



MonoSol
inspiring **material** solutions



Water Soluble Film – MonoDose™ Packaging

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Water Soluble Film



Innovations ... for every day life



MonoDose™ Soluble Film Products

Dissolvable in Water

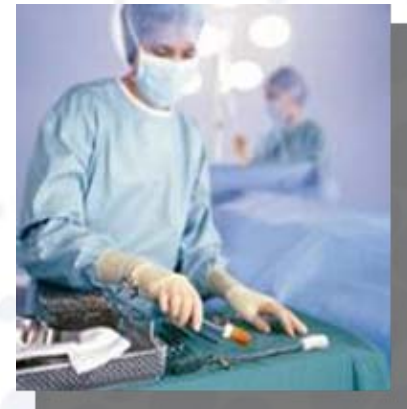
MonoDose™:

- Fabric Care
- Dishwasher Care
- Beauty Care
- Institutional Care
- Agro Chemical
- Food Services
- Edible Delivery



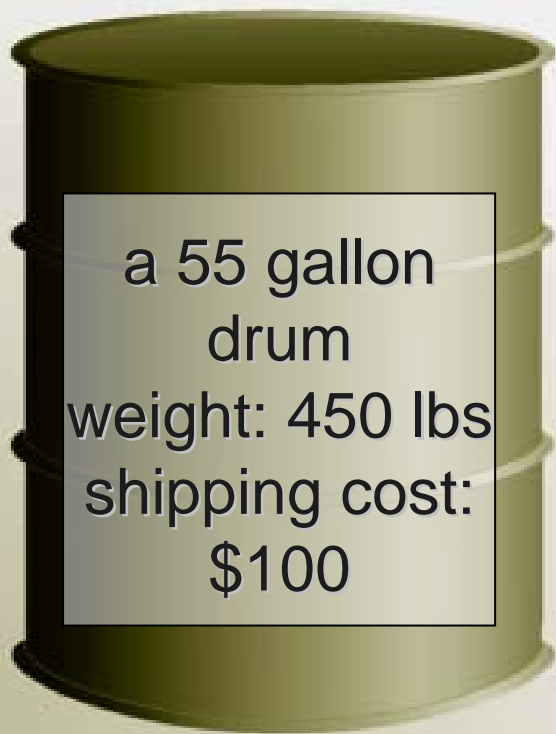
Unit Transport:

- Laundry bags
- Instrument Bags

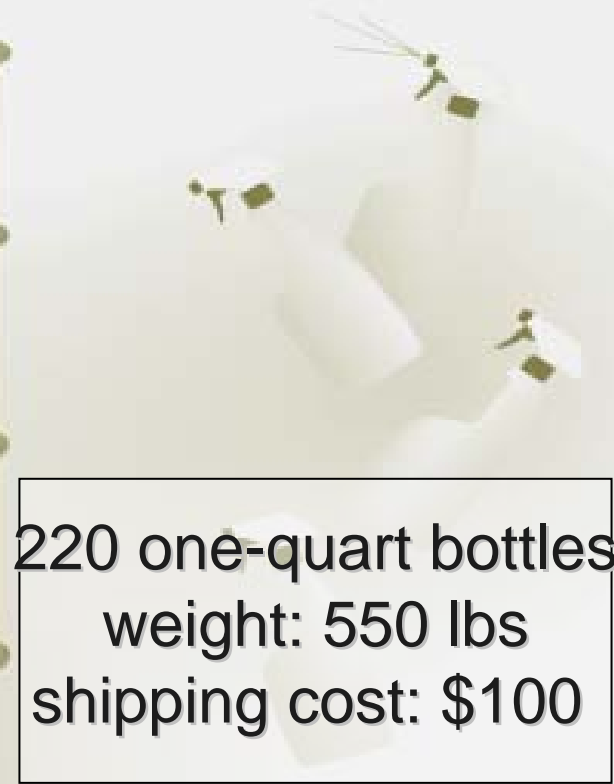


Use MonoDose™ Water Soluble Films to reduce packaging materials...

