requires high cure temperatures
Sensitive to inadequate cleaning of substrate
Is difficult to control film thickness
Tacky overspray; difficult to clean
Might require paint heater in system
Difficult to control sagging
Has narrow "time-temperature-cure" window
Cannot use in dip or flow coating
Is difficult to repair
Shorter pot-life than conventional coatings

WATERBORNE COATINGS

Advantages

Reduces VOC and HAP emissions
Can use conventional application processes
Reduces toxicity and odor
Is easy to clean up
Reduces disposal of hazardous waste
Can recover and reuse some waterborne paints
Non-hazardous waste disposal might be possible

WATERBORNE COATINGS

Disadvantages

Has tendency to foam
Clean surface required
Longer drying times or increased oven temperatures
Has difficulty obtaining high gloss finish
Has difficult cleanup once coating is cured
Higher cost
Conversion might be expensive
Lower transfer efficiencies for electrostatic
Increases runs and sags
Requires good temperature/humidity control
Heated storage

ELECTROCOATING

Advantages

Utilizes over 90 percent of coating material
Uniform coating on all surfaces
High production rates
Corrosion-resistant coating
Low VOC and HAP emissions
Can be fully automated

ELECTROCOATING

Disadvantages

Substrate limitation
Separate lines for each color
High cost to install
Requires sophisticated maintenance
Difficult coating bulky, small parts
Requires de-ionized water
Is restricted to large volume finishing
Has coating thickness limitation
Requires corrosions-resistant equipment

RADIATION CURING UV/EB

Advantages

Lower VOC and HAP content
Lower capital investment than conventional ovens
Short cure time
Low energy costs
Consistent performance
Requires small ovens
Low air movement that reduces dust contamination
Easily installed/retrofitted
Reduces fire and explosion hazard

RADIATION CURING UV/EB

Disadvantages

Cure inhibition by pigments
Higher RM costs for EB and UV coatings
Potential skin irritation problems with acrylate
Shrinkage and adhesion problems with acrylate
Curing sensitive to shape of part

POWDER COATING

Advantages

No solvent flash-off required
No coatings mix room needed
Minimal oven length required
Low ventilation required
Less floor space required
VOC and HAP compliant, i.e., no solvents
Good corrosion resistance
High transfer efficiencies, 95-99%
Saves energy
Requires little operator expertise
No hazardous overspray, waste sludge
Reduces worker exposure to solvent vapors

POWDER COATING

Disadvantages

High cure temperature
Small batches expensive to manufacture
Metallic powder coatings not as attractive
Appearance problems
Enhances Faraday cage effect
Difficult to achieve thin films below 1.0-1.5 mils
May cause powder clumping
Difficult to change colors
Needs cool, dry storage area
Must pretreat substrate

