

Demystifying Tg and MFFT

Linear, Branched, Cyclic

Polymer Backbone Length

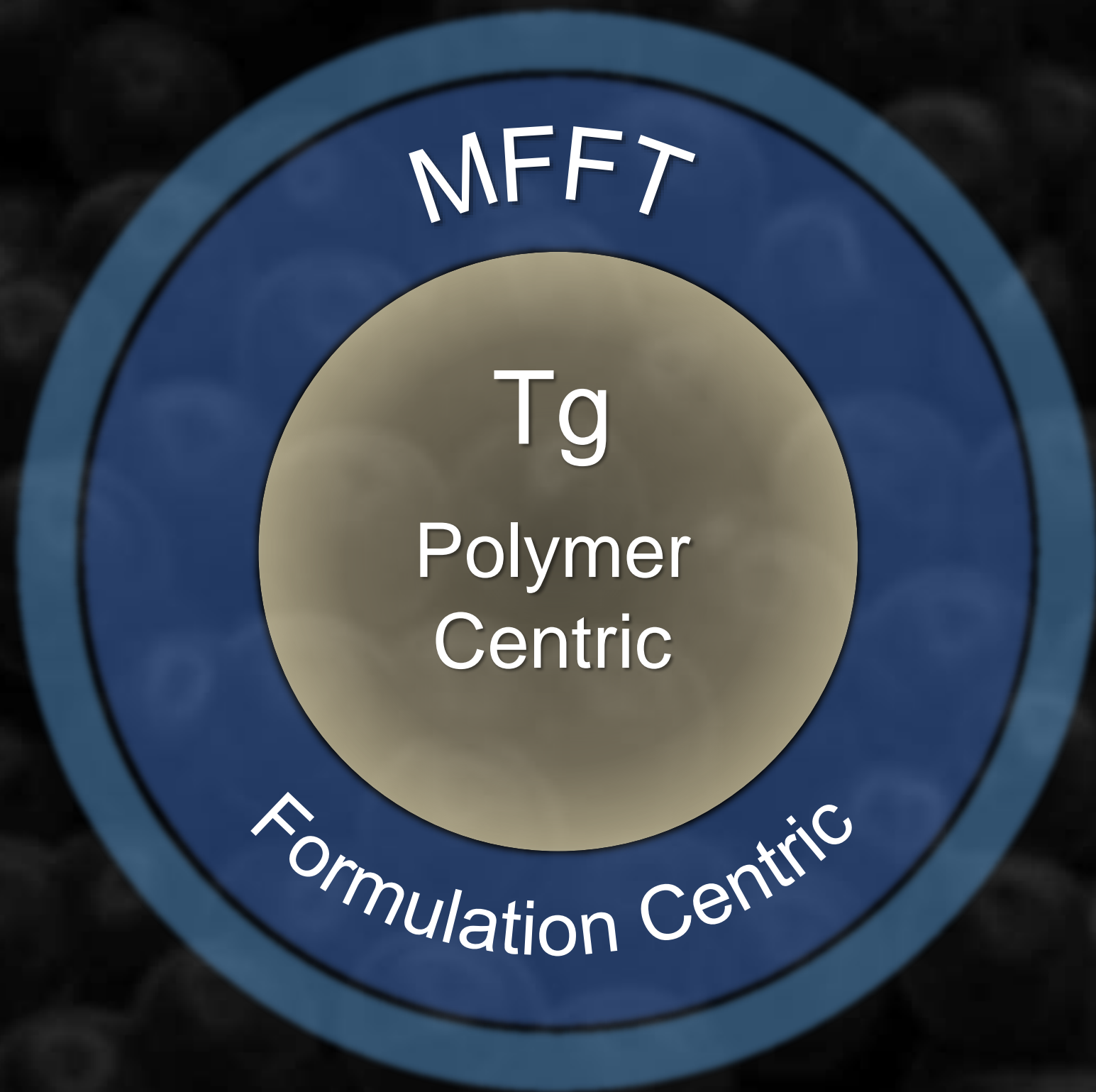
Side Chain Length/Branching

Chemistry Backbone/Side Chain

Morphology



Demystifying Tg and MFFT



Coalescing Agents

Co-Solvents

Pigmented/Clear

Polymer Blends

Drying Environment

Temperature, Humidity, Air Flow

Application Temperature

Substrate

Film Formation

Stain Resistance

Block Resistance

Scrub Resistance

Crack Resistance

Chemical Resistance

Corrosion Resistance

Dirt Pickup Resistance

Gloss

Adhesion

Stain Blocking

Tensile Strength

Youngs Modulus

Flow and Leveling

Water Permeability

Film Formation

Polymers

Liquids

Pigments

Additives

Film Formation

Polymers

Liquids

Pigments

Additives

Polymers

Polymerization

Film Formation

Tg and MFFT

Polymers

Polymerization

Film Formation

Tg and MFFT

Polymers

Polymerization

Water

Monomer

Surfactant

Initiator

Polymerization



Types

Chain Reaction

Addition Polymerization

Chain Growth

Step Reaction

Condensation

Dehydration

Polymerization

Monomer \rightarrow Polymer



Types

Chain Reaction

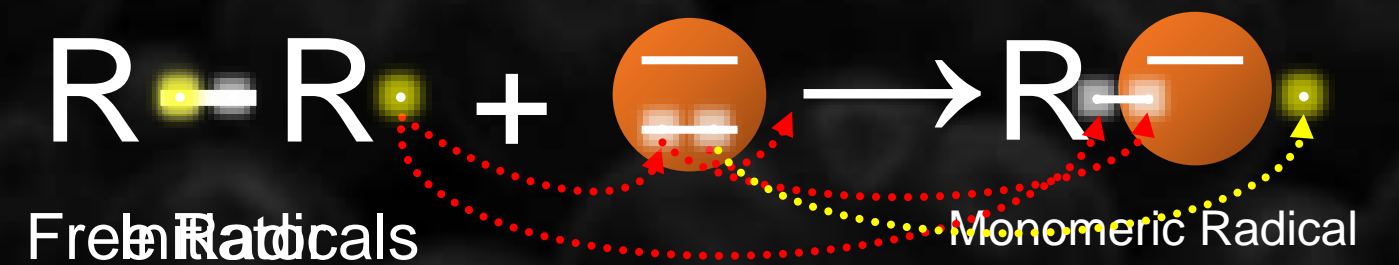
Free Radical Mechanism

Dissociation

Initiation

Propagation

Termination



Polymerization

Monomer \rightarrow Polymer



Types

Chain Reaction

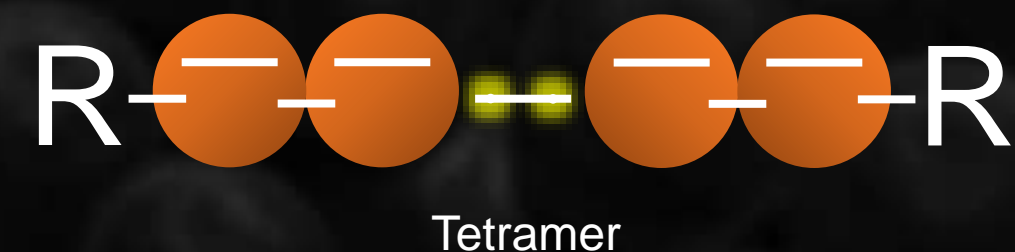
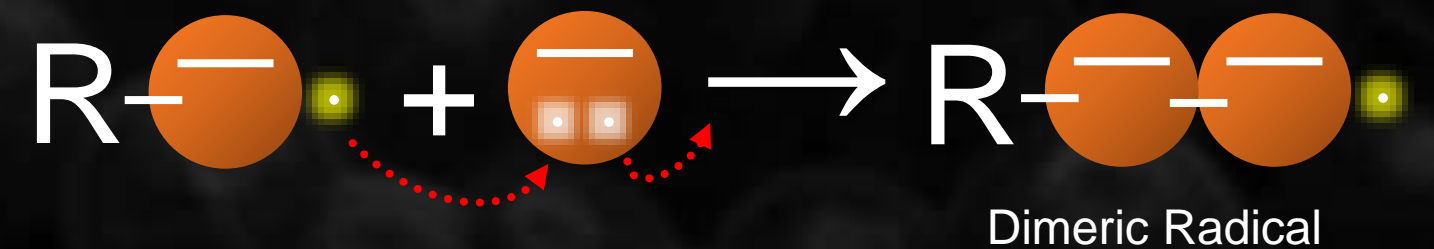
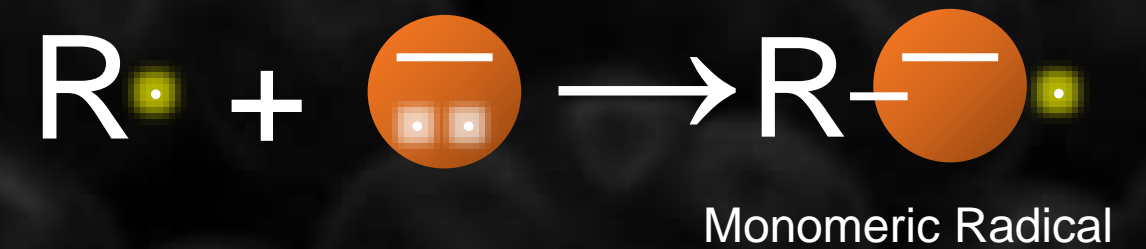
Free Radical Mechanism

Dissociation

Initiation

Propagation

Termination



Polymers

Polymerization

Film Formation

Tg and MFFT

Polymers

Polymerization

Film Formation

Tg and MFFT

Film Formation

Solventborne

Solution

Waterborne

Dispersion



Film Formation

Solventborne

Solution

Waterborne

Dispersion



Solventborne Solution

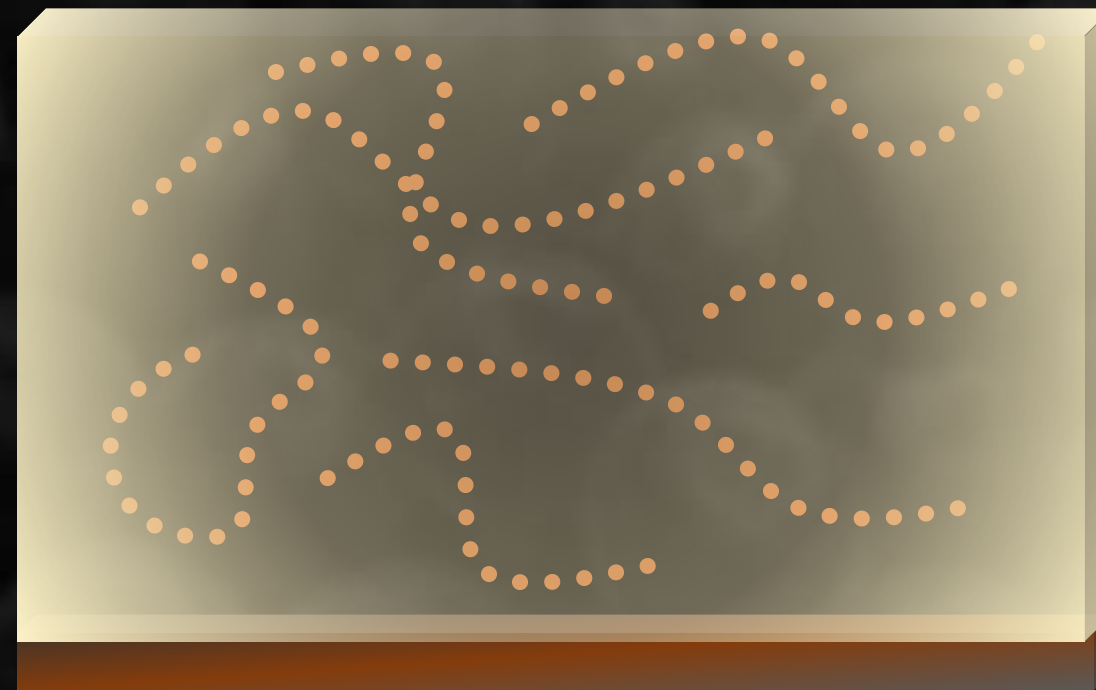
Film Formation

Solventborne

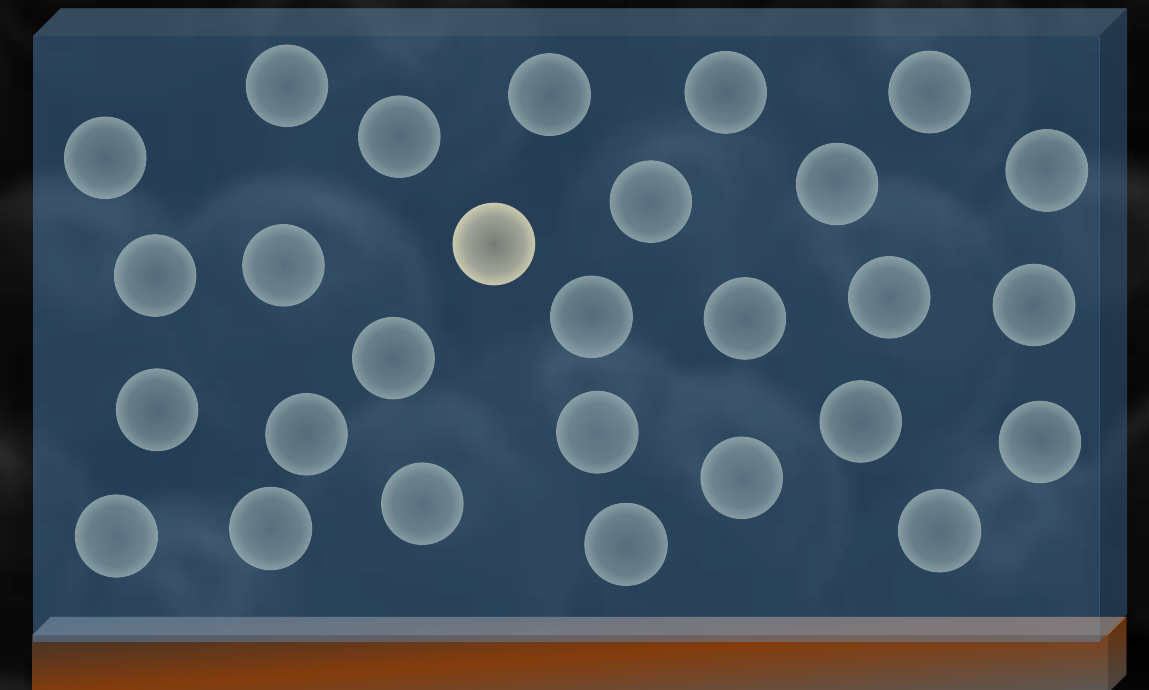
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

