



INTRODUCTION TO POLYURETHANE TECHNOLOGY



MADISON CHEMICAL INDUSTRIES INC.



WHAT IS A POLYURETHANE COATING?

ASTM Definition:

“Urethane based upon vehicles containing a minimum of 10 percent by weight (nonvolatile vehicle basis) of a polyisocyanate monomer reacted in such a manner as to yield polymers containing any ratio, proportion or combination of urethane linkages, active isocyanate groups, or polyisocyanate monomer. The reaction products may contain excess isocyanate groups available for further reaction at time of application or may contain essentially no free isocyanate as supplied.” – 68 words

Madison Chemical Definition:

“A versatile, strong and durable thermosetting chemical coating” – 8 words



POLYURETHANE CHEMISTRY IS THE MOST VERSATILE COATINGS CHEMISTRY

- A pool table for epoxy formulations



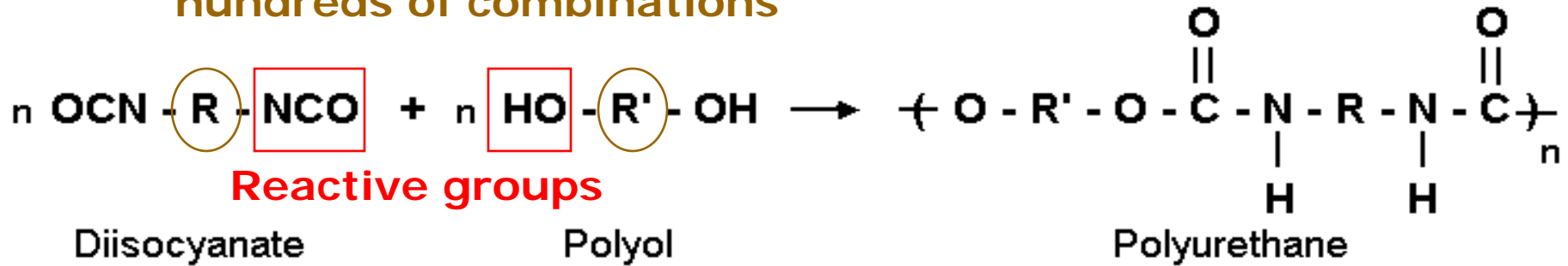
- A football field for polyurethane formulations





POLYURETHANE CHEMISTRY

R and R' groups have hundreds of combinations



Reactive groups

Diisocyanate

Polyol

Polyurethane

Iso or A-side

B-side

Tens of thousands of these repeating units make up the polymer 'backbone' which defines most performance properties



SIX ASTM POLYURETHANE COATING TYPES

	Type I	Type II	Type III	Type IV	Type V	Type VI
ASTM description	One-package pre-reacted	One-package moisture cured	One-package heat cured	Two-package catalyst	Two-package polyol	One-package non-reactive lacquer
Characteristics	Unsaturated drying oil modified; no free isocyanate	Contains free isocyanate	Blocked isocyanate	Isocyanate prepolymer plus catalyst	Part A, B	Fully polymerized polyurethane dissolved in solvents
Main curing mechanism	Oxidation of drying oil; Solvent evaporation	Reaction with atmospheric moisture	Thermal release of blocking agents and then reaction	Reaction of isocyanate with moisture and/or components in catalysts	Reaction between Part A and B; instant curing possible	Solvent evaporation

Types of concern to Madison





CONCEPTS – THERMOSET VS. THERMOPLASTIC

Thermoset Film

- result of a chemical cross linking reaction
- superior properties for industrial use
- Examples – Polyurethane, Epoxy

Thermoplastic Film

- no chemical reaction
- solvent evaporation/ coalescence to form film
- not suited for heavy duty industrial use
- Examples - Polyethylene, Vinyl, Acrylic latex





CONCEPTS - RATIO

- Can vary from 1:1 to 20:1
- By convention, the A-side (Iso) is the 1st digit, while the B-Side (Polyol) is the 2nd digit
- 1:1 ratio is easiest to apply





CONCEPTS - RATIO

1:1 Plural Component Properties

- Fast Setting
- 100% solids (no VOCs)
- Virtually unlimited thickness can be achieved
- Direct to metal application (primer-less)
- Can be applied at almost any temperature
- Highest physical performance properties
- Requires special plural component spray equipment