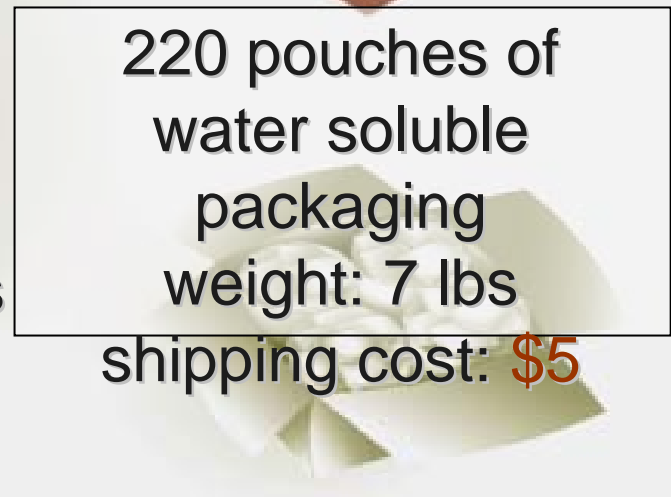
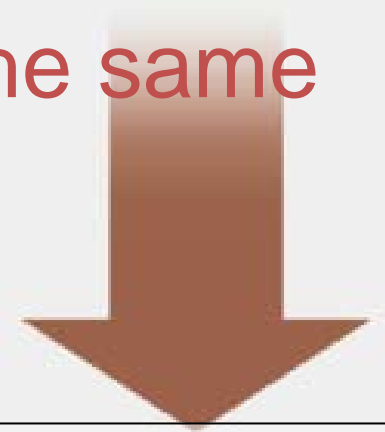
the total active ingredient is the same



a 55 gallon
drum
weight: 450 lbs
shipping cost:
\$100



220 one-quart bottles
weight: 550 lbs
shipping cost: \$100



220 pouches of
water soluble
packaging
weight: 7 lbs
shipping cost: \$5

*transportation costs are based from Chicago to Atlanta



Water Soluble Packaging Film

1. Types of water soluble films
2. Polyvinyl alcohol film properties
3. Biodegradability of Polyvinyl alcohol films
4. Benefits of MonoDose™ Films
5. Applications



Water Soluble Polymers

Synthetic

Polyvinyl Alcohol (PVOH)

Polyethylene Oxide

Polyvinyl Pyrrolidone

Polyacrylic acid

Polyacrylamide

Semi-Synthetic

Cellulose ethers: MHPC, HPC, CMC

Natural

Polysaccharides (carbohydrates including starches & gums)

Proteins

Very few water-soluble polymers compared
to water-insoluble polymers

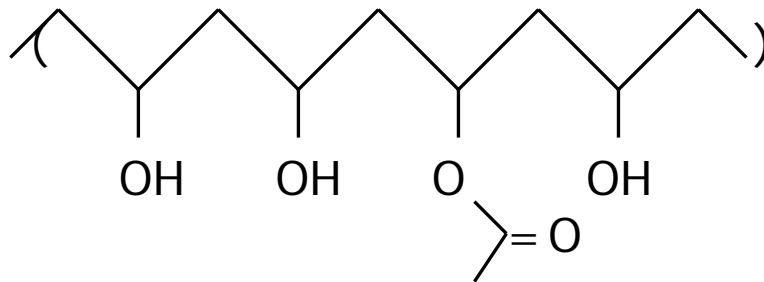
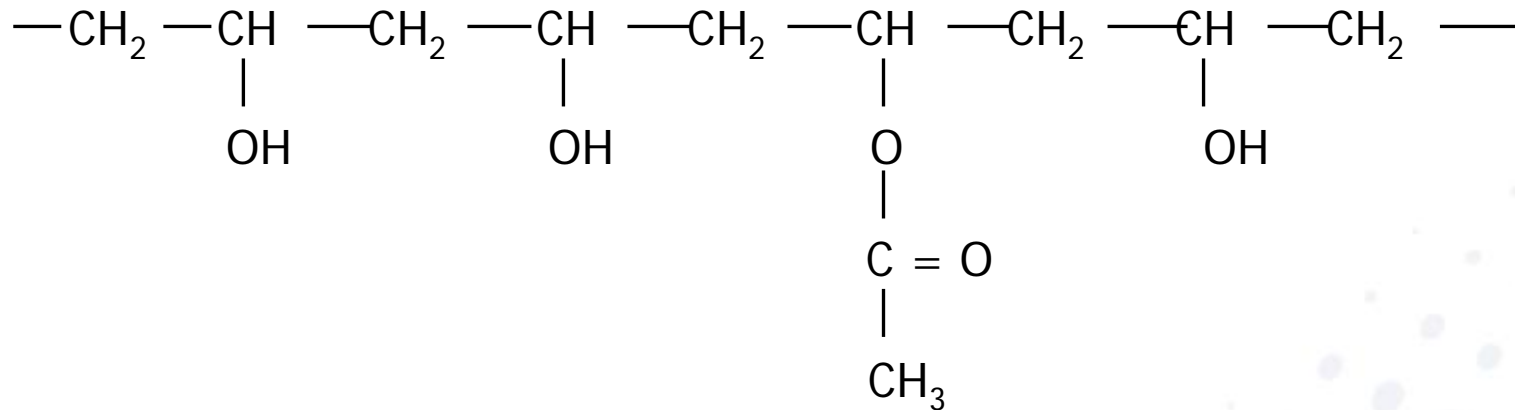