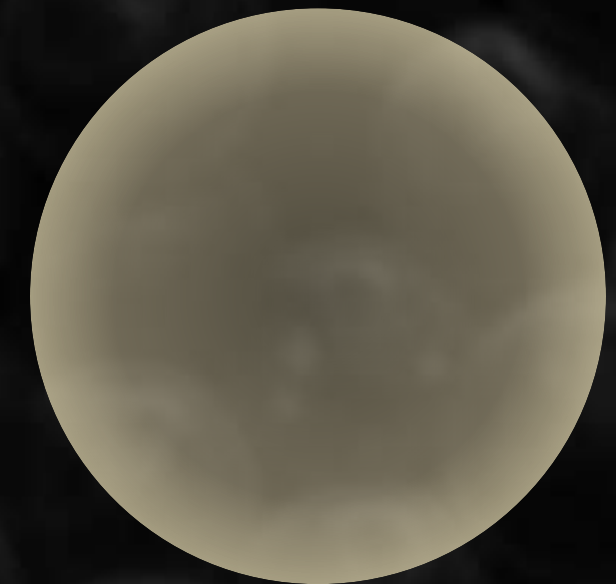
Film Formation

Solventborne

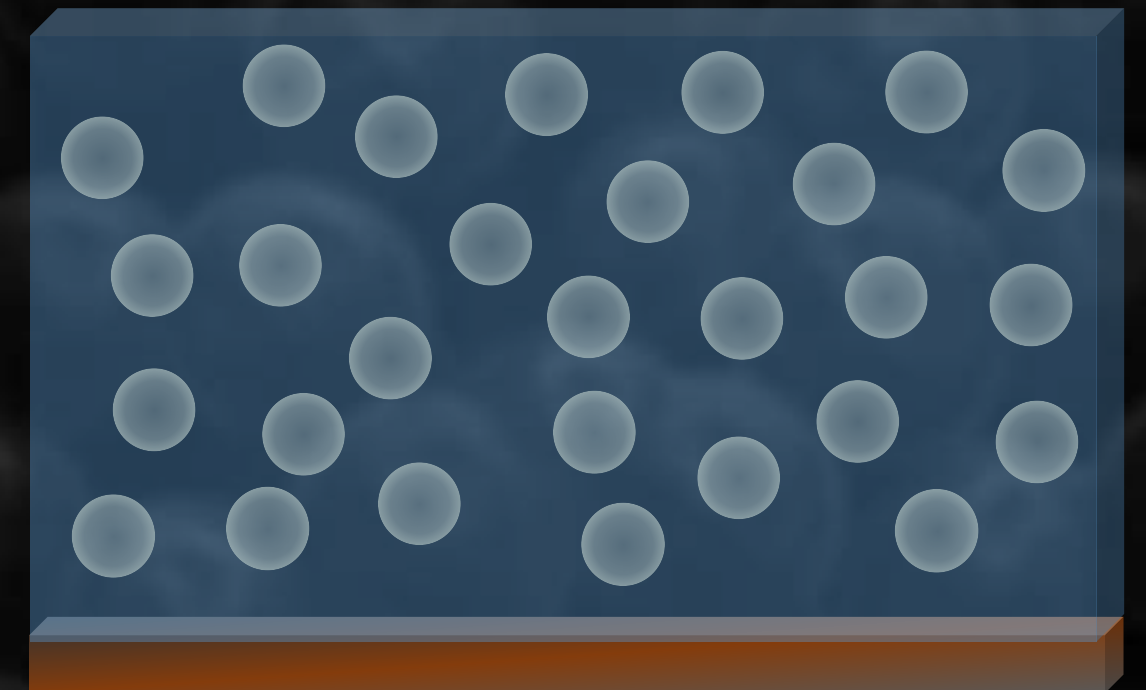
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

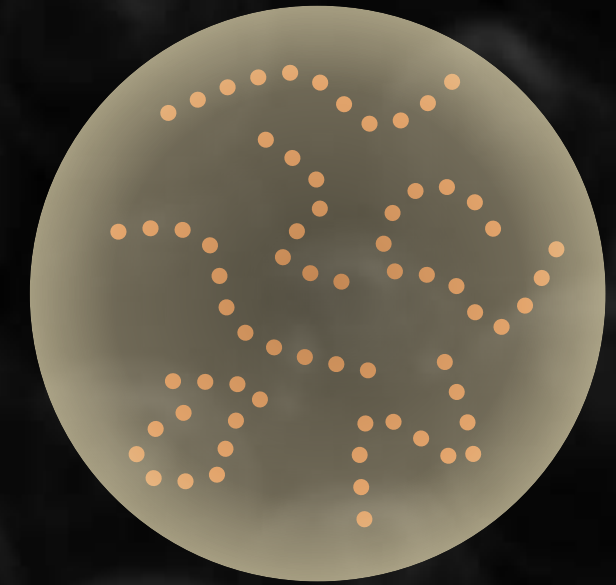
Film Formation

Solventborne

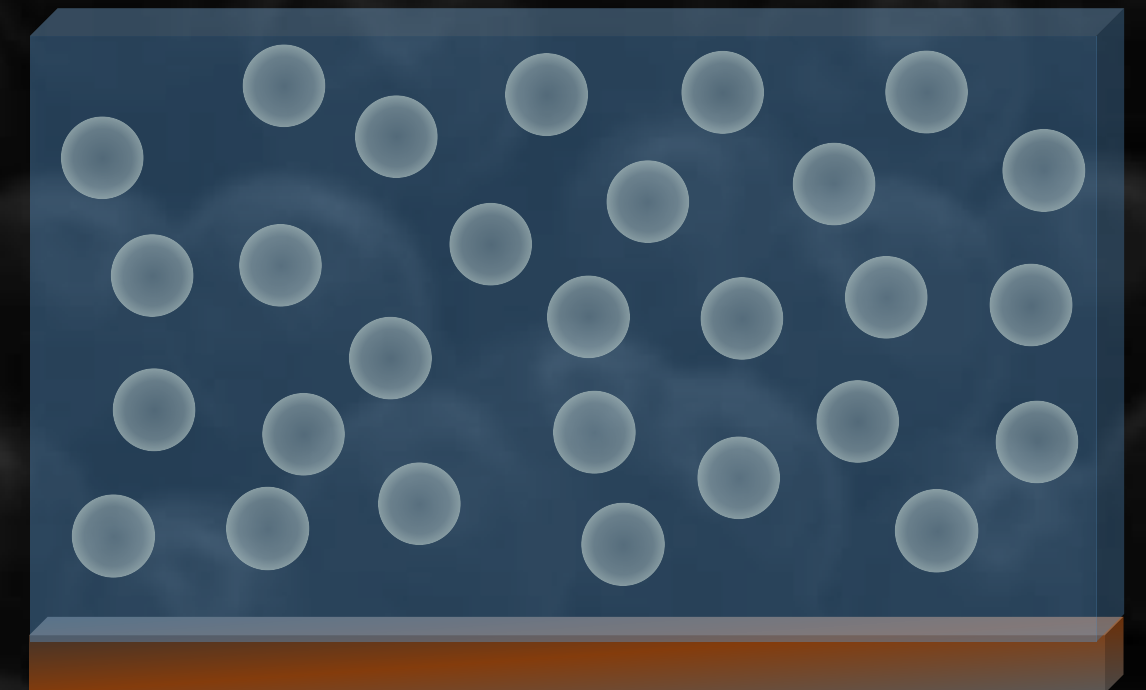
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

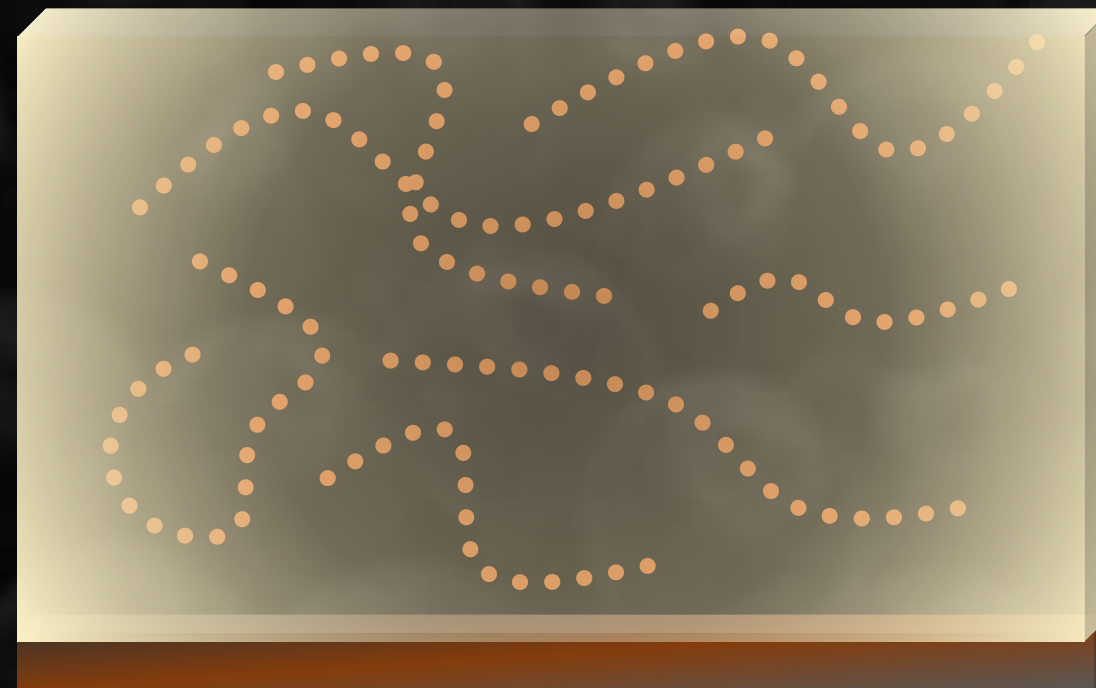
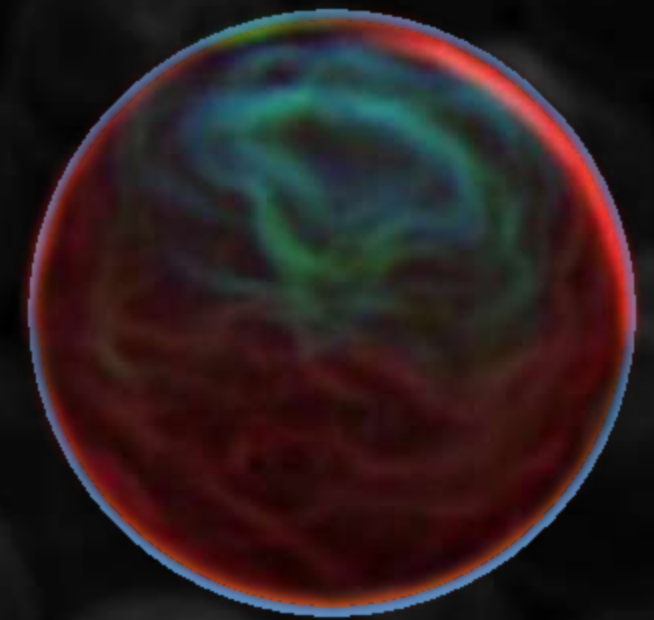
Film Formation

Solventborne

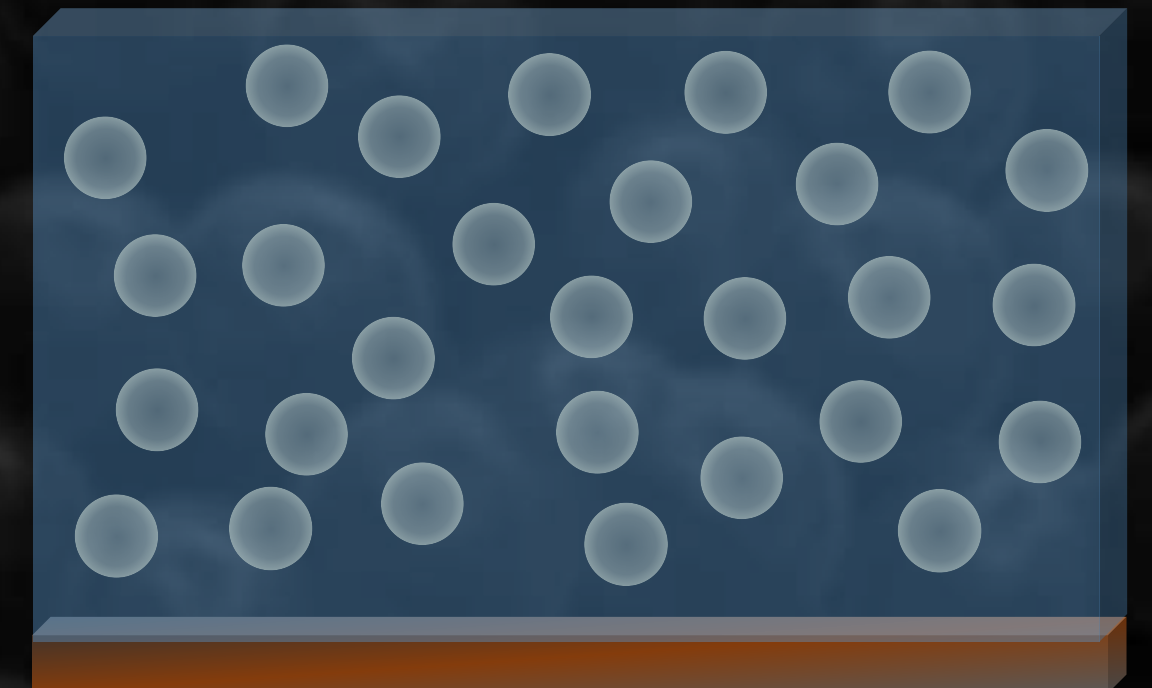
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