CONCEPTS – FORMAT 1

“PLURAL COMPONENT”

- At Madison, typically refers to 1:1 fast set format
- Various setting times
- All but the slowest are applied with plural component spray equipment
- ASTM Part V
- Ex: GalvaClad Aromatic and GalvaClad Aliphatic, plus many other CorroCote products



CONCEPTS – FORMAT 2

“MIX & APPLY”

- Could be several ratios in this format grouping:
 - ‘S’ System (resin + catalyst; essentially a 20:1 format); e.g. AlumiZinc ‘S’ and GalvaClad Liquid Zinc
 - 1:4 System; e.g. AcrylaThane 5200, AcrylaThane 55
 - 1:1 System (essentially, a slow set plural component); e.g. CorroCote II Classic Slow Set
- Can be applied by brush, roller or airless spray
- ASTM Part V





CONCEPTS - FORMAT 3 "PRE-CATALYZED"

- Single component, paint-like—"all in one can"
- Denoted as 'PC'
- Two curing mechanisms - partial chemical cure as inhibitors flash off and also moisture cure
- Examples include Flexcel PC
- Unique technology but we treat as ASTM Type II



CONCEPTS - CROSS LINK DENSITY

Low Density - Elastomeric



- Elastomeric, soft & rubbery
- Excellent abrasion resistance
- Lower chemical resistance
- Lower corrosion resistance
- Excellent for concrete

High Density - Rigid



- ▶ Rigid, hard
- ▶ Very good chemical resistance
- ▶ Very high adhesion
- ▶ Excellent corrosion resistance
- ▶ Excellent for steel



CONCEPTS - SETTING TIME

- Less than 60 seconds.....snap set
 - plural component spray / conveyor application
- 1-15 minutes.....fast set
 - plural component spray
- 15-30 minutes.....medium set
 - plural component spray





CONCEPTS - SETTING TIME

- < 30-60 minutes.....delayed set
 - mix & apply, spray with conventional airless, brush or roll

- >60 minutes..... slow set
 - open & apply, spray with conventional airless, brush or roll
 - usually 1 component





CONCEPTS - RECOAT WINDOW

- For hand spray applications the work must be planned to maximize the coating recoat window. Factors affecting the recoat window include:
 - Set time of the material
 - Thickness
 - Temperature (Spray, ambient, substrate)
 - Product





CONCEPTS - VISCOSITY

- **High** (up to 100,000 cps)
 - touchups and mastics
 - brush, roller or spatula application
- **Medium** (400-1500 cps)
 - 'paint like' for spraying
- **Low** (< 400 cps)
 - casting, primers
- Balanced viscosities are desirable for 1:1 fast set products





AROMATIC POLYURETHANE

- Aromatic polyurethanes
 - Cheaper
 - Often used for interior lining or underground applications
 - Exhibit a certain degree of color change ("yellowing")
 - However, their UV resistance is generally better than that of common epoxies
- Most 100% solids polyurethanes available today are aromatic polyurethanes





ALIPHATIC POLYURETHANE

- Aliphatic polyurethanes
 - More expensive
 - Provides the best UV resistance
 - Used for exterior applications and any other places where color stability is a concern
- The design of a 100% solids aliphatic polyurethane system is difficult and few coating manufacturers have such technology
 - Case history
 - Formulation properties





RECENT DEVELOPMENTS

- Anti-Microbial Additive
- Ceramic Modification
- Edge Retention Technology





PREVENTION OF MICROBIAL INDUCED CORROSION

- Two commonly used methods for preventing pipelines from MIC
 - PROTECTIVE BARRIER
 - Use a lining material
 - ALTERING THE ENVIRONMENT
 - Change the environmental conditions by reducing the level of bacteria

LET'S COMBINE THE TWO...