COATING TECHNOLOGIES

HIGH SOLIDS - SOLVENT FREE

VISCOSITY/SOLIDS, REACTION PRODUCTS

WATERBORNE

COSOLVENT, REACTION PRODUCTS

ELECTROCOATING

COSOLVENTS, REACTION PRODUCTS

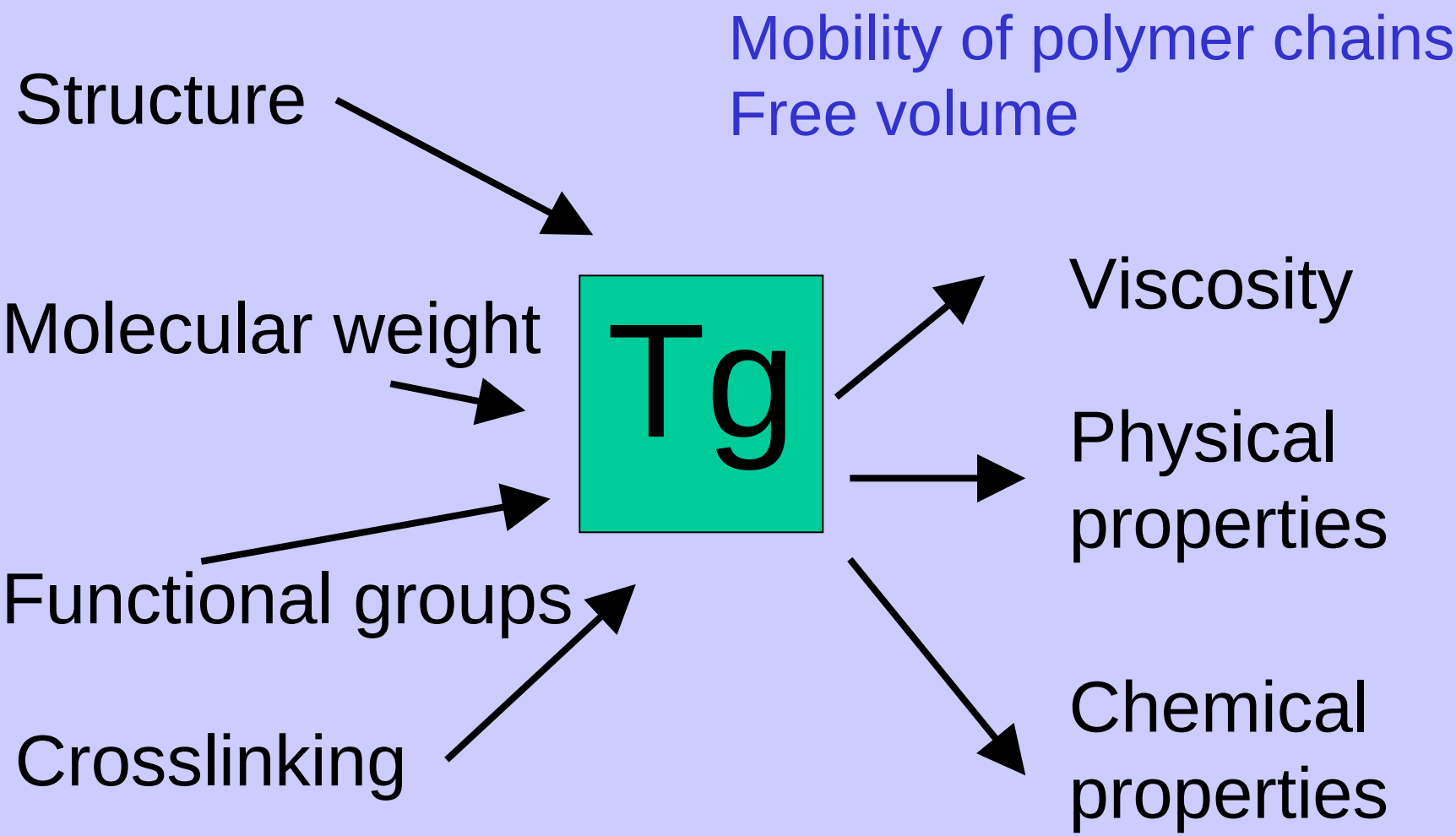
UV/EB COATING

POWDER COATING

High Solids Challenges

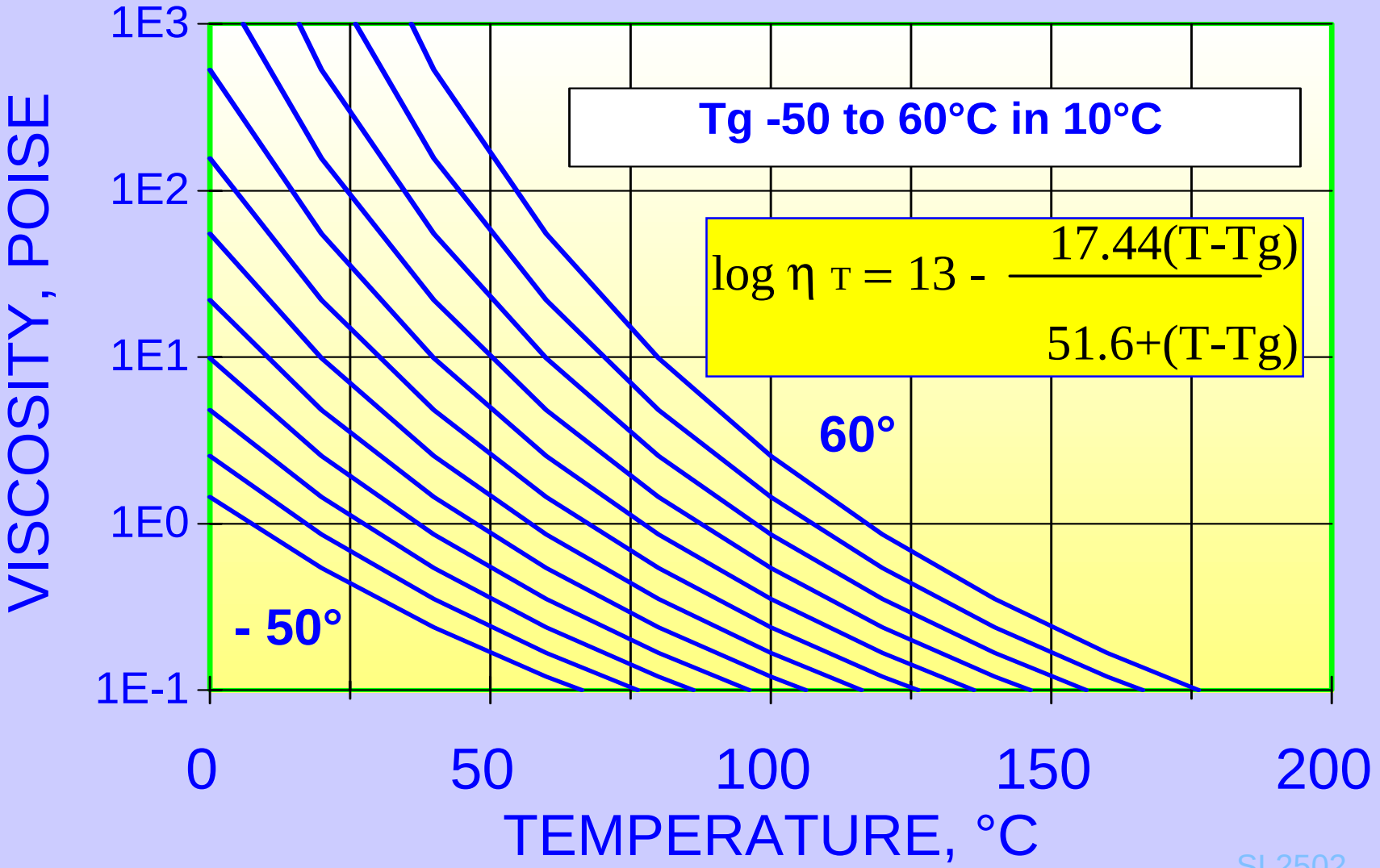
Nonvolatile - Viscosity
Crosslinking
Network formation
Application characteristics
    Potlife - reactivity
Rheology
    Sagging
Pigmentation - Flocculation