Film Formation

Solventborne

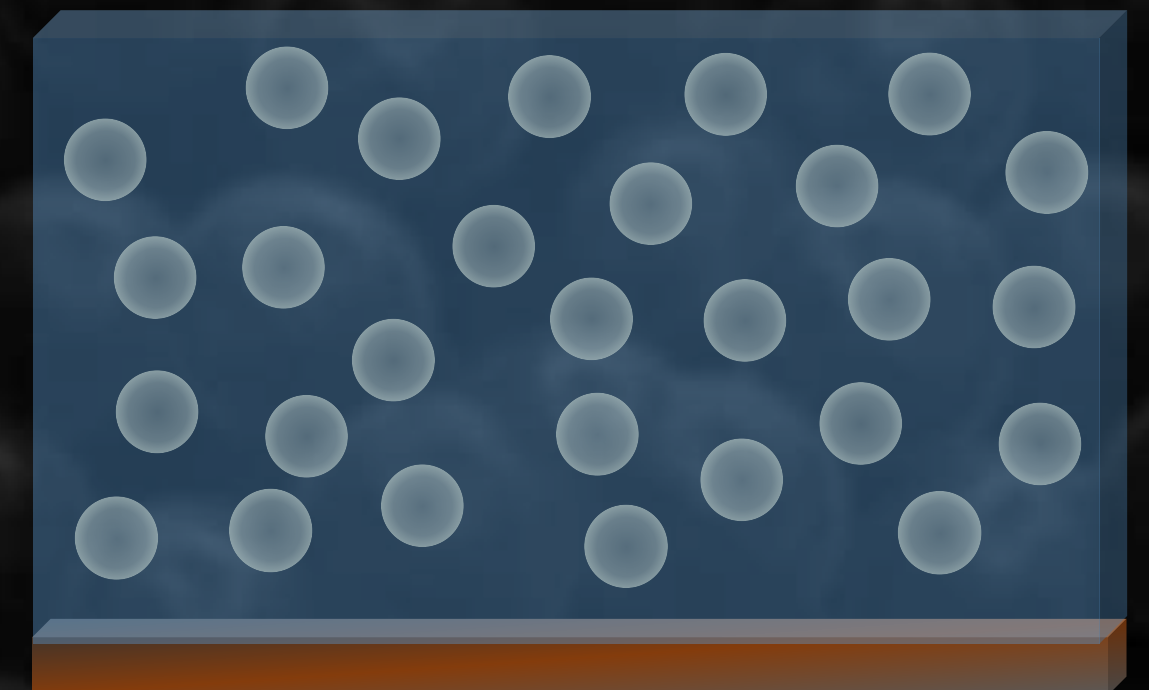
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

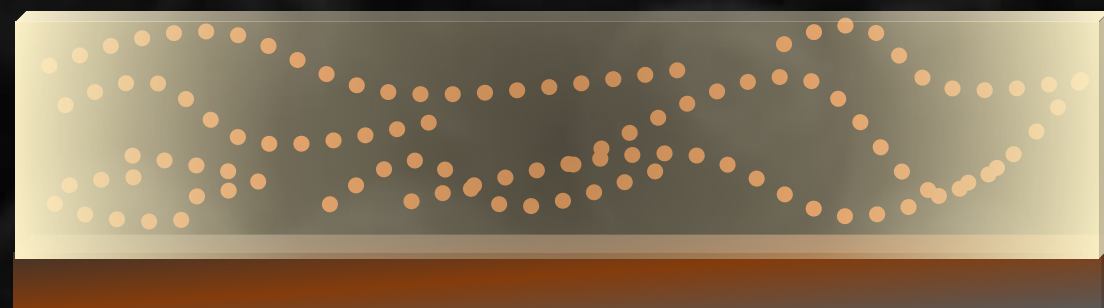
Film Formation

Solventborne

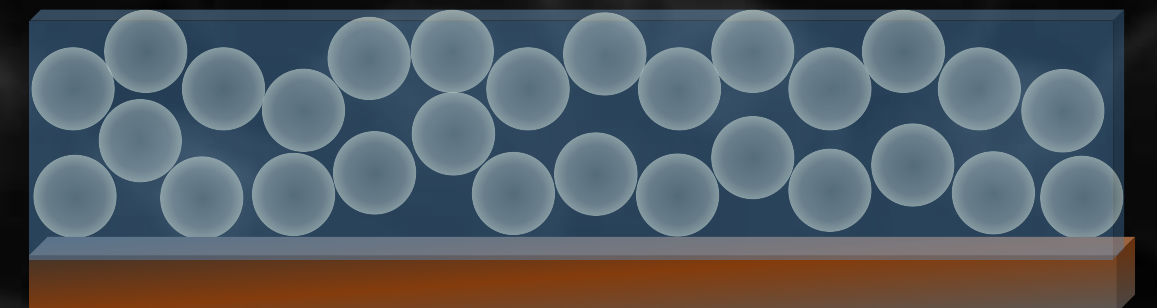
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

Film Formation

Solventborne

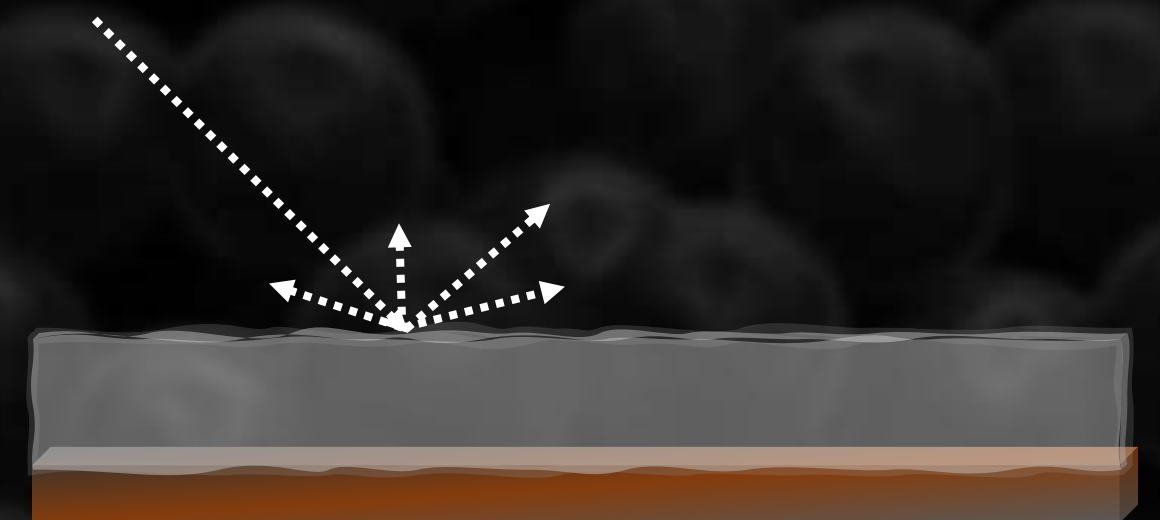
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