Chemistry of Polyvinyl Alcohol

- PVOH is made in two stages, and from another polymer:
 - 1) Vinyl acetate is polymerized to form Polyvinyl acetate
 - 2) Polyvinyl acetate is hydrolyzed to form Polyvinyl alcohol
- The Degree of Polymerization (DP) and the Degree of Hydrolysis (DH) govern both the mechanical properties and the water solubility characteristics of film derived from the polymer.
- DP has the major influence on mechanical properties
- DH has the major influence on solubility



Structure of Cold Water Soluble Polyvinyl Alcohol



alternate depiction



Effect of DP and %DH on Polyvinyl Alcohol

Characteristic	DP		%DH	
	Low	High	Low	High
Viscosity of Solution	↓ ↓	↑ ↑	↓	↑
Mechanical Properties	↓ ↓	↑ ↑	↓	↑
Water Solubility	↑	↓	↑ ↑	↓ ↓
Water Resistance	↓	↑	↓ ↓	↑ ↑

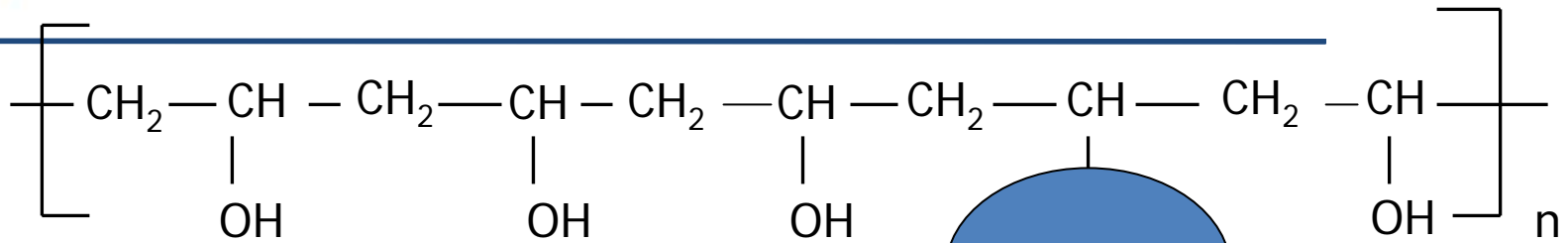


Types of Polyvinyl Alcohol

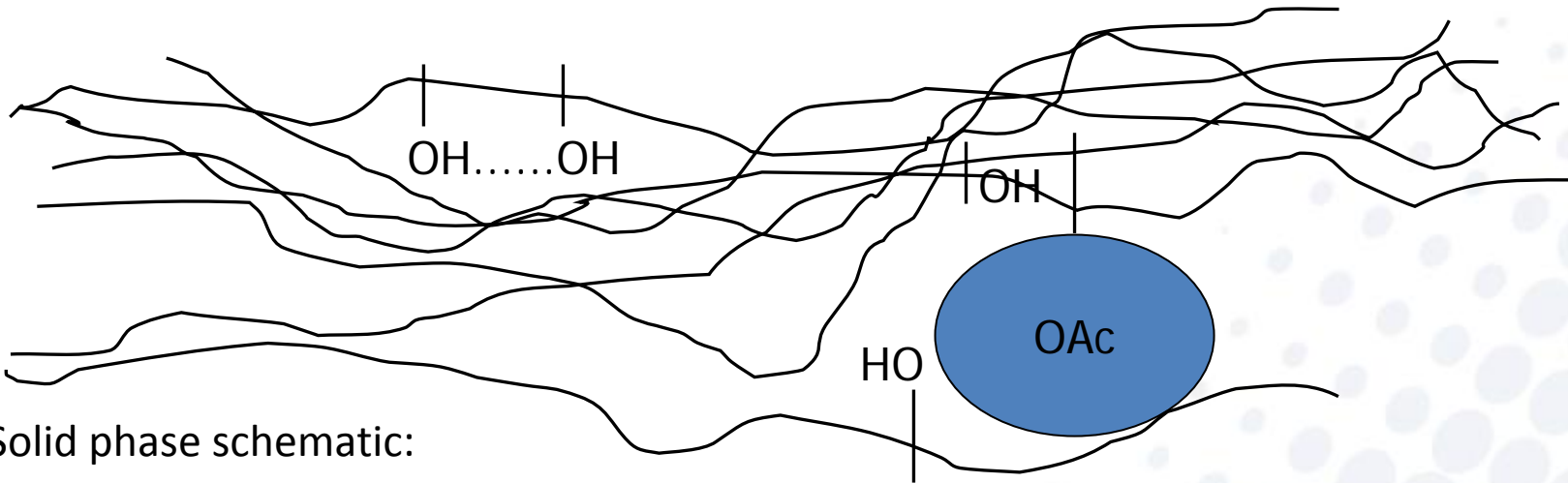
- Partially hydrolyzed grades
 - Typically have a 88% degree of hydrolysis (i.e. conversion of acetate groups)
 - Cold water soluble
- Fully hydrolyzed grades
 - Typically have a 98-99% degree of hydrolysis (i.e. conversion of acetate groups)
 - Increase crystallinity
 - Soluble in hot water



Solubility of Polyvinyl Alcohol



Polymer chain structure:



Large acetate groups weakens strong hydrogen bonding between hydroxyl groups, allowing water to penetrate - this creates solubility