Glass Transition Temperature



VISCOSITY - TEMPERATURE

OLIGOMERS MW 500



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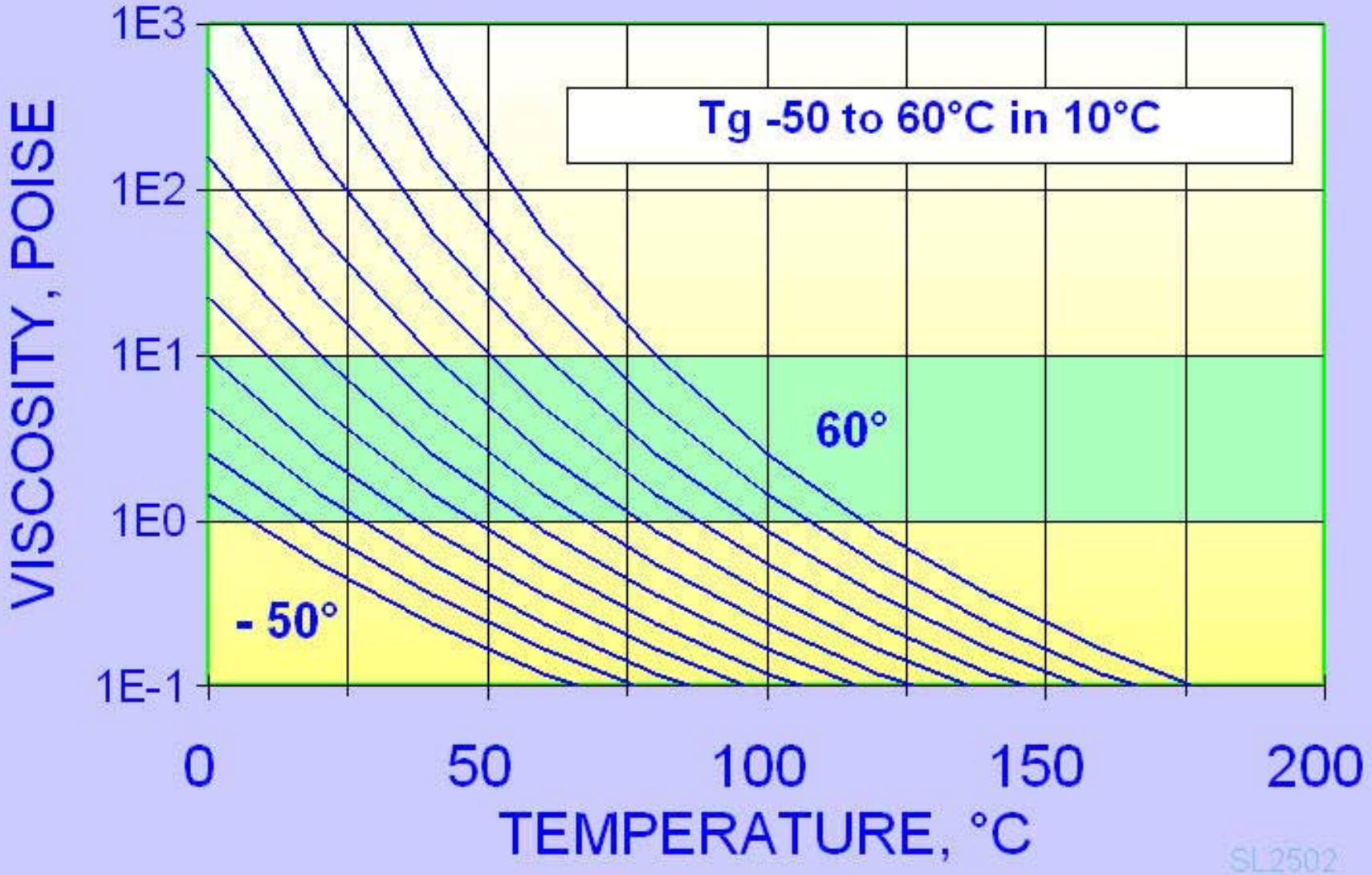
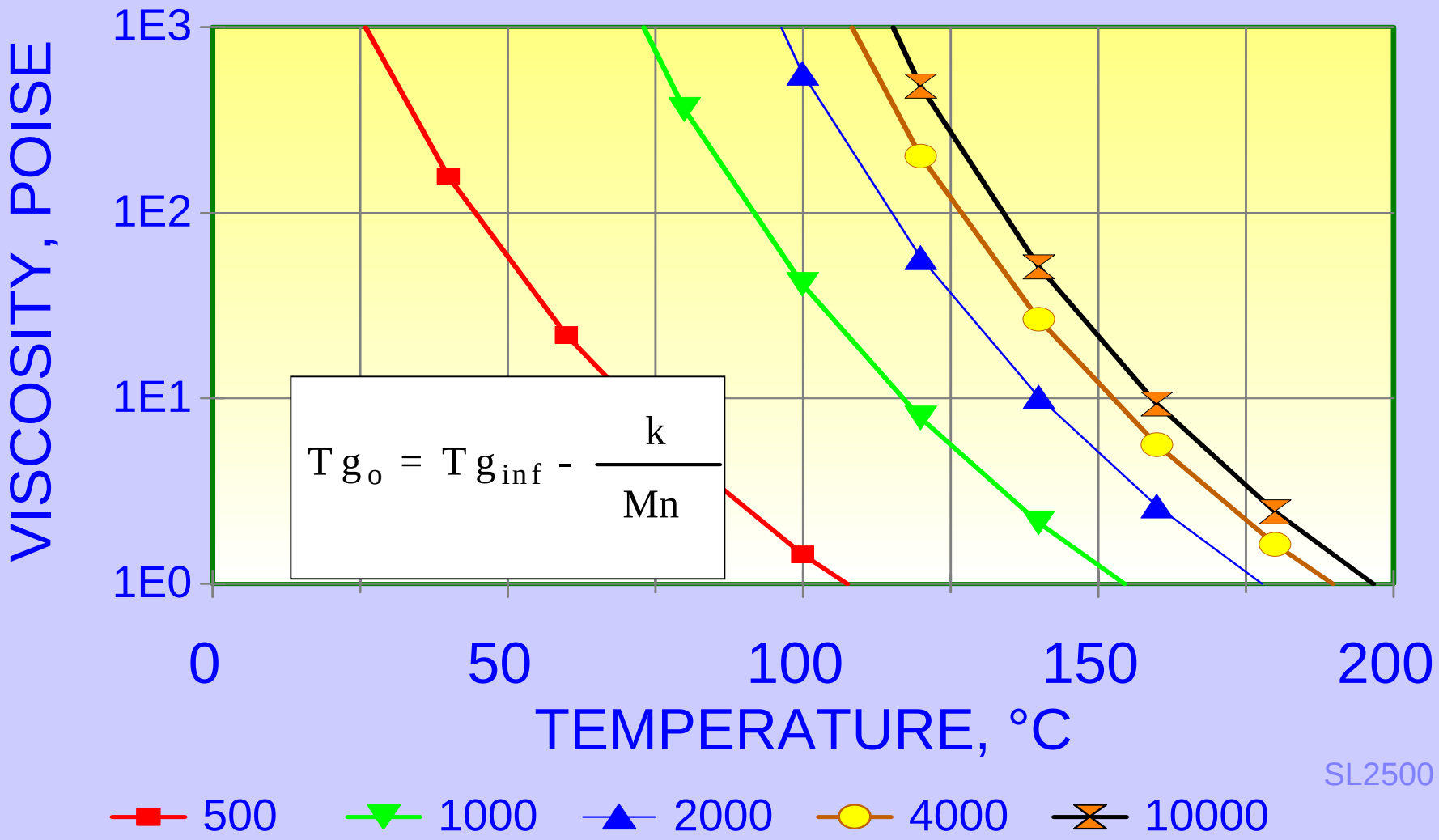
VISCOSITY - TEMPERATURE