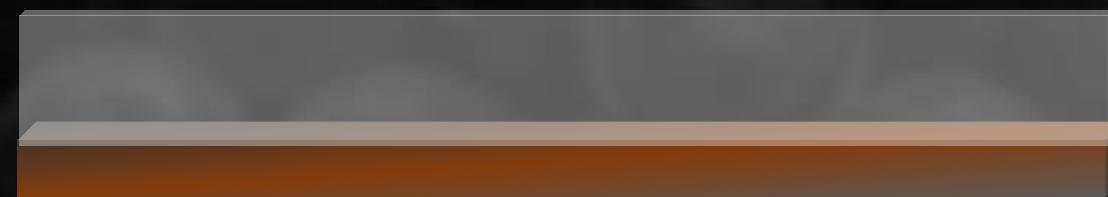
Film Formation

Solventborne

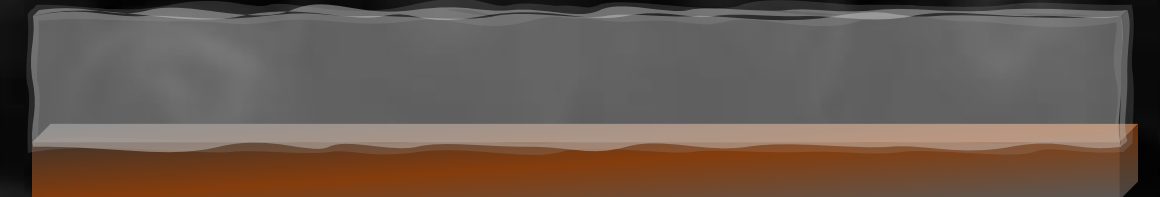
Solution

Waterborne

Dispersion



Solventborne Solution



Waterborne Dispersion

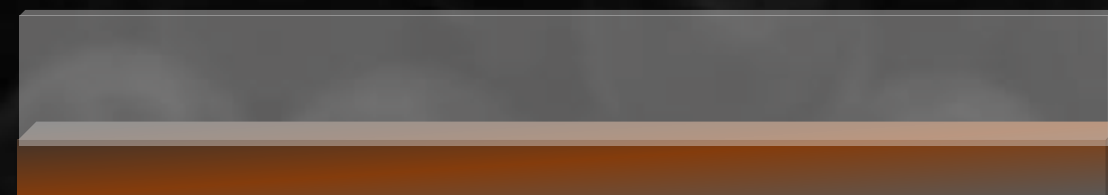
Film Formation

Solventborne

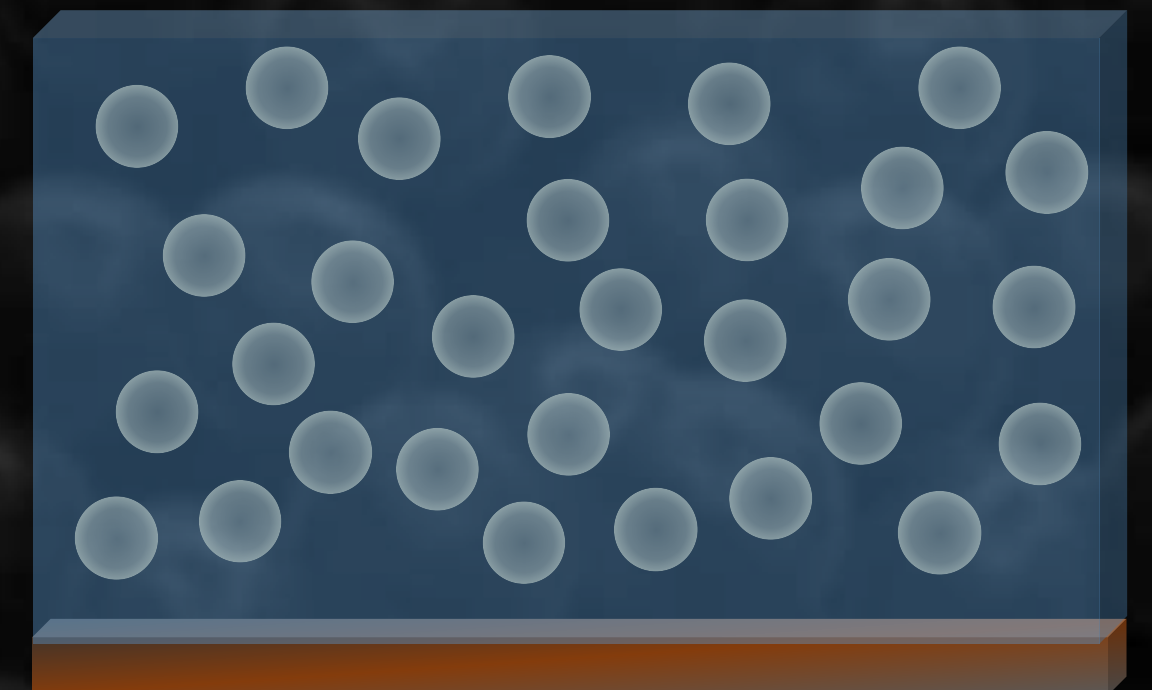
Solution

Waterborne

Dispersion

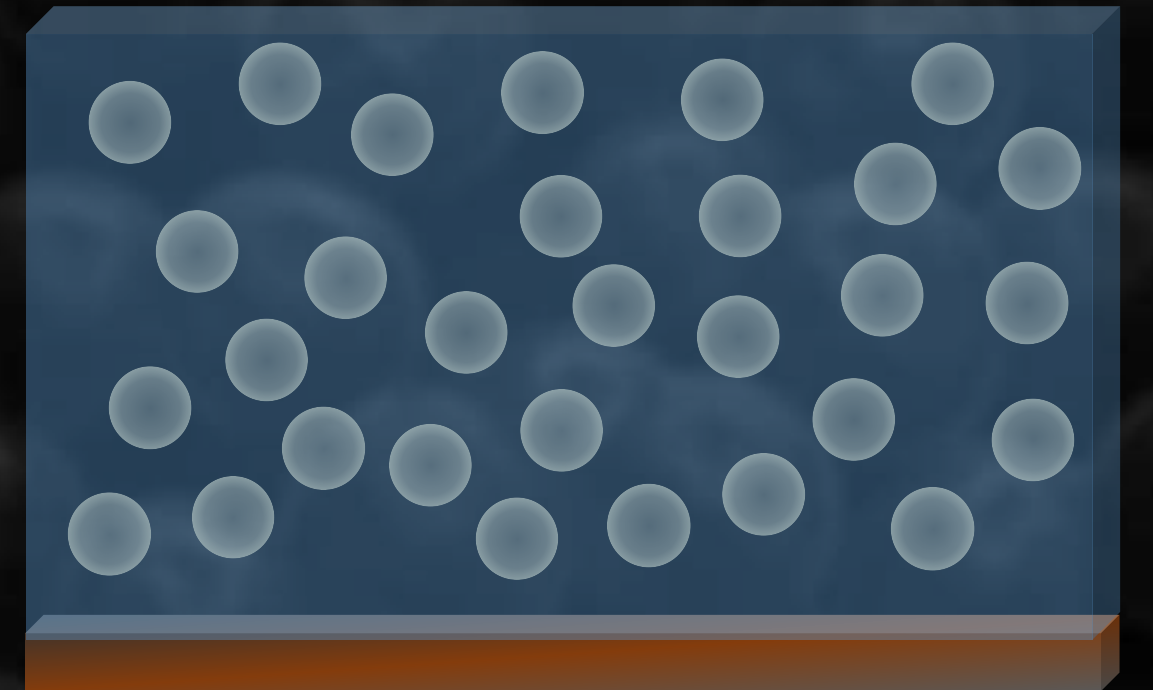


Solventborne Solution



Waterborne Dispersion

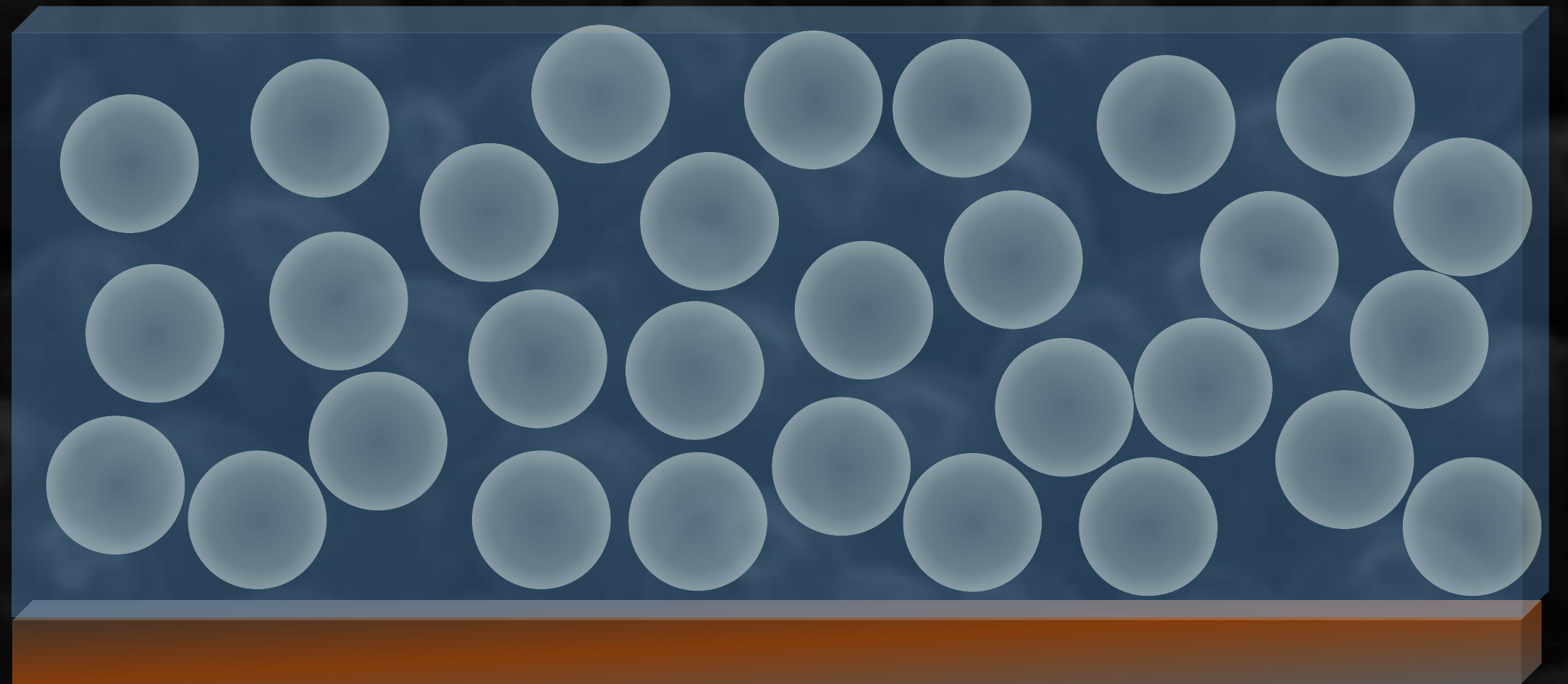
Film Formation



Film Formation

Stage 1

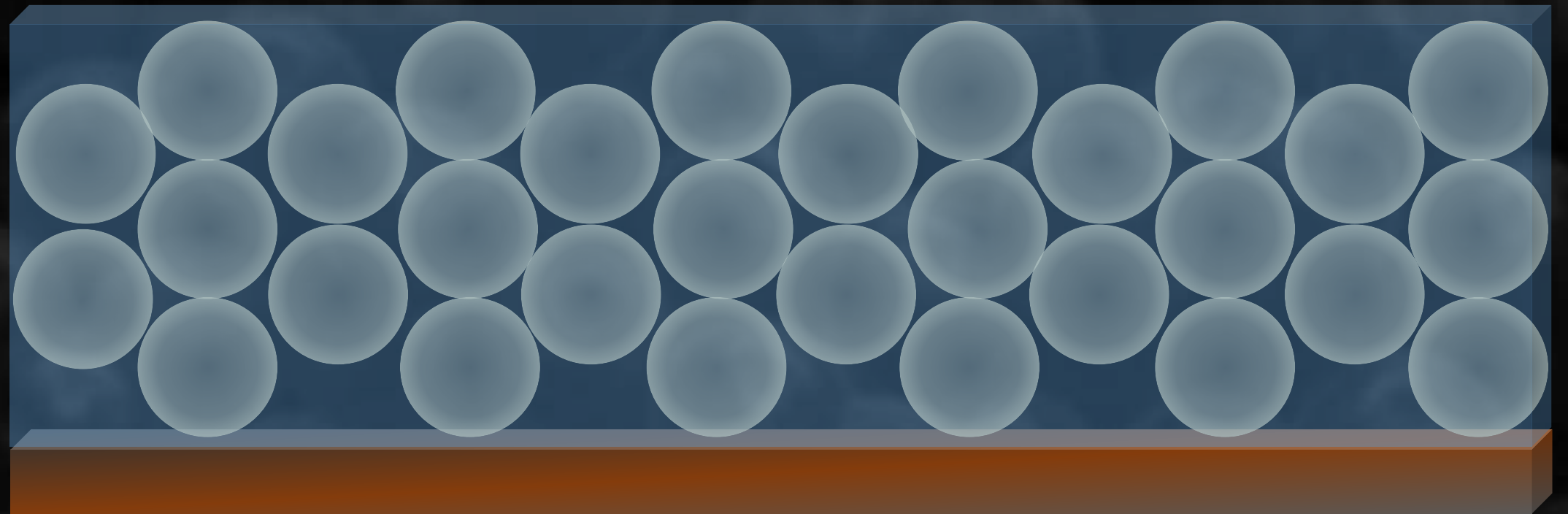
Water Evaporation



Film Formation

Stage 1

Water Evaporation



Film Formation

Stage 1

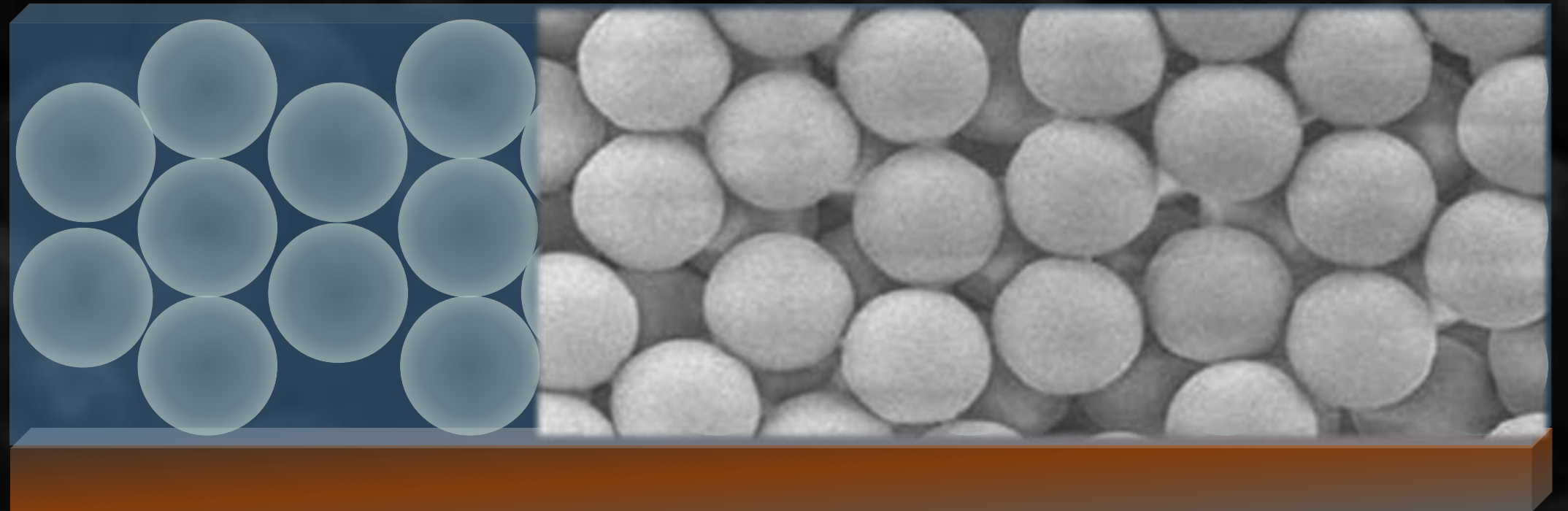
Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation



Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

Particle Deformation

Transparent Film



Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

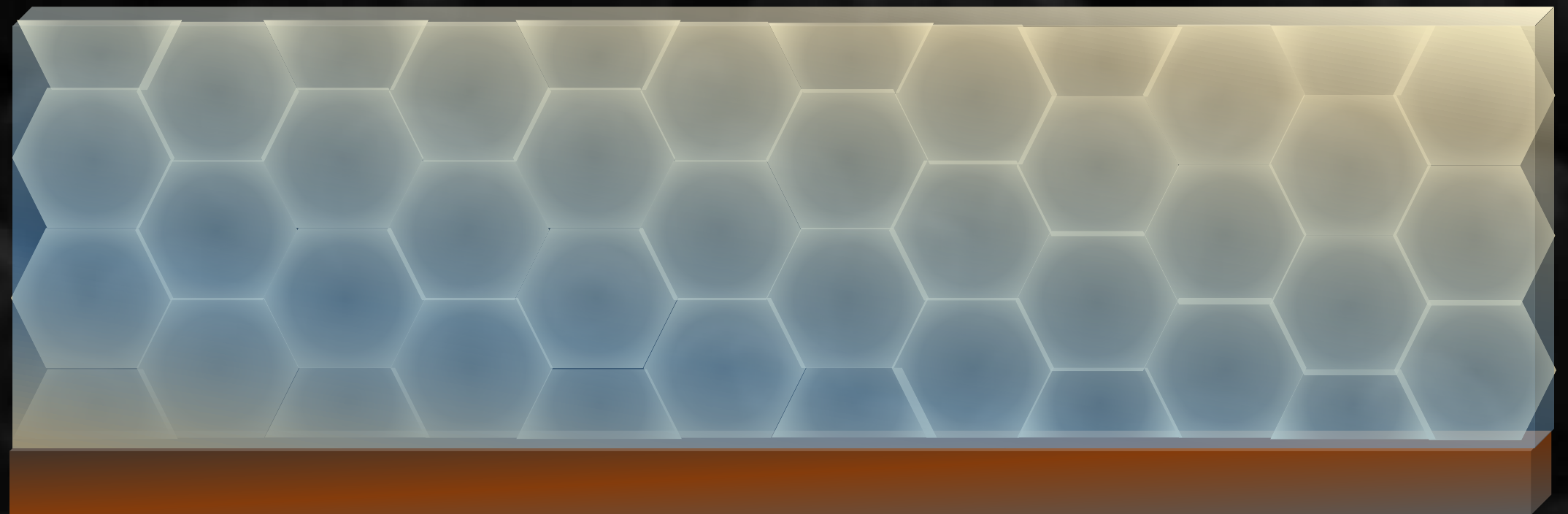
Particle Deformation

Transparent Film

Stage 3

Temperature $>$ T_g

Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

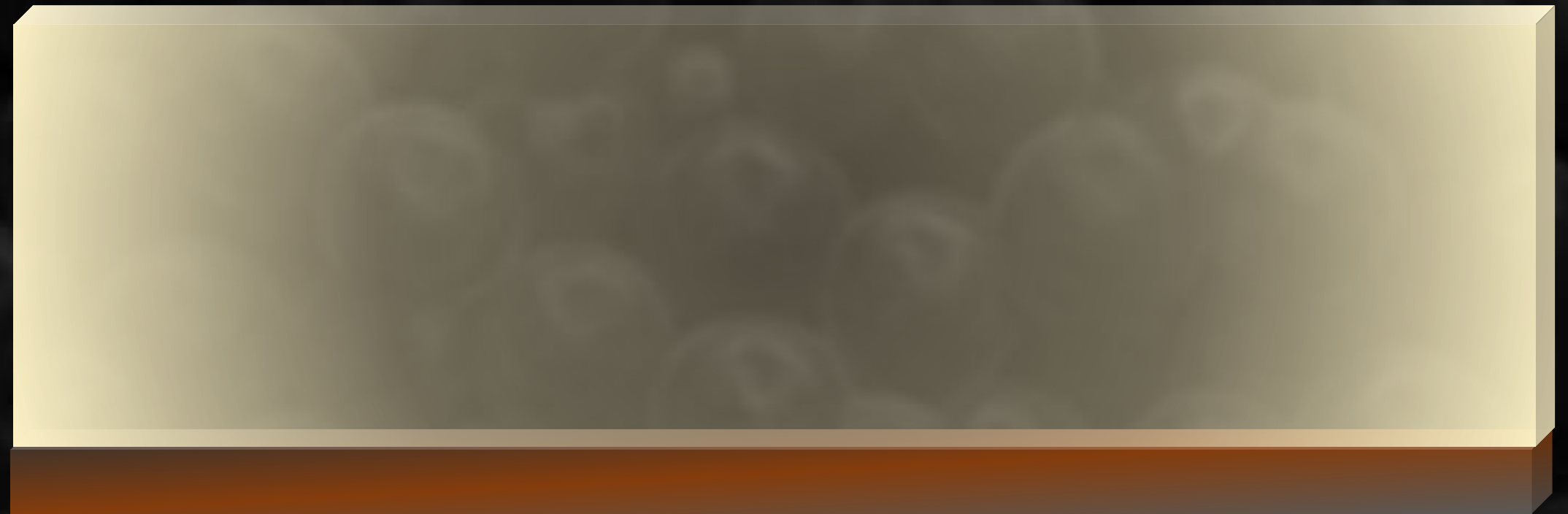
Particle Deformation

Transparent Film

Stage 3

Temperature $>$ T_g

Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

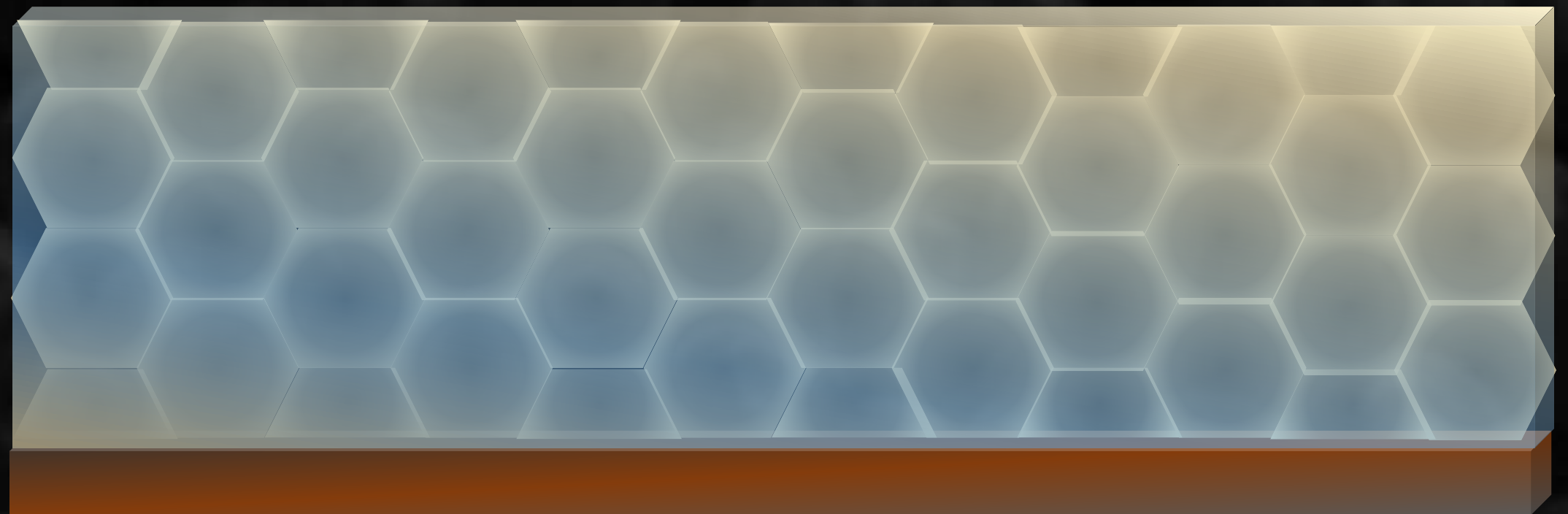
Particle Deformation

Transparent Film

Stage 3

Temperature $>$ T_g

Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

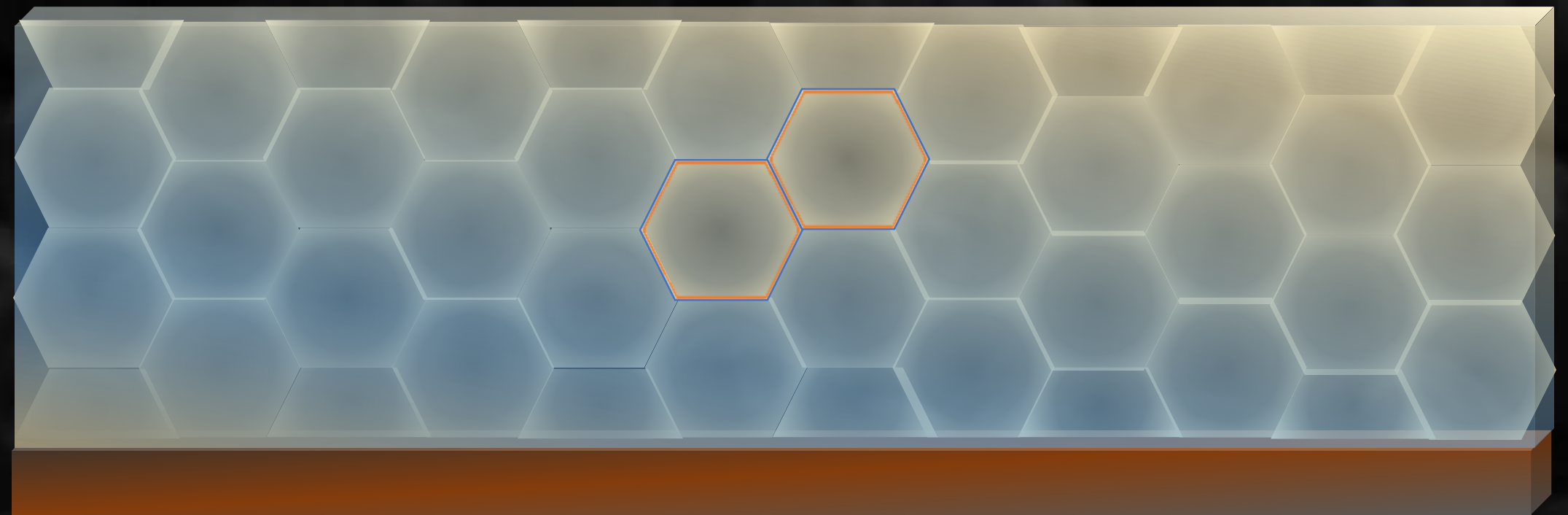
Particle Deformation

Transparent Film

Stage 3

Temperature $>$ T_g

Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

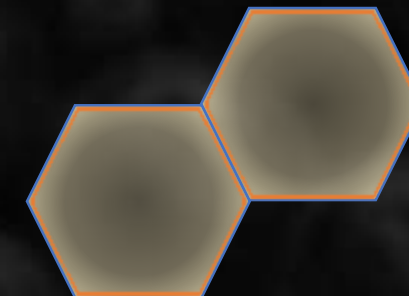
Particle Deformation

Transparent Film

Stage 3

Temperature $>$ T_g

Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

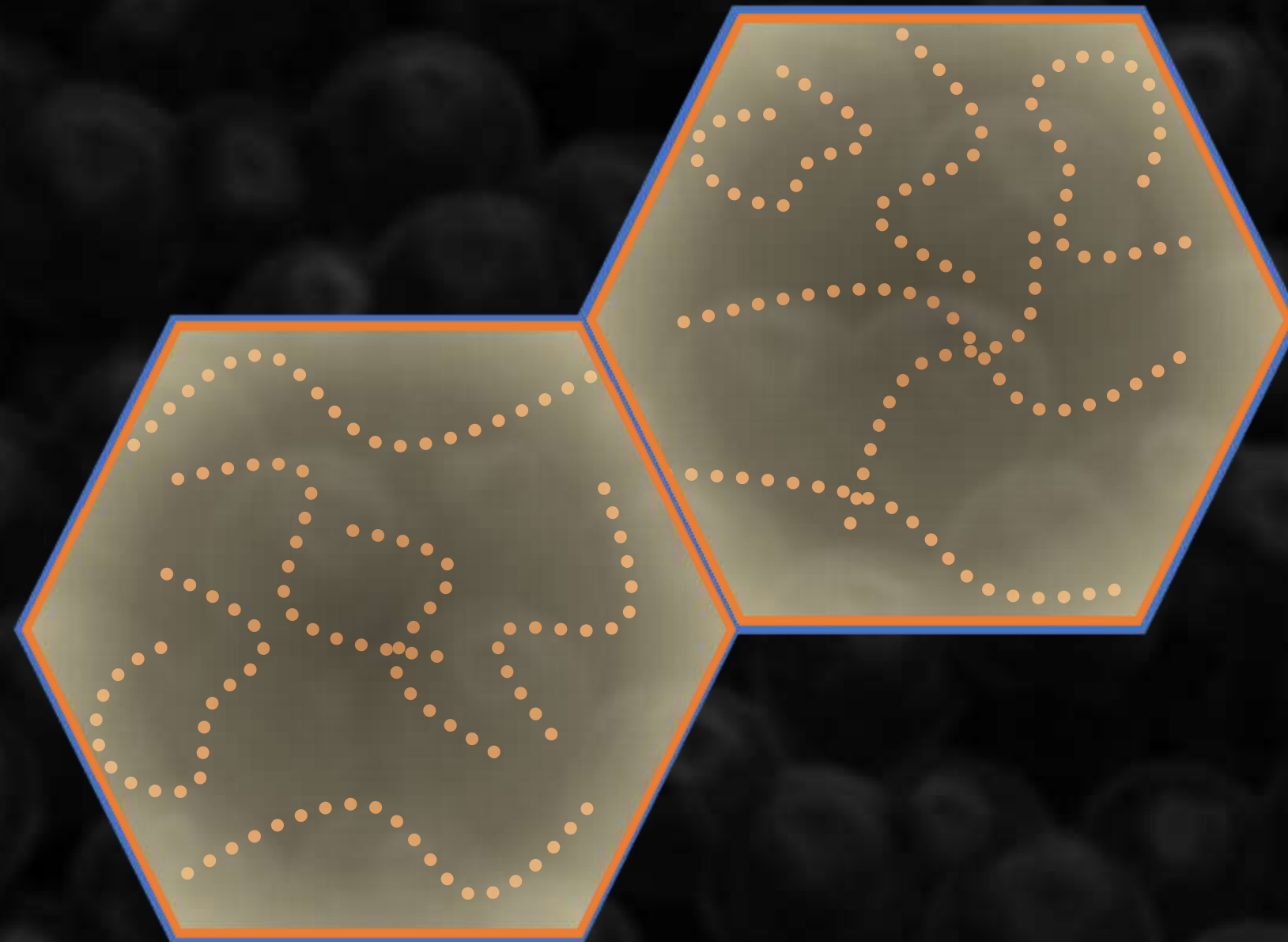
Water Evaporation
Packed Polymer Particles
Water-Filled Interstices

Stage 2

Interstitial Evaporation
Particle Deformation
Transparent Film

Stage 3

Temperature $>$ T_g
Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

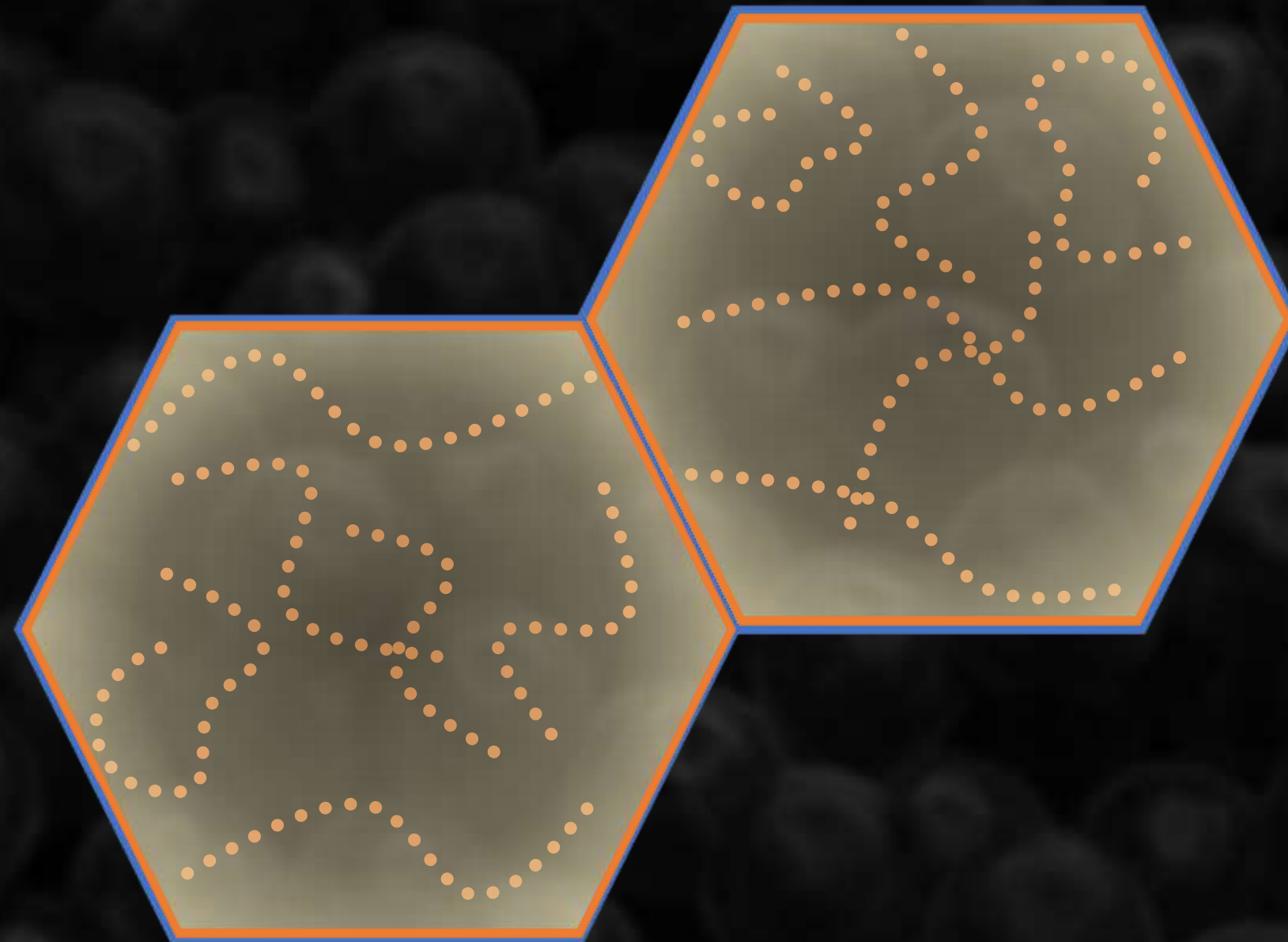
Water Evaporation
Packed Polymer Particles
Water-Filled Interstices

Stage 2

Interstitial Evaporation
Particle Deformation
Transparent Film

Stage 3

Temperature > T_g
Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

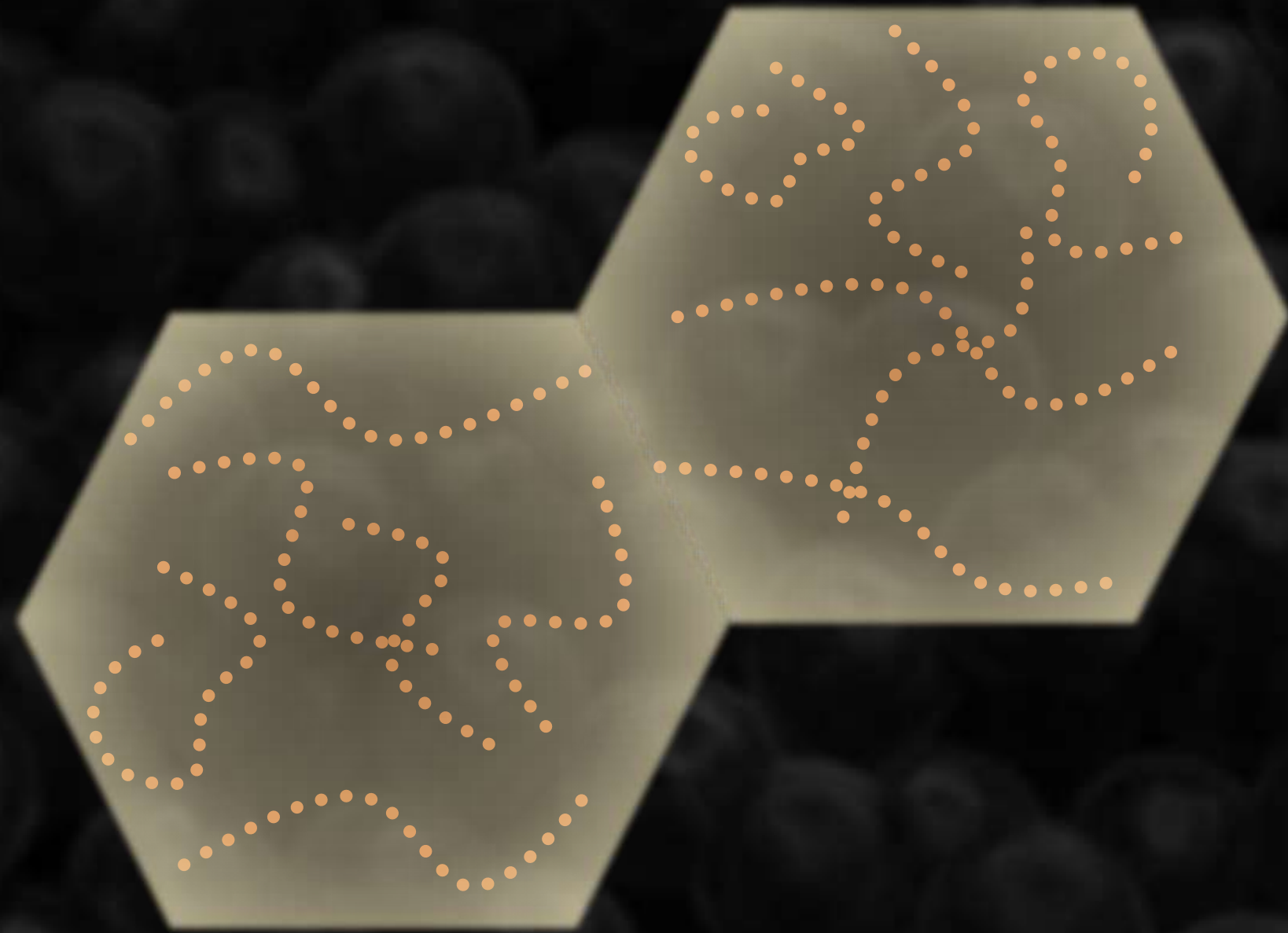
Water Evaporation
Packed Polymer Particles
Water-Filled Interstices