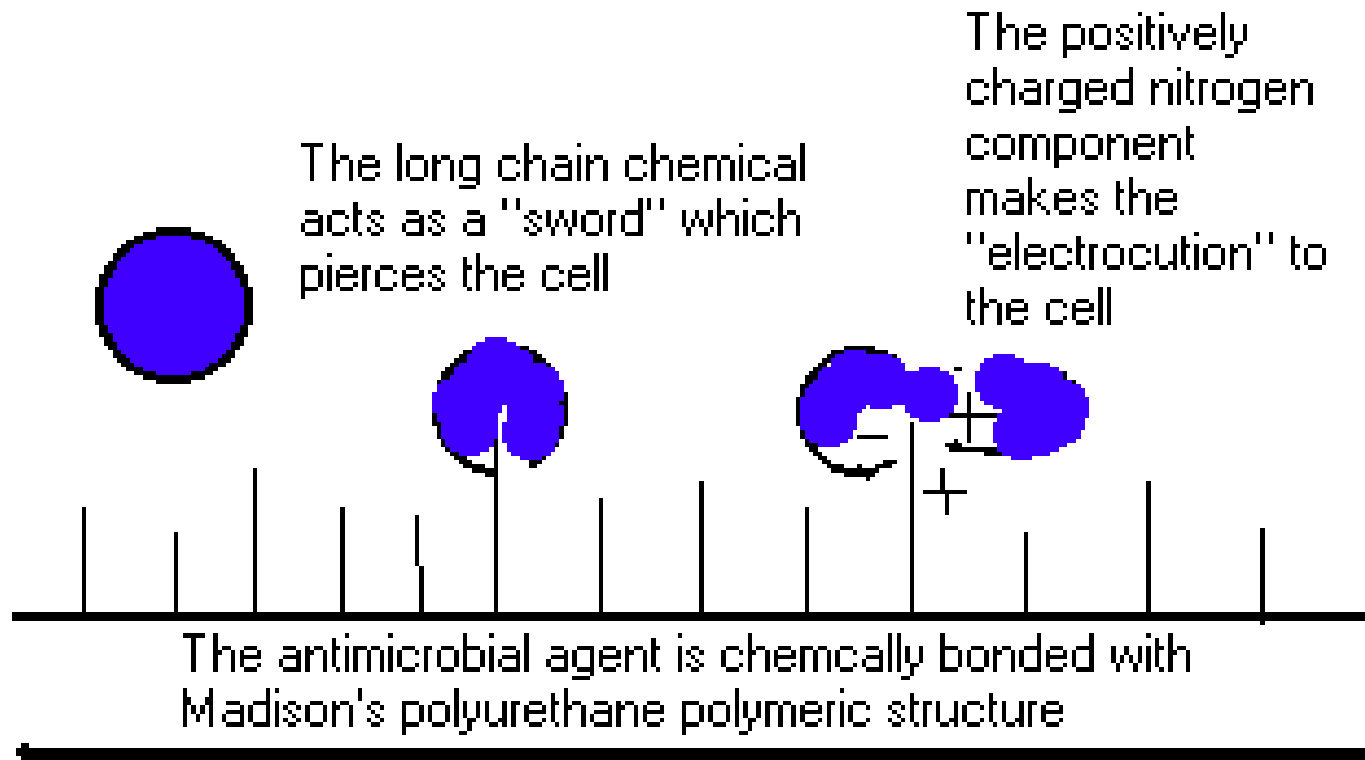


ANTI-MICROBIAL (AM) VERSION

- Proprietary Madison Technology
- Permanent technology, remains effective throughout the life of the coating
- Extremely effective in preventing microbial induced corrosion. The AM additive bursts microbes and "electrocutes" them



ANTI-MICROBIAL (AM) VERSION



Synergistic Protection From (MIC) Microbiologically Influenced Corrosion

AM technology prevents the colonization of bacteria which produce sulfide gas which in turn creates extremely acidic and corrosive conditions on the pipe crown



Flowing Sewage



CERAMIC MODIFIED VERSION

Ceramic Modified 100% Solids
Polyurethane coatings offer at least 3X
greater abrasion resistance

Interior – Meets challenge of highly abrasive
and aggressive flow applications

Exterior – Abrasive applications, e.g.
scuffing, gouging and marring from rocky
terrain and faying metal surfaces



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E RETENTION HNOLOGY

Coatings tend to 'pull back' from edges and sharp corners due to surface tension effects

This results in thin films with the potential to be starting points for corrosion and is particularly problematic for immersion service

Developed in 2003, this technology dramatically improves the ability of the coating to keep high build on edges



EN AND SAFE

- Coal Tar
- Styrenes
- Amines
- Monomeric Isocyanate
- Solvents
- Flammability
- Leachate