OLIGOMERS MW 500



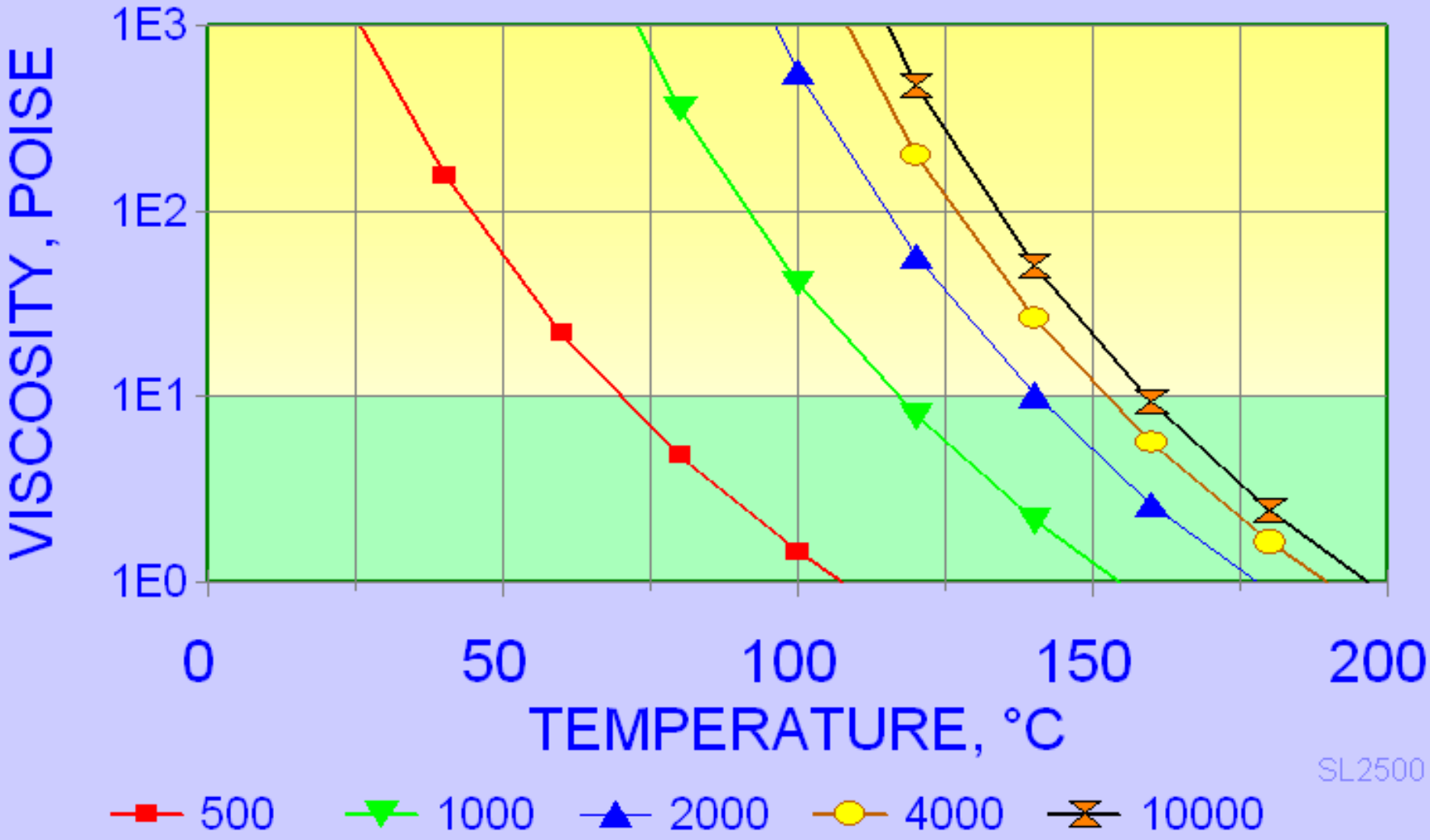
VISCOSITY - TEMPERATURE

OLIGOMERS, Tg 50°C



VISCOSITY - TEMPERATURE

OLIGOMERS, Tg 50°C



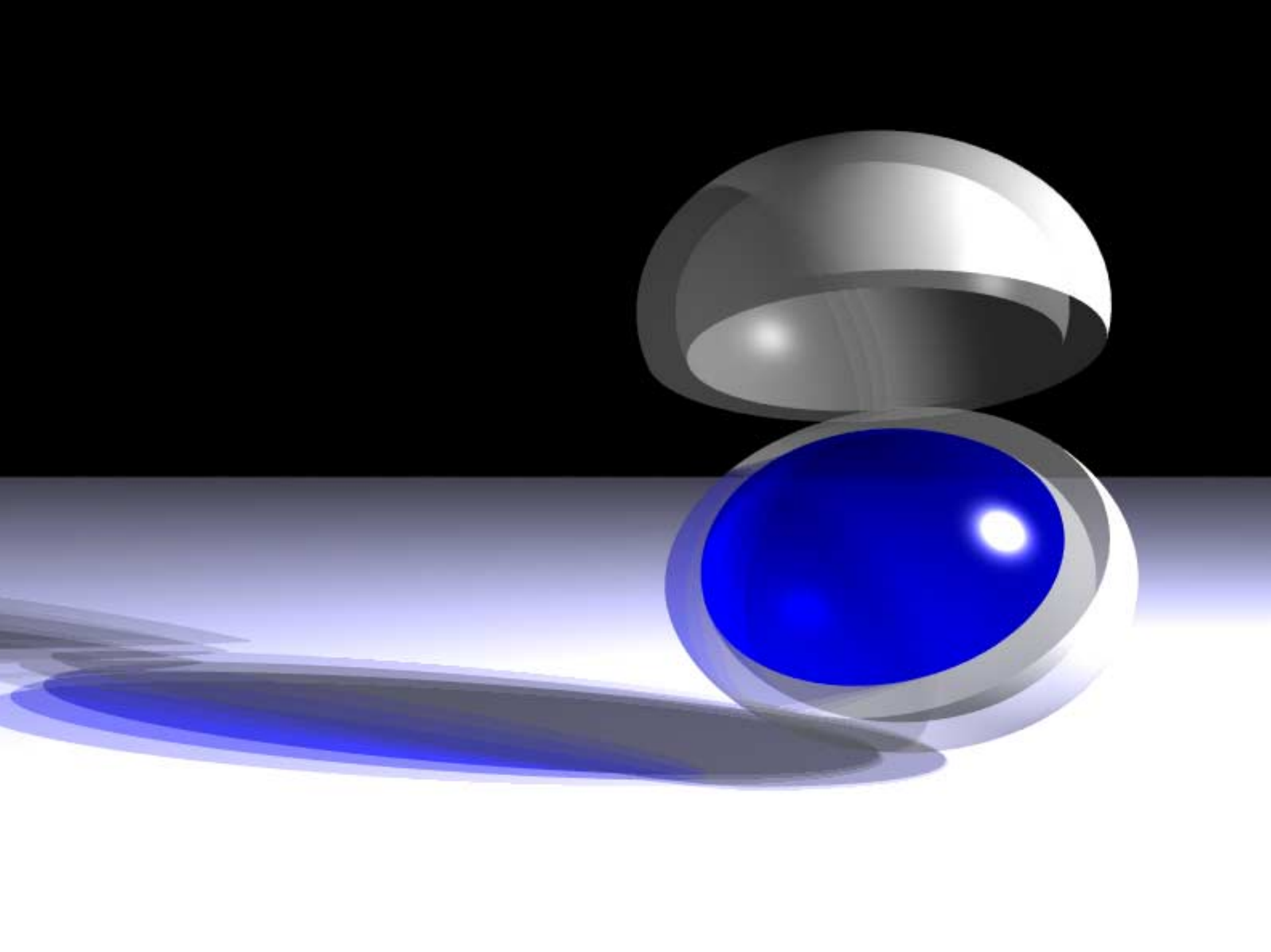
WATERBORNE COATINGS - COSOLVENTS

EMULSIONS-DISPERSIONS

COALESCENCE
OPEN TIME
FLOW - LEVELING
GLOSS
ADDITIVES

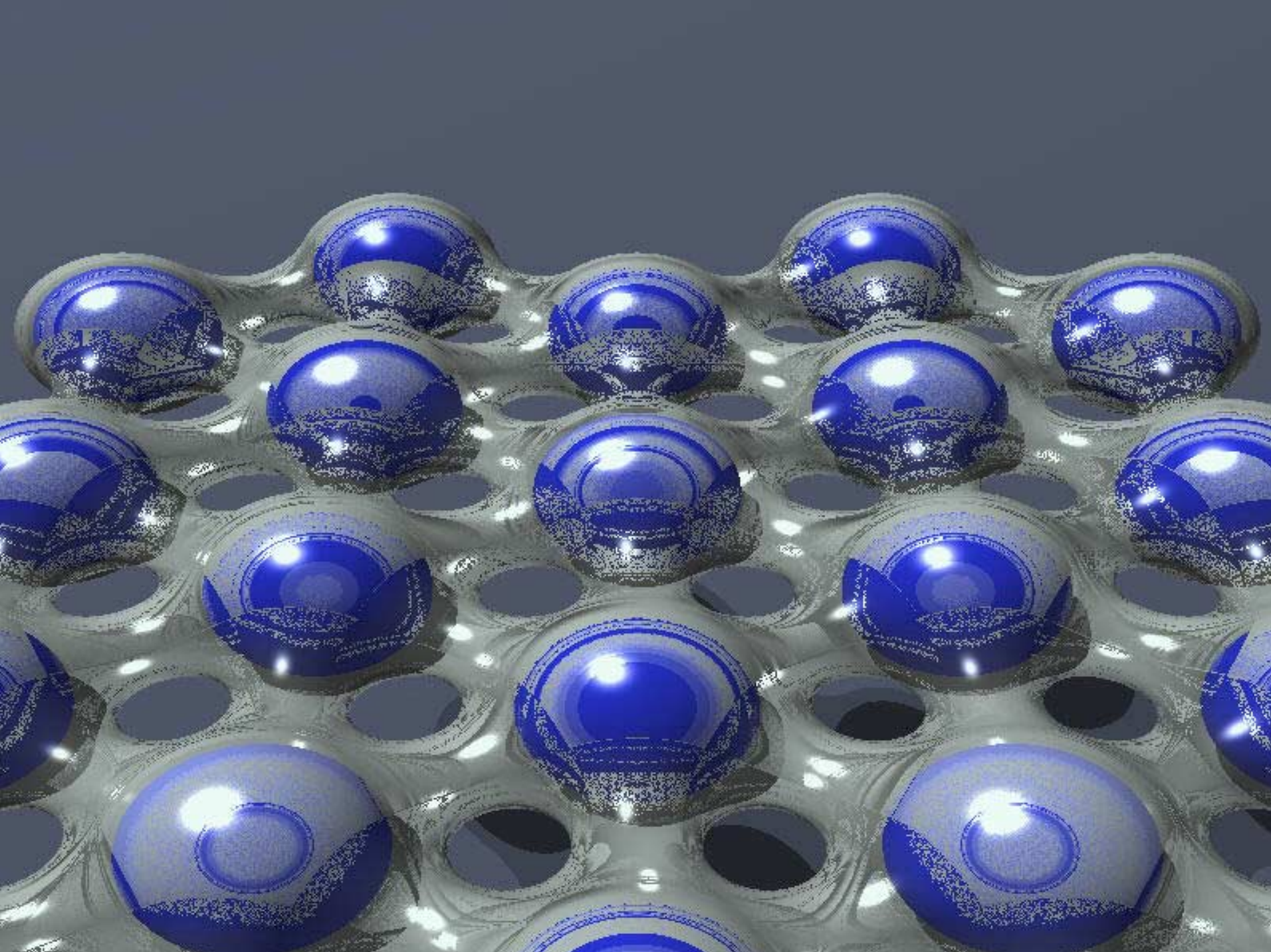
WATER-SOLUBLE

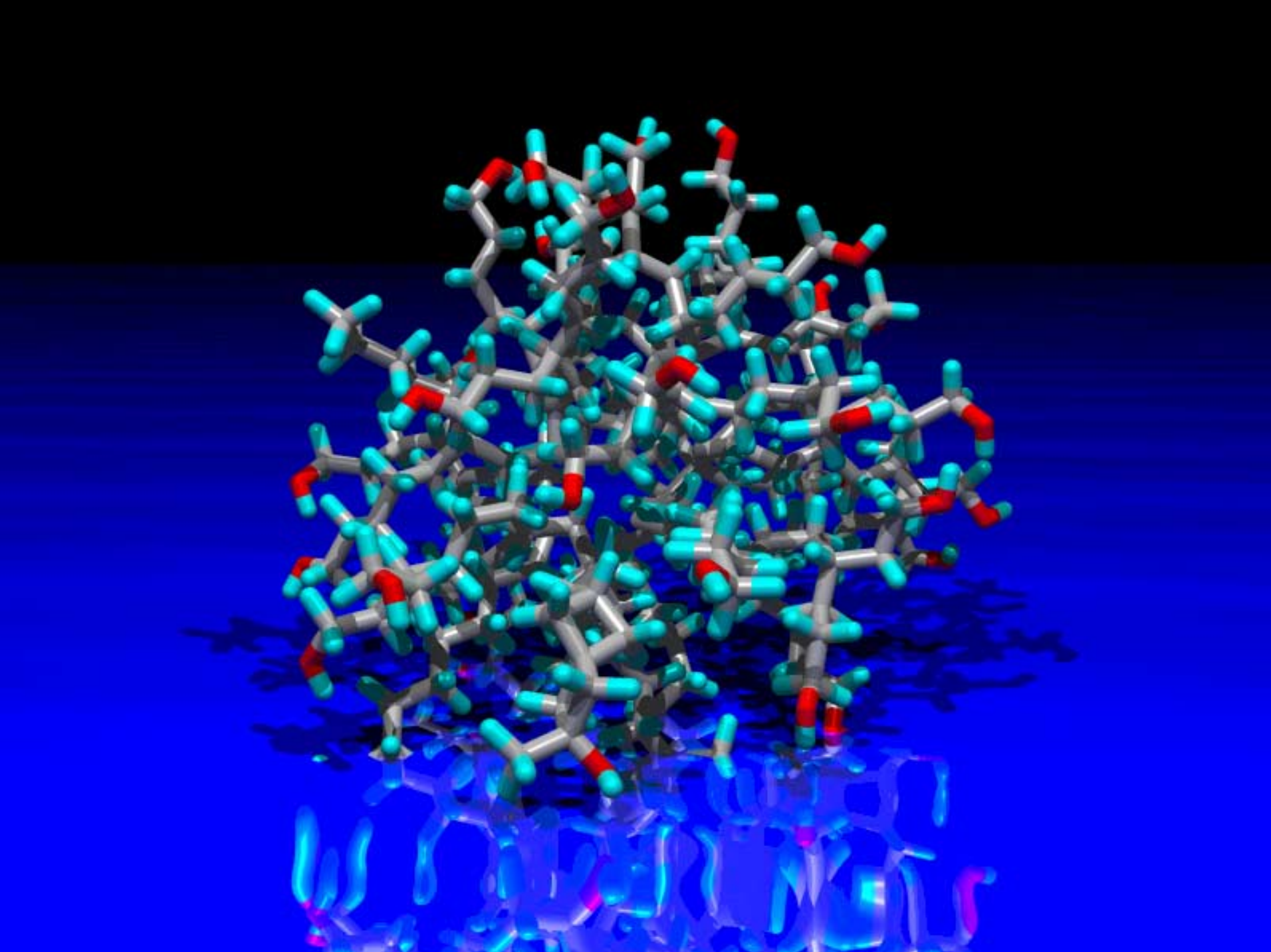
MANUFACTURE
HANDLING
DILUTION
OPEN TIME
BLISTERING
FLOW - LEVELING



WATERBORNE POLYMERS

Characteristic	Emulsion/ dispersion polymer
Functional groups	Non-random
Amount of functional groups*, MEQ/g	0 to 2
Surfactant	Yes
Particle size, micron	0.1-2.0
Molecular weight	10^4-10^6
Film uniformity	Heterogeneous
Film formation	Tg dependent
Cosolvent	Coalescence





WATERBORNE POLYMERS

Characteristic	Solution or bulk
Functional groups	Random distribution
Amount of functional groups, MEQ/g	0.5 to 2
Surfactant	No
Particle size, micron	0.01 to 0.1
Molecular weight	10^3-10^4
Film uniformity	Homogenous
Film formation	No Tg effect
Cosolvent	Dispersion-synthesis