Stage 2

Interstitial Evaporation
Particle Deformation
Transparent Film

Stage 3

Temperature > T_g
Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

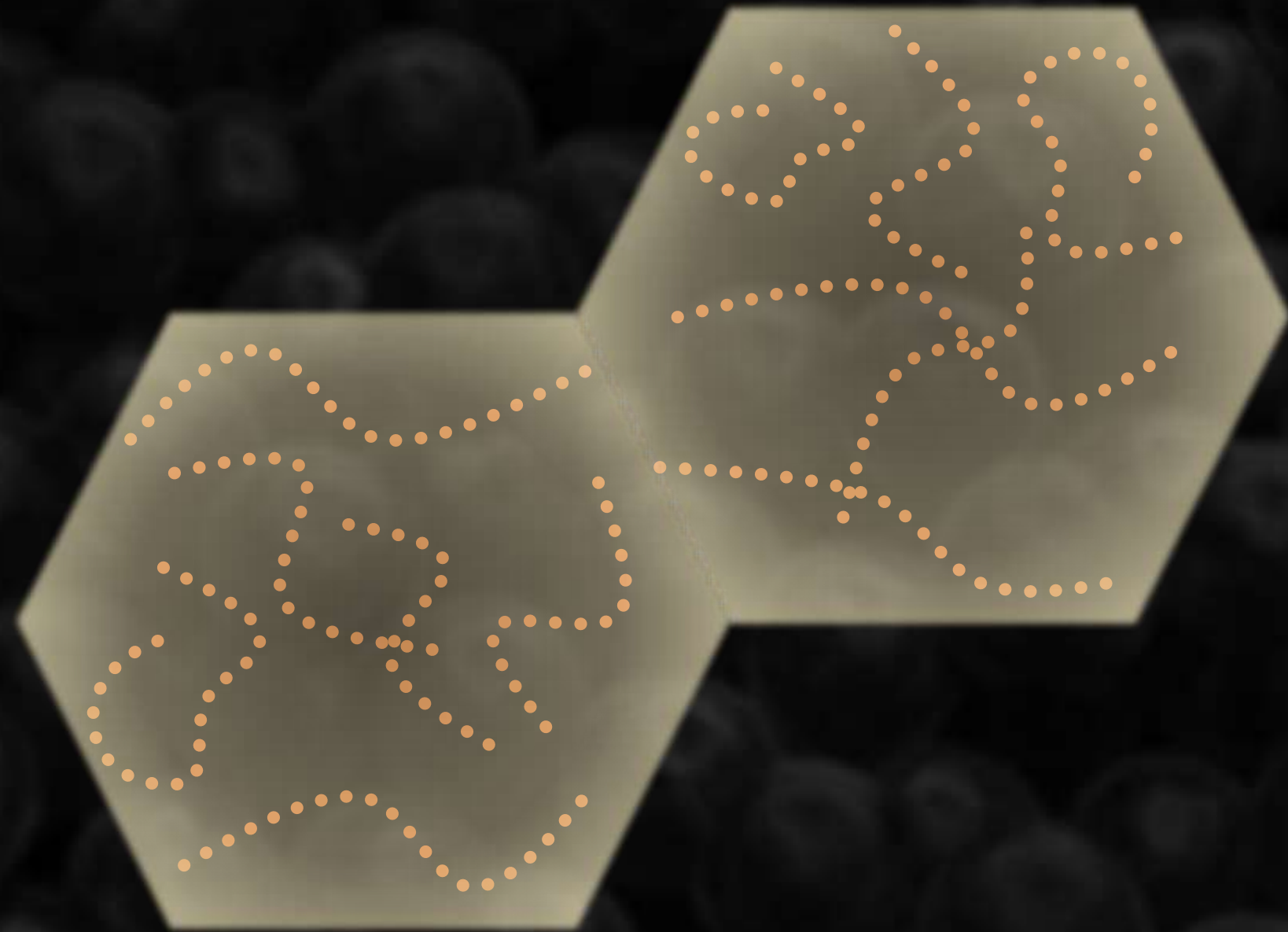
Water Evaporation
Packed Polymer Particles
Water-Filled Interstices

Stage 2

Interstitial Evaporation
Particle Deformation
Transparent Film

Stage 3

Temperature $>$ T_g
Polymer Chains Mobile/Interfuse/Entangle



Film Formation

Stage 1

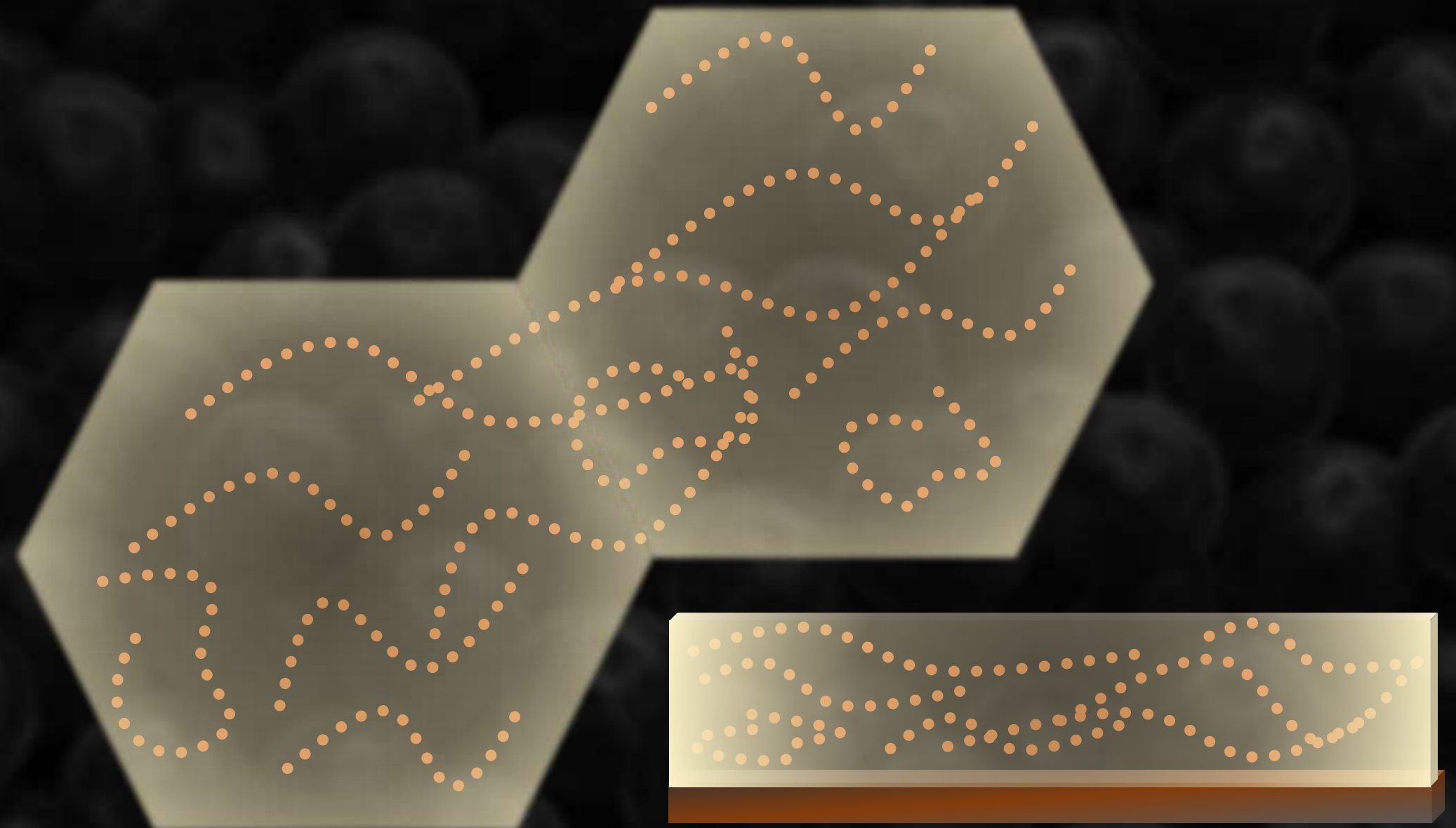
Water Evaporation
Packed Polymer Particles
Water-Filled Interstices

Stage 2

Interstitial Evaporation
Particle Deformation
Transparent Film

Stage 3

Temperature > T_g
Polymer Chains Mobile/Interfuse/Entangle



Solventborne Solution

Film Formation

Stage 1

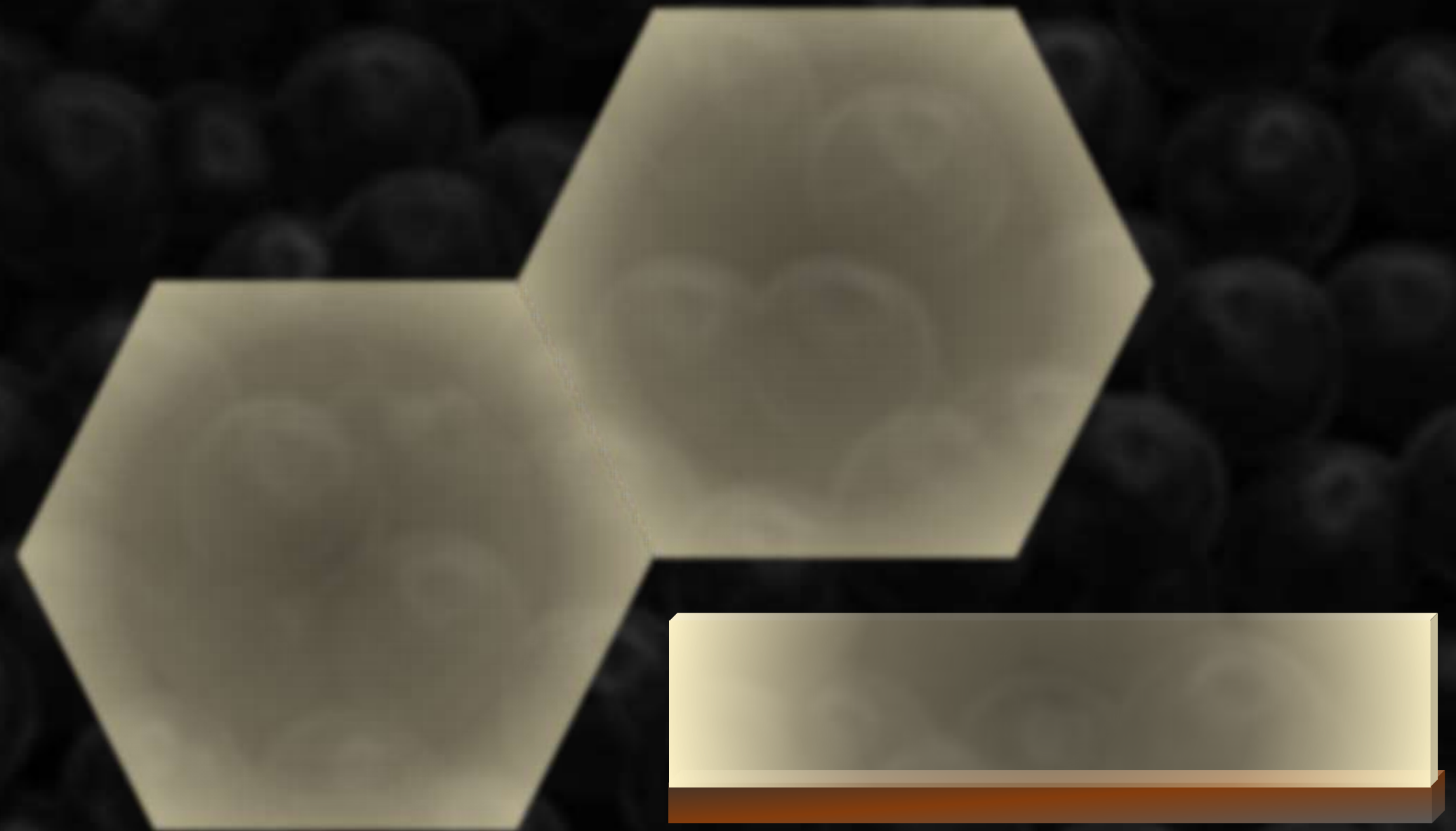
Water Evaporation
Packed Polymer Particles
Water-Filled Interstices

Stage 2

Interstitial Evaporation
Particle Deformation
Transparent Film

Stage 3

Temperature > T_g
Polymer Chains Mobile/Interfuse/Entangle



Solventborne Solution

Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

Particle Deformation

Transparent Film

Stage 3

Temperature $>$ T_g

Polymer Chains Mobile/Interfuse/Entangle

Film Formation

Stage 1

Water Evaporation

Packed Polymer Particles

Water-Filled Interstices

Stage 2

Interstitial Evaporation

Particle Deformation

Transparent Film

Stage 3

Temperature $>$ T_g

Polymer Chains Mobile/Interfuse/Entangle

Film Formation

Maximize

Stain Resistance
Block Resistance
Scrub Resistance
Crack Resistance
Chemical Resistance
Corrosion Resistance
Dirt Pickup Resistance

Gloss
Adhesion
Stain Blocking
Tensile Strength
Youngs Modulus
Flow and Leveling
Water Permeability

Minimize

Glass Transition Temperature (T_g)

Minimum Film Formation Temperature (MFFT)