Chemistry of Polyvinyl Alcohol

- Homopolymers: Both fully and partially hydrolyzed Polyvinyl alcohol grades are commonly referred to as homopolymers although the partially hydrolyzed type is technically a vinyl alcohol-vinyl acetate copolymer
- Copolymers: The term copolymer is generally used to describe polyvinyl alcohol grades that are derived by the hydrolysis of a vinyl acetate copolymer (with another monomer)



Polyvinyl Alcohol Film Properties

- Variable water solubility (DH of the resin)
- Excellent gas barrier properties
 - 12,000 times less permeable to CO₂ than LDPE
 - 5 million times less permeable to O₂ than LDPE
- Highly resistant to many organic solvents and oils
- Good film former
- Excellent mechanical properties
 - Tough, elastic and resilient
- Antistatic and release properties
- Printable without surface treatment
- Secondary processing
 - Bag making, heat seals, printing, slitting etc
- Flushable/biodegradable



Select Polyvinyl Alcohol Film Properties

Cast Films

Typical Properties @ 23°C and 50% RH		M8630 ^(A)	M8900 ^(A)	M7031 ^(B)	M1030 ^(A)
Type (Cold/Hot Water Soluble)		CWS	CWS	CWS	HWS
Tensile Strength (ASTM D882, ISO 527)	N/sq mm	37	27	41	56
Modulus 100% (ASTM D882, ISO 527)	N/sq mm	10	10	16	21
% Elongation (ASTM D882, ISO 527)	%	590	440	410	490
Tear Resistance (ASTM 1922, ISO 6983)	Kg/mm	37	30	47	16
Equilibrium Moisture Content	%	8.3	4.4	5.8	6.1