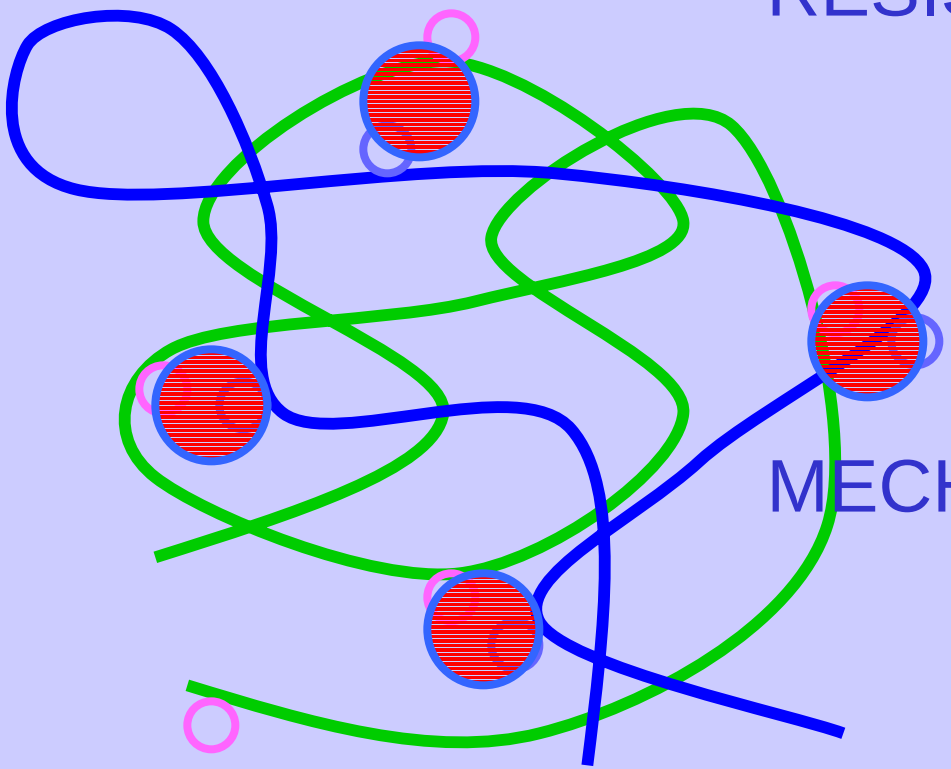
WATERBORNE REACTIVE DILUENT-COSOLVENTS

Chemistry	Advantage - disadvantage
Non-ionic	Water sensitivity
Polyether polyol	Exterior durability
Bisphenol A EO-PO diols	Exterior durability
Urethane diols	Cost
Polyester polyol	Hydrolytic stability
Melamine resins	Heat cure, formaldehyde
Epoxy aliphatic	Not stable
Unsaturated compound	Light stability, color
Resin COOH functional	Amine