Polymers

Polymerization

Film Formation

Tg and MFFT

Polymers

Polymerization

Film Formation

Tg and MFFT

Polymers

Polymerization

Film Formation

T_g and MFFT

Glass Transition Temperature

Materials

Crystalline

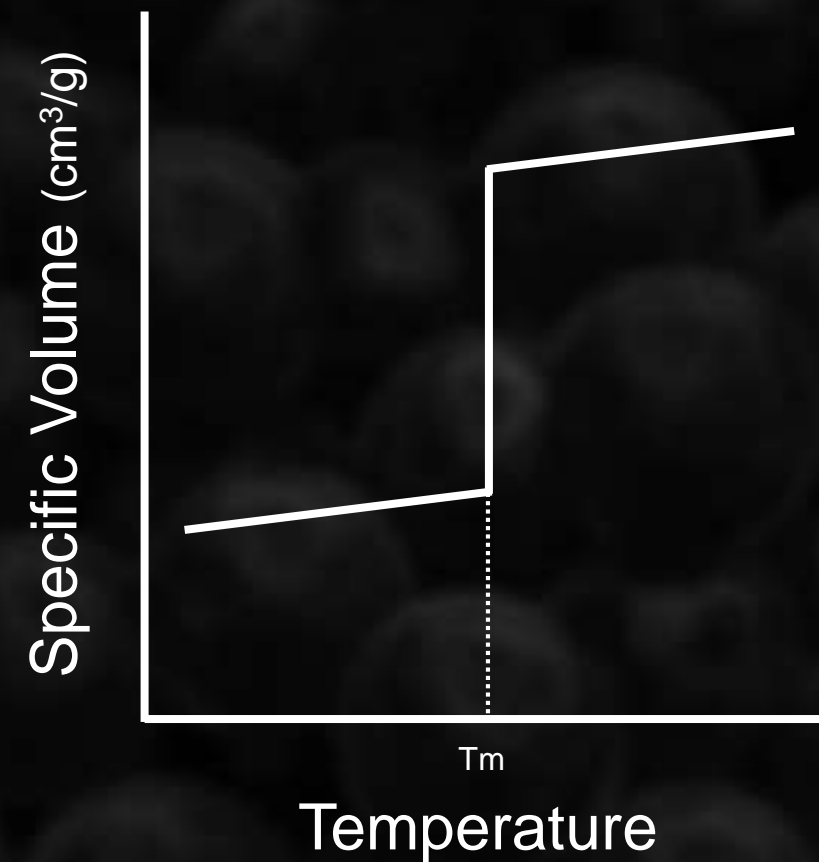
Amorphous

Glass Transition Temperature

Materials

Crystalline

Amorphous

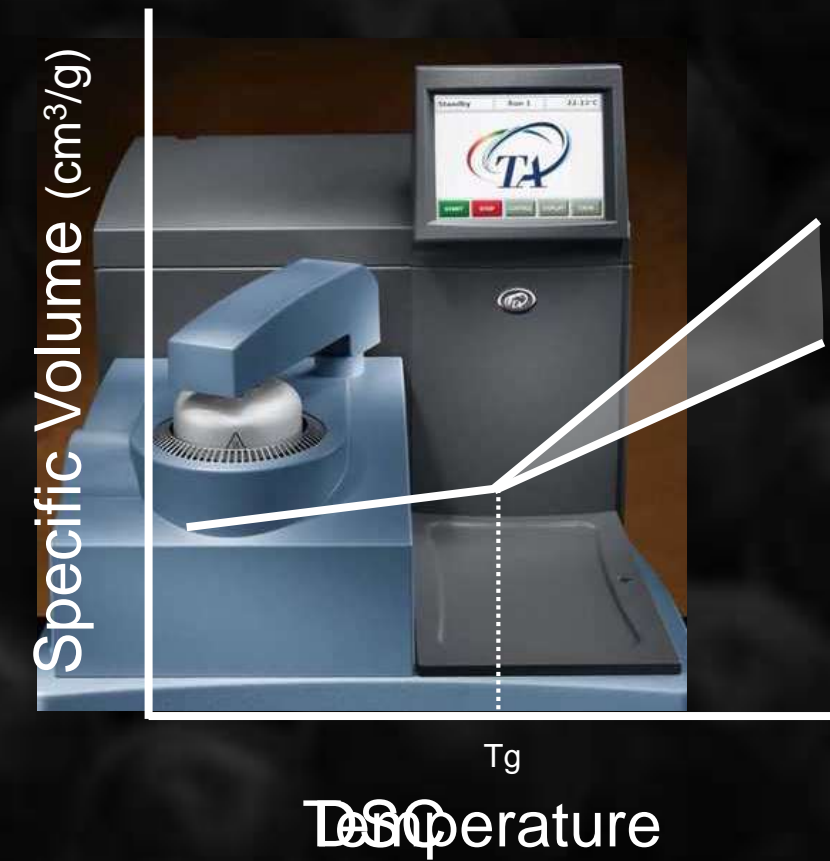
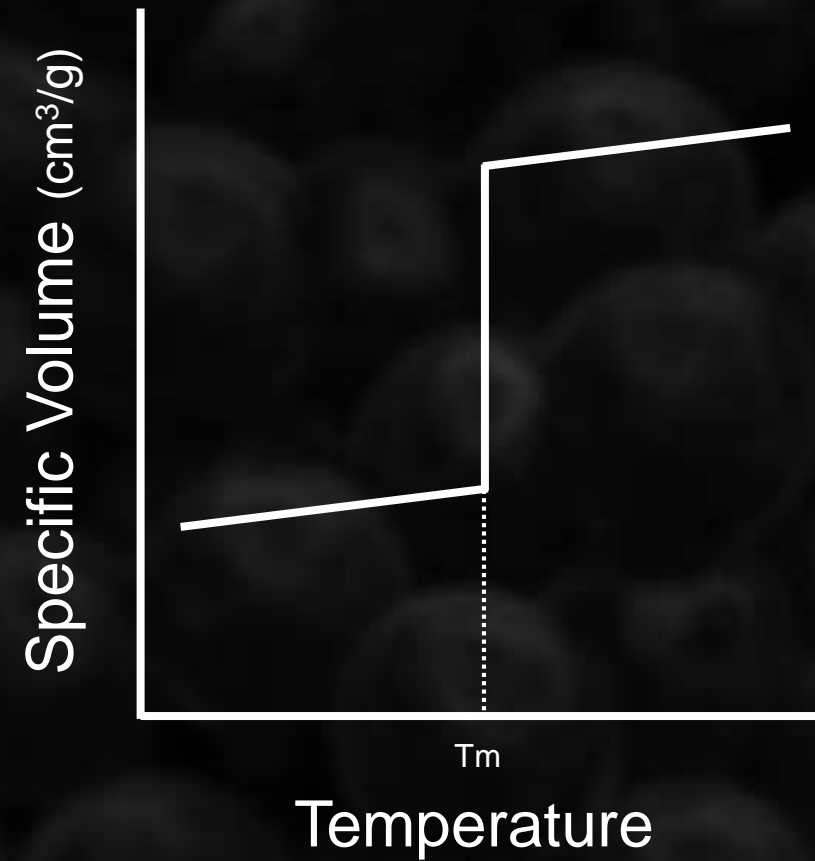


Glass Transition Temperature

Materials

Crystalline

Amorphous



Glass Transition Temperature

Materials

Crystalline

Amorphous

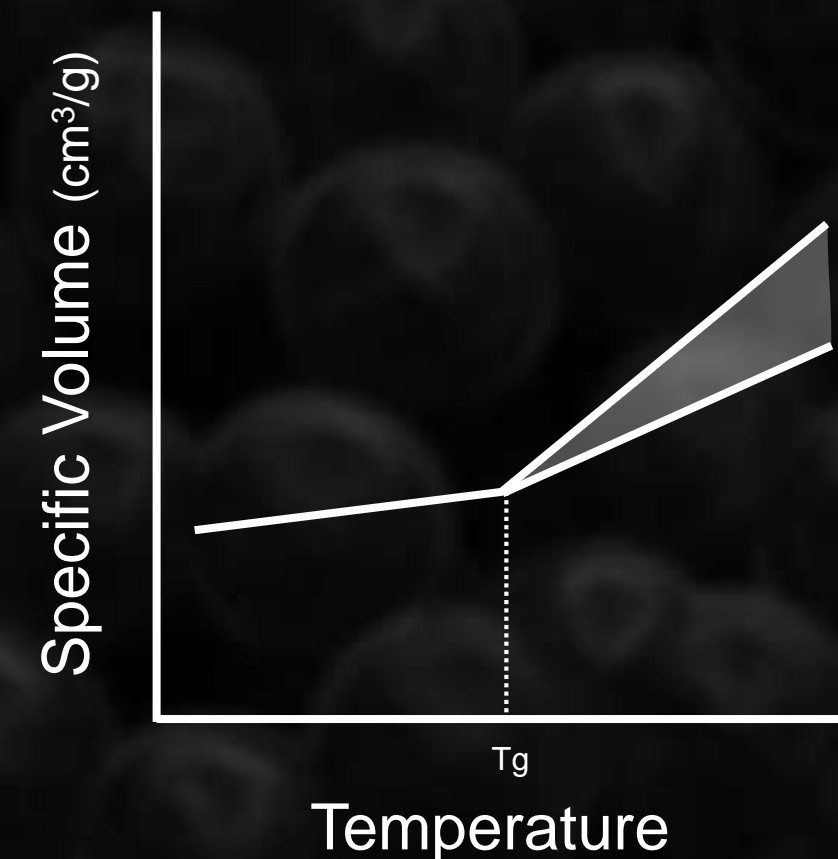
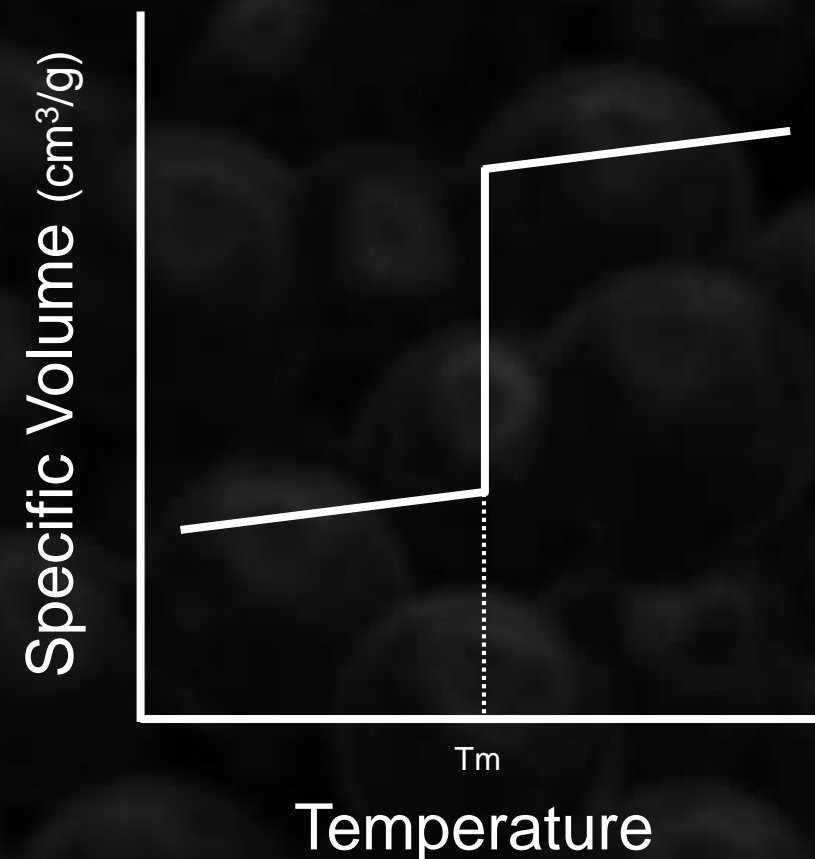
Tg Factors

Polymer Chemistry

Particle Morphology

Molecular Weight

Hydroplasticization



Glass Transition Temperature

Materials

Crystalline

Amorphous

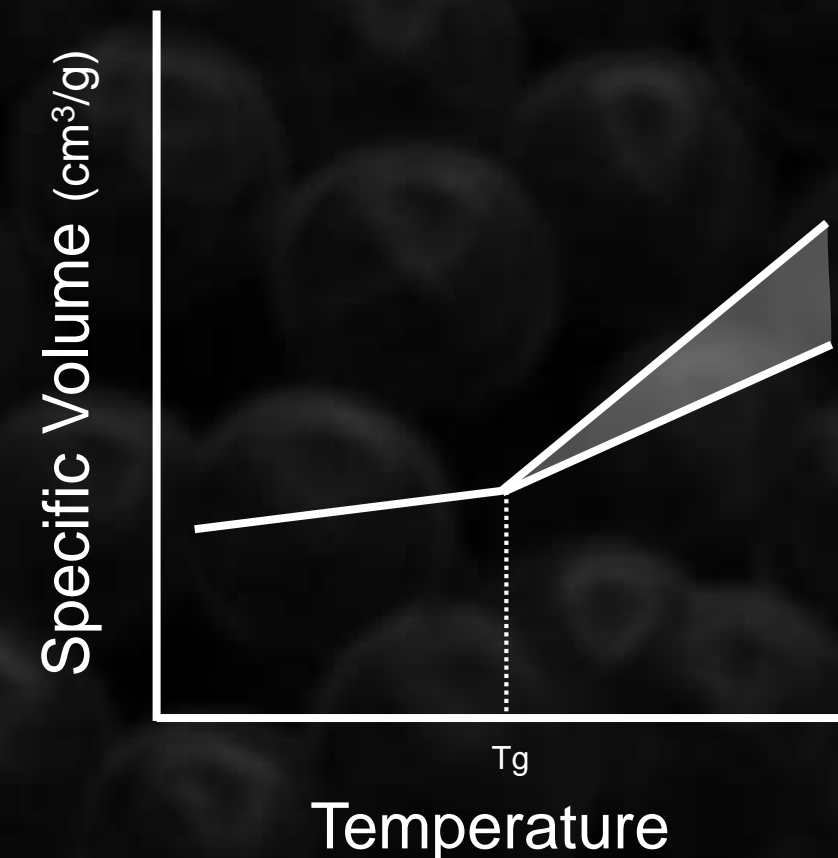
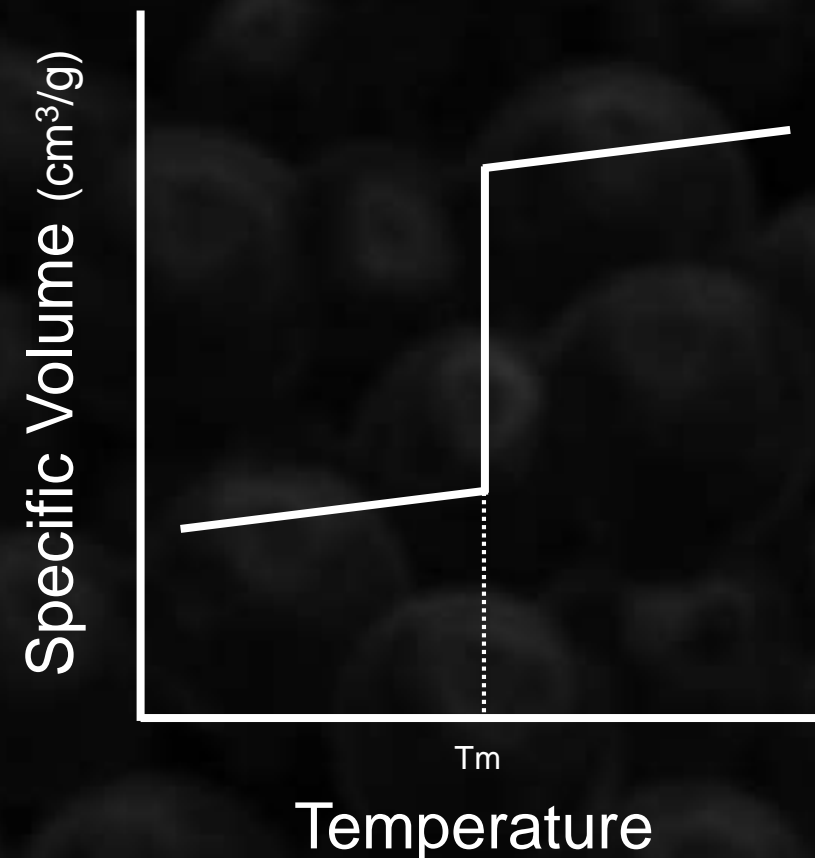
Tg Factors