(A)76 micron

(B)38micron



Select Polyvinyl Alcohol Film Properties

Blown Films				
Typical Properties @ 23°C and 50% RH		L711^(A)	L337^(B)	A200^(C)
Type (Cold/Hot Water Soluble)		CWS	CWS	HWS
Tensile Strength (ASTM D882, ISO 527)	N/sq mm	45/44	30/32	72/78
Modulus 10% (ASTM D882, ISO 527)	N/sq mm	91/82	49/43	240/290
Modulus 100% (ASTM D882, ISO 527)	N/sq mm	34/23	18/9	65/46
% Elongation (ASTM D882, ISO 527)	%	180/230	230/420	130/230
Tear Resistance (ASTM 1922, ISO 6983)	Kg/mm	16/16	50/59	12/12
Equilibrium Moisture Content	%	7.1	7.6	6.7

(A)35 micron

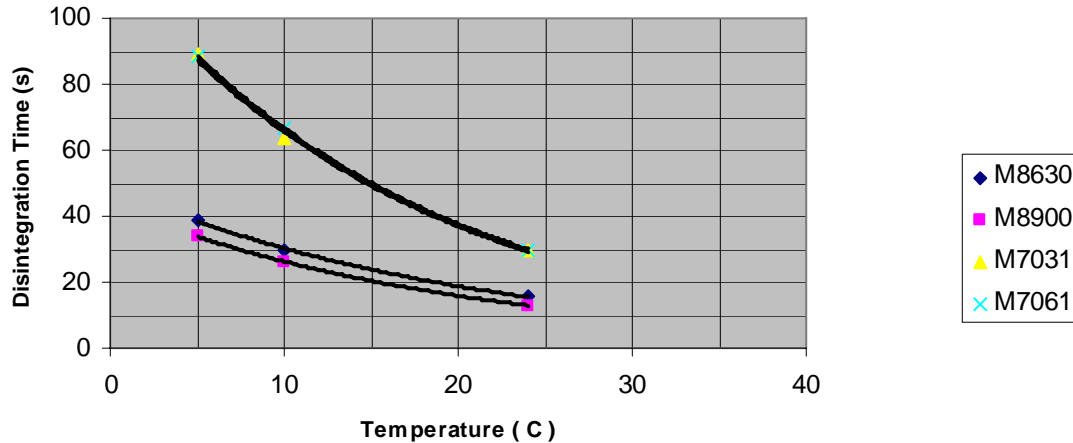
(B)50 micron

(C)20 micron



Select Polyvinyl Alcohol Film Properties

Disintegration versus Temperature



Thickness of film is 3 mil or 76 microns

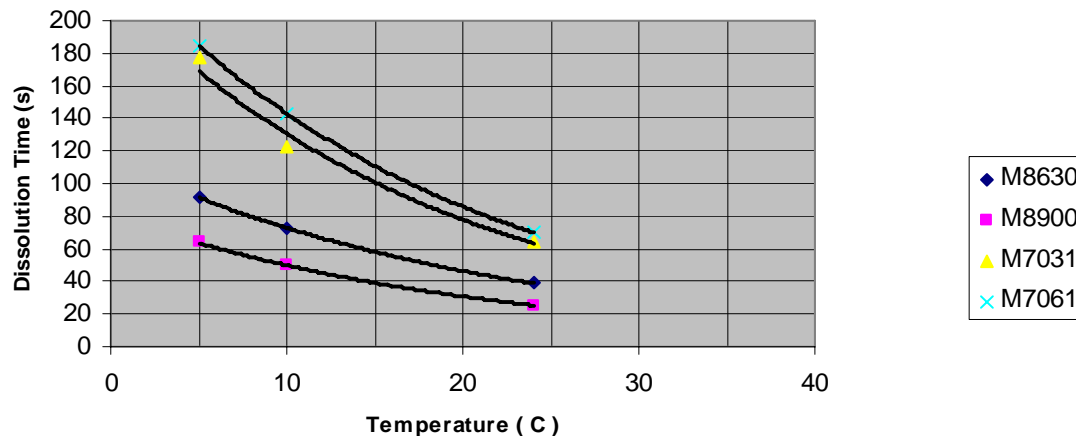
M8630: Resistant to alkaline hydrolysis and offers rapid solubility.

M8900: Specially designed to be resistant to both acid and alkaline hydrolysis.

M7031: Standard grade of PVOH used where there are no special compatibility issues. Engineered to have optimum performance on vacuum forming machines.