CROSSLINKING REACTION

WHY CROSSLINKING

INCREASE IN MOLECULAR WEIGHT-NETWORK



RESISTANCE PROPERTIES

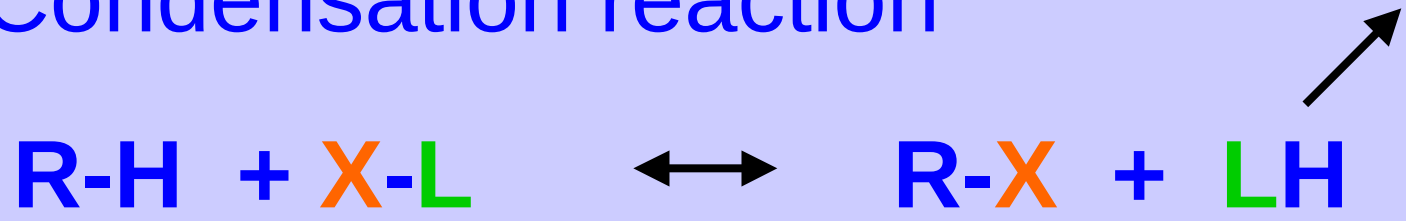
- CHEMICAL
- SOLVENT
- CORROSION

MECHANICAL PROPERTIES

- HARDNESS
- FLEXIBILITY

CROSSLINKING REACTION

Condensation reaction



ADVANTAGE

STABILITY-
CURE RESPONSE

DISADVANTAGE

WEIGHT LOSS
VOC
FILM SHRINKAGE
STRESS
GLOSS
COST

CONDENSATION REACTIONS

Amino resins, melamine, urea formaldehyde

FORMALDEHYDE, ALCOHOL, WATER

Blocked isocyanate

KETOXIME, PYRAZOL, ALCOHOL

Silane, siloxane

ALCOHOL

Hydroxyethyl amide -carboxyl

WATER

Methylol amide, glycoluril, cyclic urea

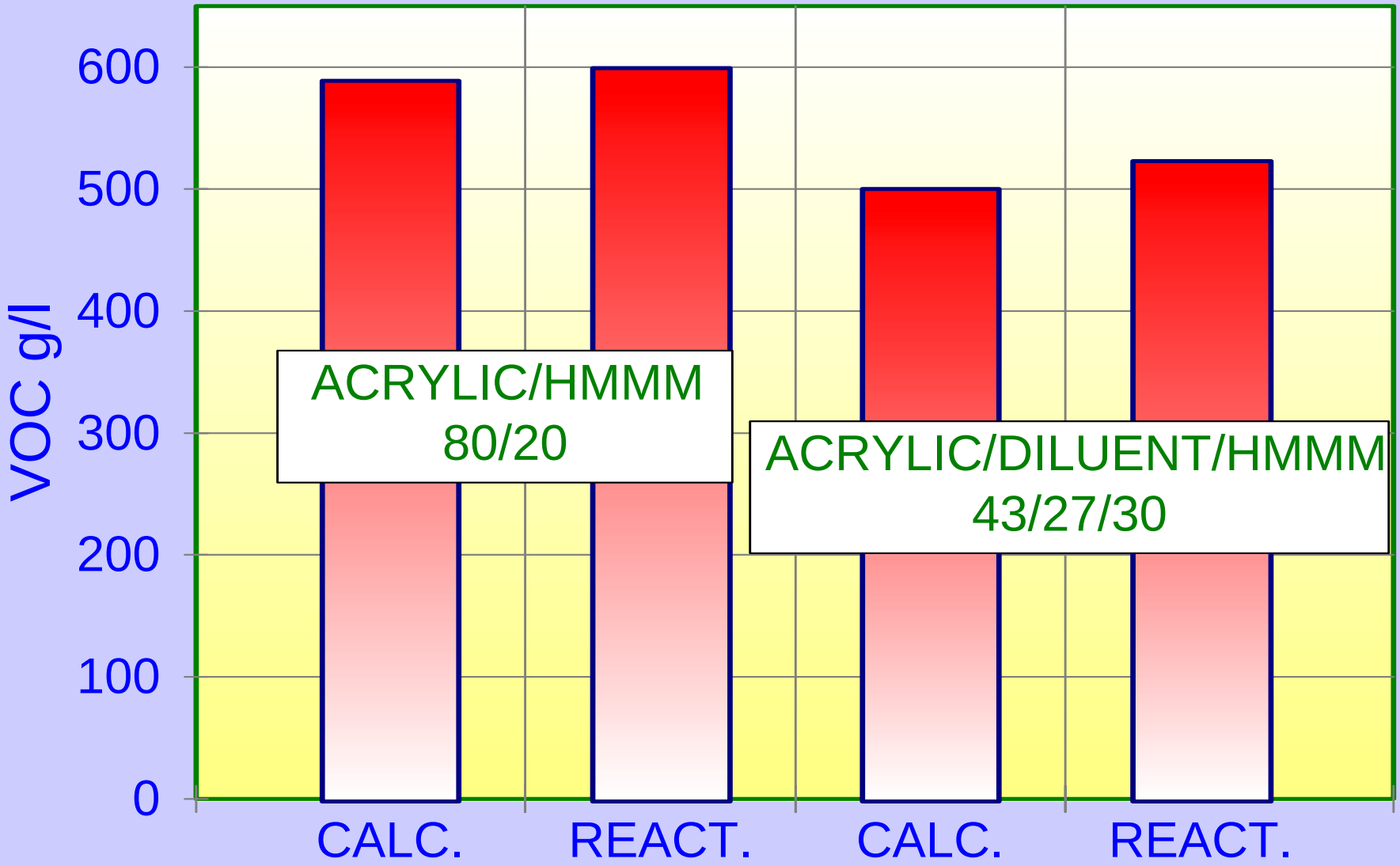
WATER

Hydroxyl-carboxyl

WATER

VOC OF ACRYLIC/HMMM & DILUENT

REACTION WEIGHT LOSS



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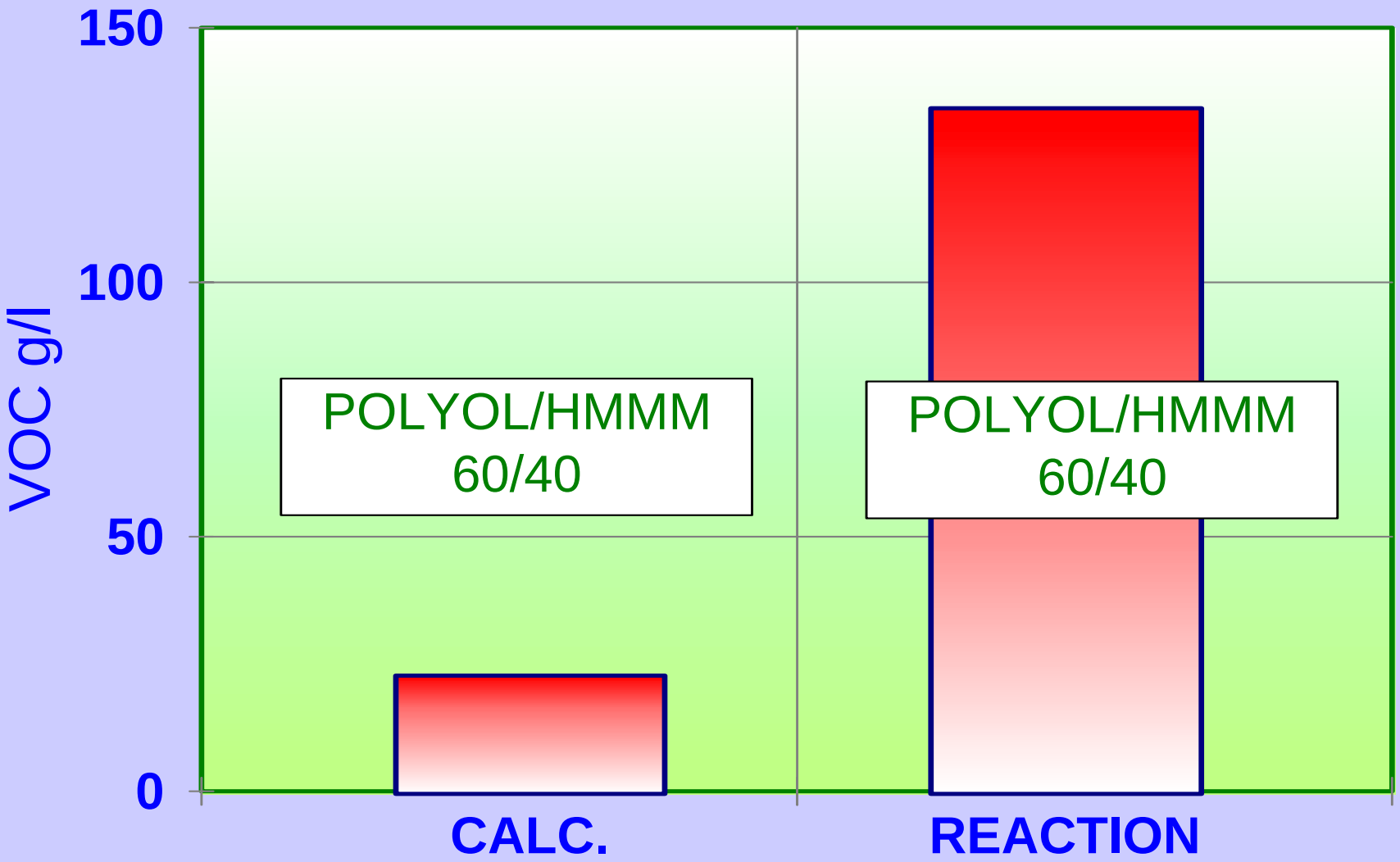
VOC OF POLYOL/HMMM

REACTION WEIGHT LOSS



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Ring Opening and Addition Reaction