Polymer Chemistry

Particle Morphology

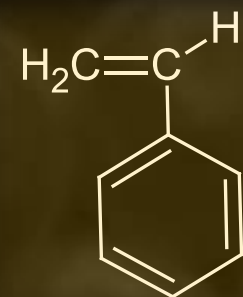
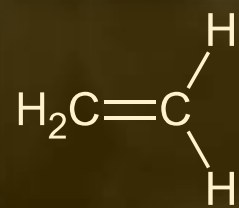
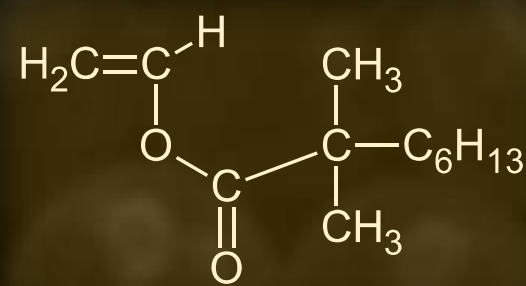
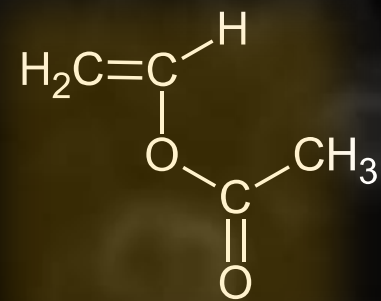
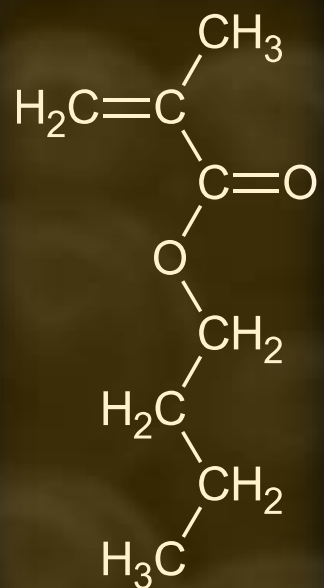
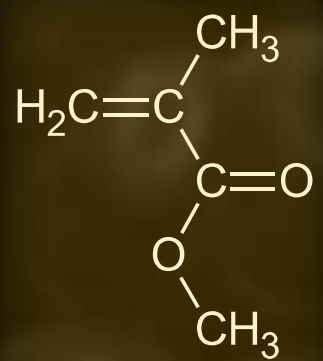
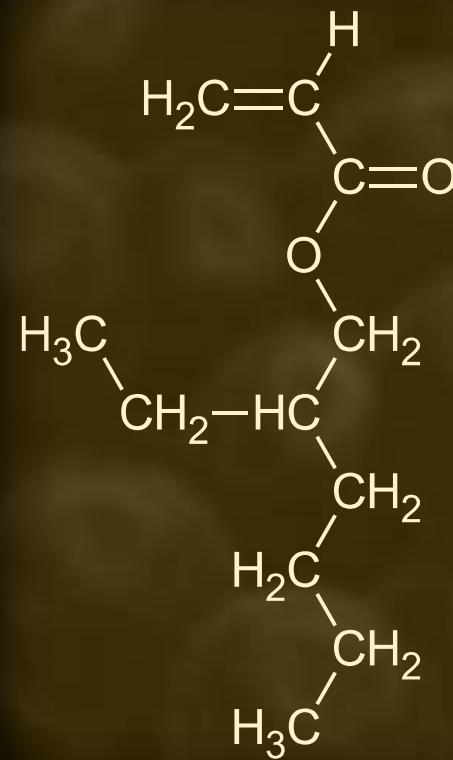
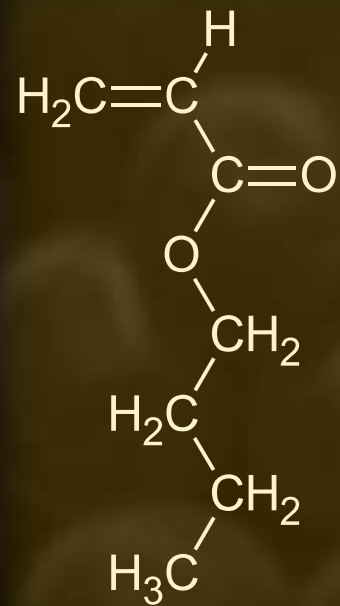
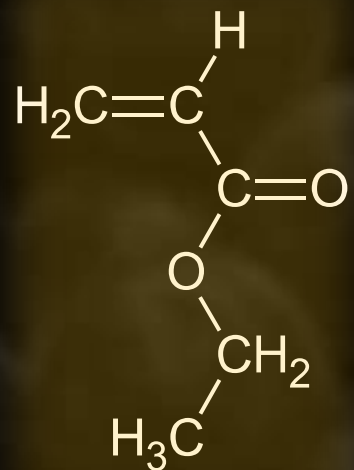
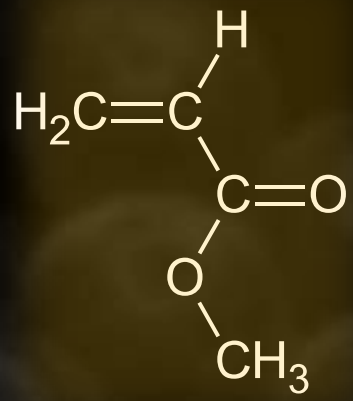
Molecular Weight

Hydroplasticization



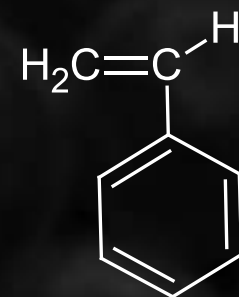
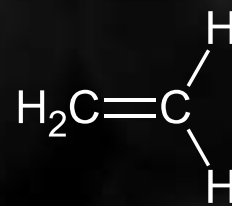
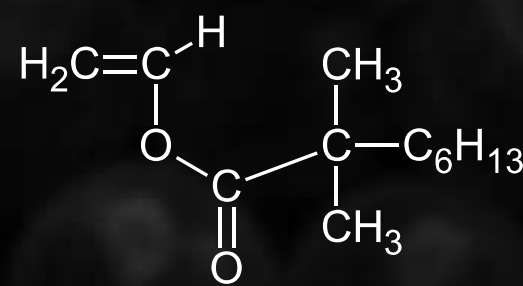
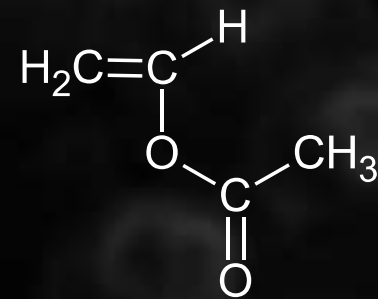
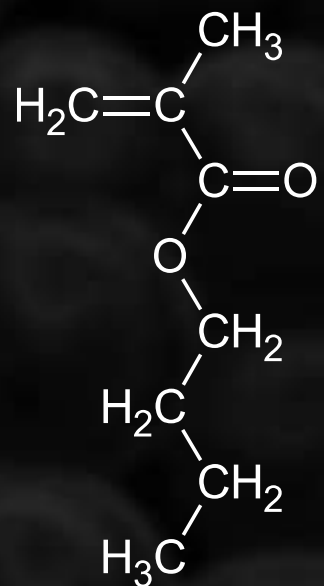
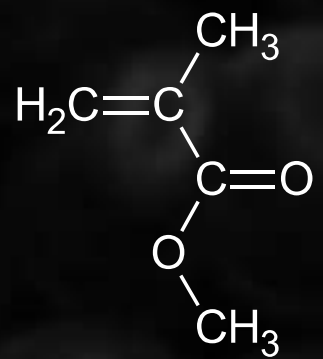
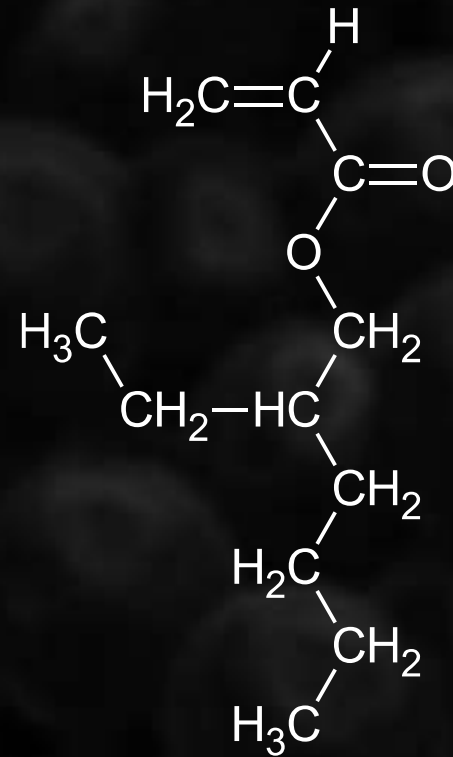
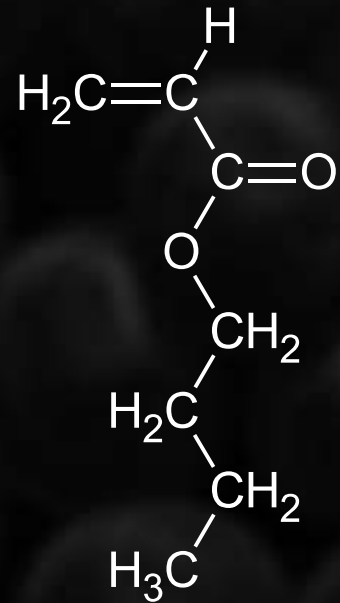
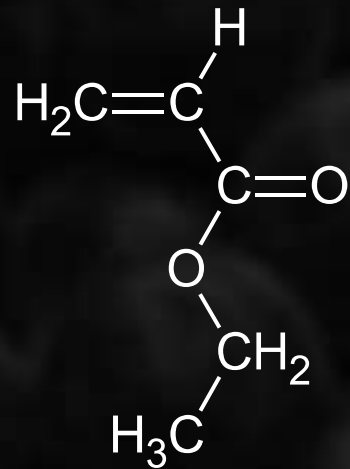
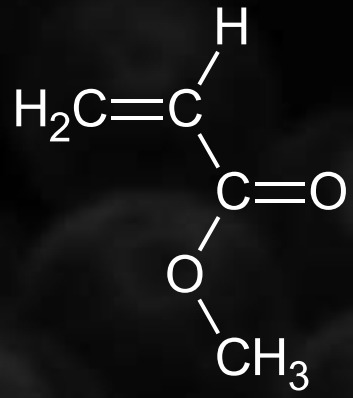
Polymer Chemistry

Polymer Chemistry



Monomer	T _g
Methyl Acrylate	12
Ethyl Acrylate	-23
Butyl Acrylate	-52
2-Ethyl Hexyl Acrylate	-50
Methyl Methacrylate	108
Butyl Methacrylate	25
Vinyl Acetate	32
Vinyl Versatate	-3
Ethylene	-75
Styrene	101

Polymer Chemistry



Monomer	T _g
Methyl Acrylate	12
Ethyl Acrylate	-23
Butyl Acrylate	-52
2-Ethyl Hexyl Acrylate	-50
Methyl Methacrylate	108
Butyl Methacrylate	25
Vinyl Acetate	32
Vinyl Versatate	-3
Ethylene	-75
Styrene	101

Glass Transition Temperature

Materials

Crystalline

Amorphous

Tg Factors

Polymer Chemistry

Particle Morphology

Molecular Weight

Hydroplasticization

Glass Transition Temperature

Materials

Crystalline

Amorphous

Tg Factors

Polymer Chemistry

Particle Morphology

Molecular Weight

Hydroplasticization

Polymers

Polymerization

Film Formation

T_g and MFFT

Polymers

Polymerization

Film Formation

Tg and **MFFT**

MFFT

Latex Polymer

Formulation

Drying Environment

Time

MFFT

Latex Polymer

Formulation

Drying Environment

Time

Glass Transition Temperature

Lower → Mobility/Entanglement

Particle Morphology

Smaller → Higher Surface Area

Molecular Weight

Lower → Mobility/Entanglement

Hydroplasticization

Hydrophilic Monomers

Water → Free Volume → Mobility

MFFT

Latex Polymer

Formulation

Drying Environment

Time

MFFT

Latex Polymer

Formulation

Drying Environment

Time

Coalescent/Plasticizer

Lower Tg

Solvents

Lower Tg

Humectants

Slows Water Evaporation

Pigmentation

Constrains Polymer Flow

MFFT

Latex Polymer

Formulation

Drying Environment

Time

MFFT

Latex Polymer

Formulation

Drying Environment

Time

Temperature

Improves Film Formation

Humidity

Slows Water Evaporation

Air Flow

Increases Water Evaporation

Application Temperature

Application Temperature $>$ T_g

Substrate Porosity

Substrate Wicking

MFFT

Latex Polymer

Formulation

Drying Environment

Time

MFFT

Latex Polymer
Formulation
Drying Environment
Time

Polymer Deformation
Coalescence
Interdiffusion
Curing
 Crosslinking
 Chemical Reaction

Polymers

Polymerization

Film Formation

Tg and **MFFT**



Raw Materials

Polymers

Liquids

Pigments

Additives

Raw Materials

Polymers

Liquids

Pigments

Additives

Demystifying Tg and MFFT