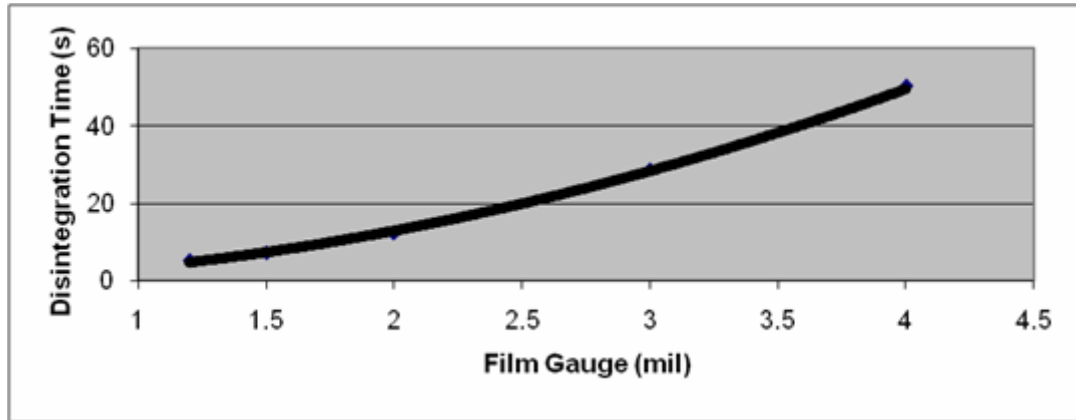
M7061: While similar in characteristics to M7031, the plasticizer system will improve cold storage and shipping performance.

Dissolution versus Temperature

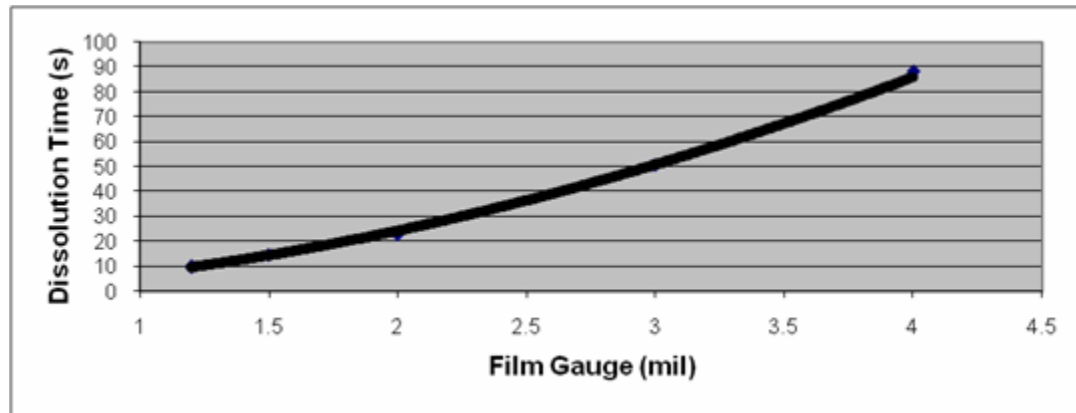




Select Polyvinyl Alcohol Film Properties



Temperature is 10 C
or 50 F





Chemical Compatibility of Polyvinyl Alcohol Film

- Further hydrolysis of residual acetate (pH effect)
- Crosslinking:
 - Gelation by boron compounds,
 - Esterification by polycarboxylic acids, and via Intermolecular dehydration
- Formation of acetic acid from sodium acetate
- Oxidation (by chlorine)
- Reverse salting out effect (by salts/ionic strength)
- Reactions on hydroxyl by reactive functional groups

All the above principally affect solubility but can also affect physical properties



PVOH Film Compatibility Overview

Class	Examples	Neutral pH	Laundry	Automatic Dish Washer	Strong Acid - Alkali	Halogens
Traditional	M7031 L711	G	G	G	NR	NR
Specialty Type 1	M8630	G	G	G	NR - G	NR
Specialty Type 2	M8900	G	G	G	G	C