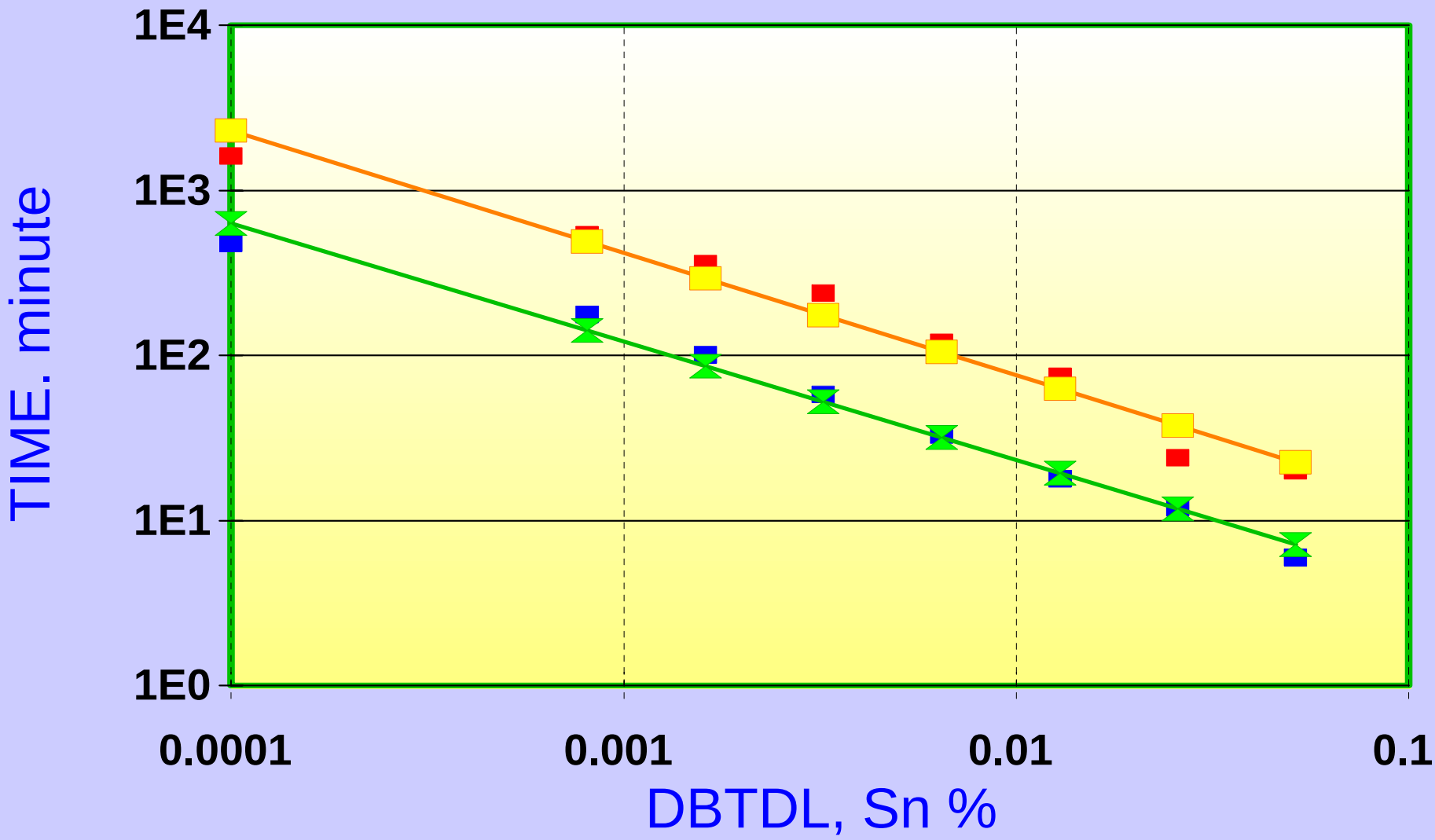
Epoxy, Glycidyl, Cycloaliphatic,
Oxetane
Uretdione
Carbonate
Azetidine
2-Oxazoline
Carbodiimide
Aziridine
Azlactone
Cyclic urea acyl
Isocyanate
Michael Addition

REDUCTION OF VOC IN HIGH SOLIDS

Approach	Details
Molecular weight	<500
Molecular weight	Narrow MW distribution
Functional groups	2-3 per polymer chain
Functional groups type	End groups, H-bond.
Crosslinking type	Ring opening
Crosslinking	Hydrogen bonding
Dispersion of resin	High Tg hetero. phase
Water addition	Breaking of H-bonds

PE/HDI-TRIMER

CATALYST REACTION RATE



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COATING TECHNOLOGIES

UV/EB COATING

POWDER COATING

HIGH SOLIDS - SOLVENT FREE

LOW MW, X-LINKING, H-BONDING

WATERBORNE

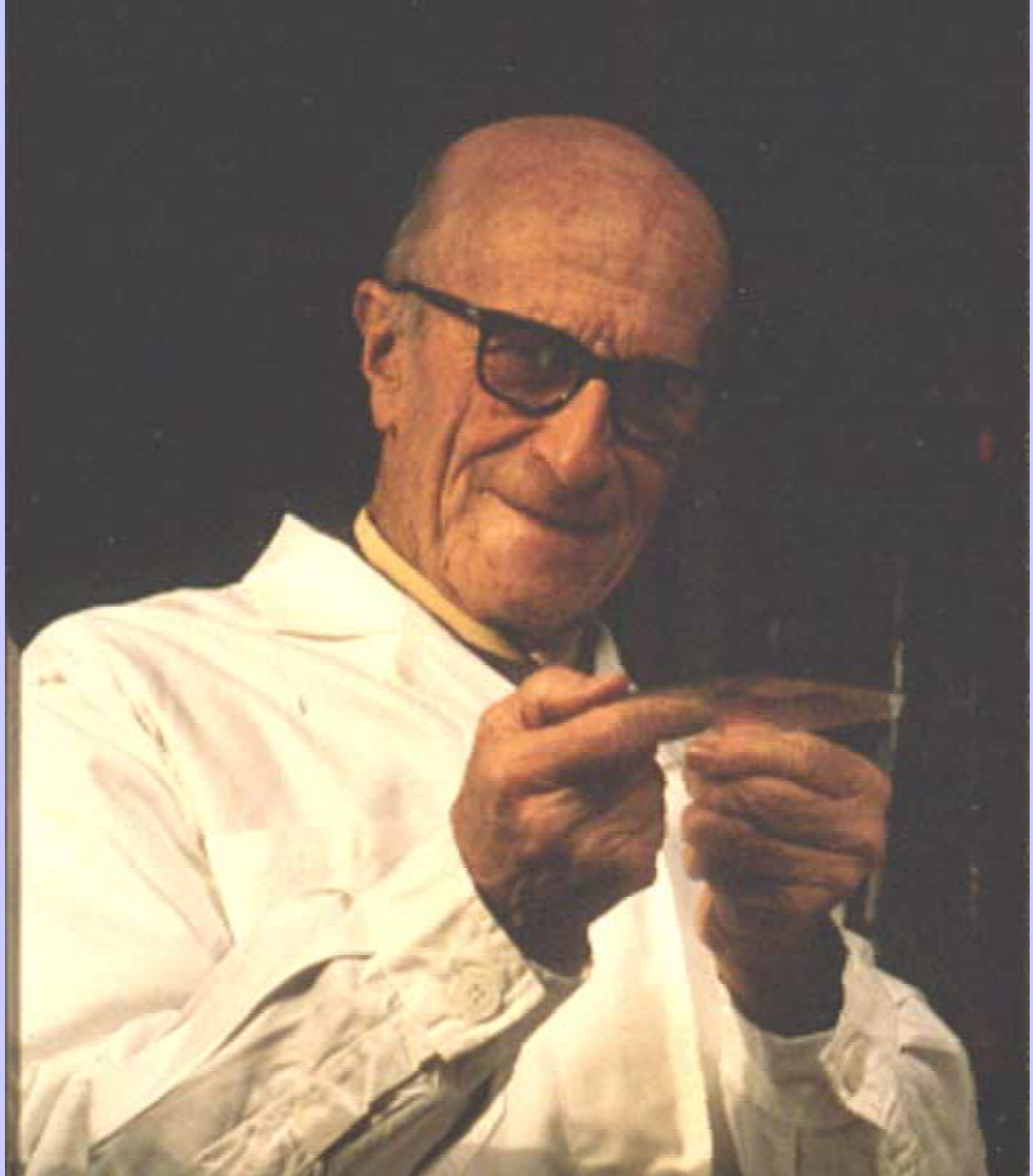
REACTIVE DILUENT, X-LINKING

ELECTROCOATING

REACTIVE DILUENT, X-LINKING

Pioneer in Waterborne Coatings Dr. Herbert Hönel

Vionova



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wblank@kingindustries.com
www.wernerblank.com
www.kingindustries.com