G – Generally performs well

NR – Not recommended generally does not perform well

C – Caution varies significantly based on concentration

Note: In all applications MonoPACSM Testing is highly recommended



Physical Compatibility of Polyvinyl Alcohol Film

- Dehydration
- Plasticizer depletion
 - Mainly by absorbent/hygroscopic solids and by solvents
 - Principally causes embrittlement and low temperature cracking
 - Slows disintegration and dissolution times.
- Solvent migration



Performance Assessment of Compatibility



- Selection of films for testing based on knowledge of the product chemistry & on end-use requirements
- Typical 42 day test period at various climatic conditions in secondary packaging
 - Conduct ambient and accelerated aging tests
 - Check physical properties & solubility after exposure
 - Before and after chemical analysis of product and film
- Go/No-Go and specific film recommendations



How “Green” is Polyvinyl Alcohol?

- Compostable?
 - It cannot be certified as “compostable”
- Biodegradable?
 - Yes, in acclimated environments in the presence of water in solution. This property is well established in municipal sewage systems
 - Mechanical action will speed this process



Biodegradation and Toxicity of Polyvinyl Alcohol

- At least 55 species of microorganisms involved with degradation of Polyvinyl alcohol
- Will degrade in wastewater treatment facilities
- Acclimation period is rapid and generally degradation takes 20-28 days
- Low toxicity in fish & daphnia studies
- Approved as a pharmaceutical excipient
- Metabolism of acclimated organisms not inhibited
- Plasticizers in film are more biodegradable than base resin



Secondary Processing Options

- Vertical Form, Fill & Seal
 - Hayssen, Bosch, UVA Butler, Rovema, et al.
- Rotary thermoforming, water-sealing
 - Cloud Corp., and others.
- Horizontal thermoforming
 - Tiromat, Multivac, Harro Höfliger, et al.



Value Proposition of MonoDose™

- Convenience
- Functional Packaging
 - Triggered when desired
- Accurate pre-measured doses
 - Solids, liquids or combination of solids and liquids
- Safe handling of contents of package
 - Eliminates need to be in direct contact with contents
- Environmentally safe
- Competitive advantage
 - Category & Brand extension



Packaging Applications

- Fabric Care
- Dishwasher Care
- Beauty Care
- Institutional Care
- Agro Chemical



- Laundry bags
- Instrument Bags





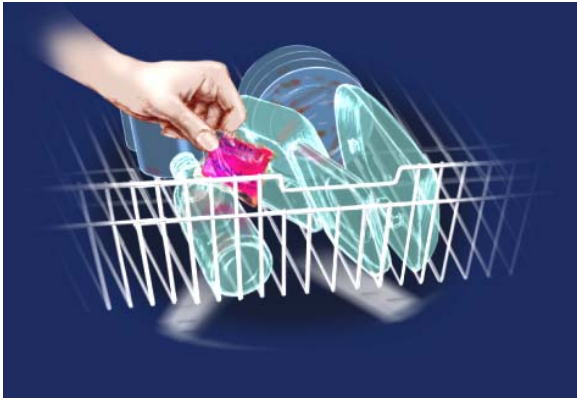
MonoPol™ Water-Soluble Molding Compounds

- Advances in processing and formulating technology allow Polyvinyl alcohol polymers to be melt-processed in typical thermoplastic molding operations
- MonoPol™ molding compounds have a range of solubility temperatures
- These compounds can be
 - Injection molded
 - Blow molded
 - Rotational molded
 - Profile extruded
 - Sheet extruded
 - Thermoformed

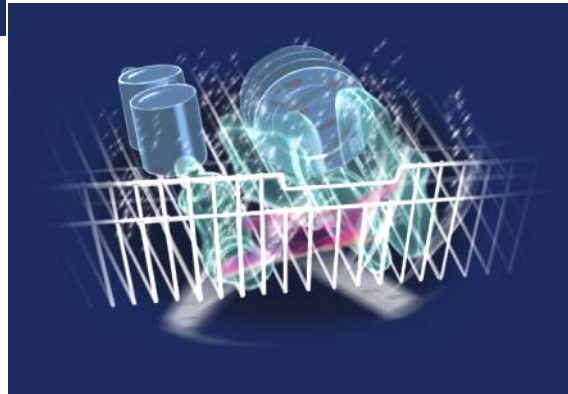




Convenience with



Inside...



Soluble +
Biodegradable



Inside...

