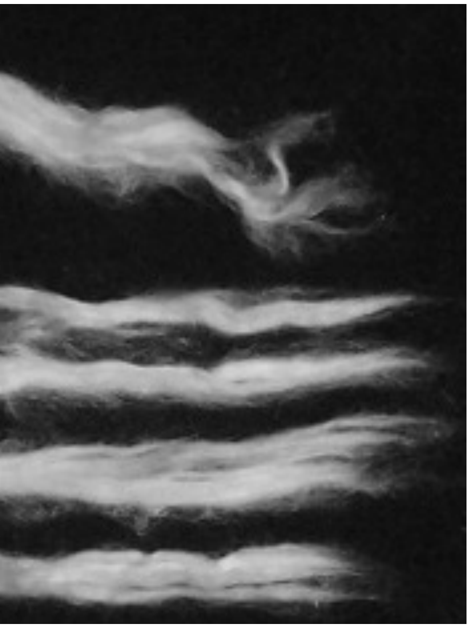
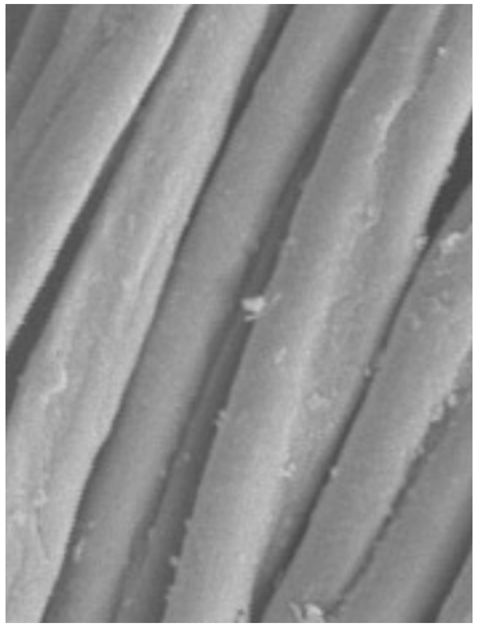


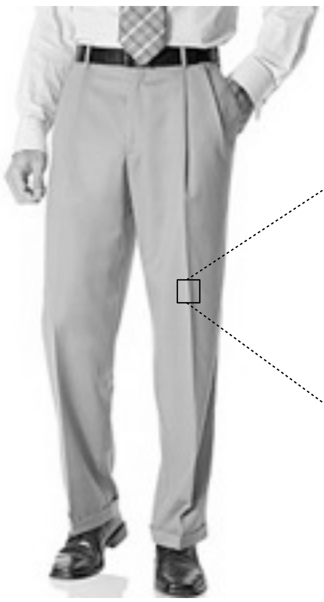



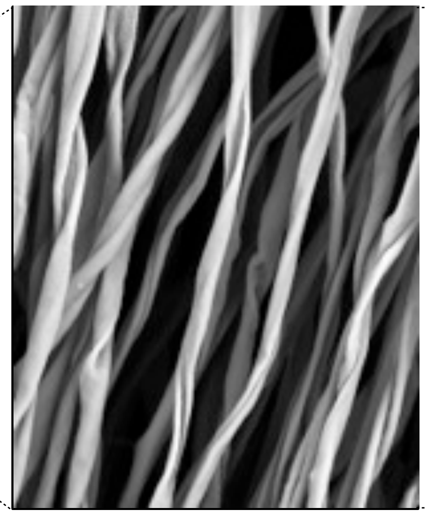

NEW APPROACHES IN COTTON CROSSLINKING

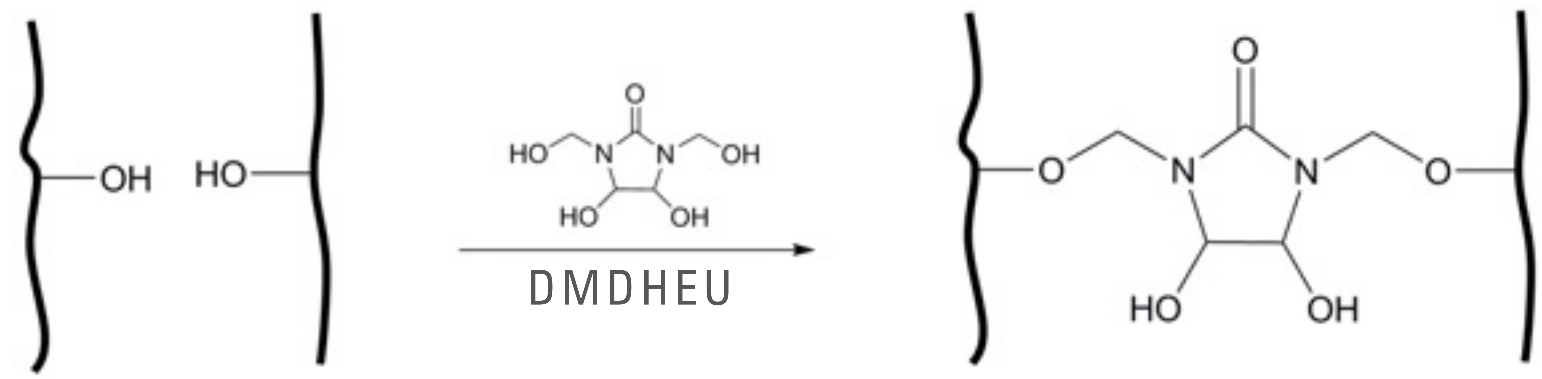
GREENER SOLUTIONS 2013

JOE CHARBONNET
JEN LAWRENCE
LEAH RUBIN
SARA TEPFER

CURRENT TECHNOLOGY: WRINKLE RESISTANCE







WRINKLES ARE CREATED BY DISORDERLY HYDROGEN BONDS BETWEEN WATER AND COTTON

DMDHEU CROSSLINKS COTTON FIBERS IN ORDERED, WRINKLE FREE PATTERN

VARIETY OF NAMES: PERMANENT PRESS, WRINKLE-FREE, EASY CARE, NEVER-IRON

CONTRIBUTES TO FREE FORMALDEHYDE IN FABRICS

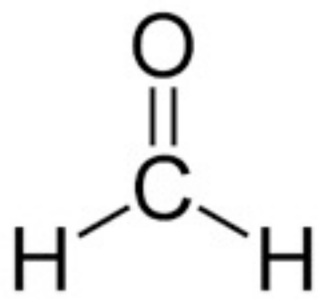
CURRENT TECHNOLOGY: WATER REPELLENCY

WATER REPELLENCY ACHIEVED THROUGH CROSSLINKING TO A DURABLE WATER REPELLENT [DWR]

LEVI'S COMMUTER JEANS CROSSLINK A PARAFFIN-BASED DWR, ECOREPEL, WITH

DIISOCYANATES

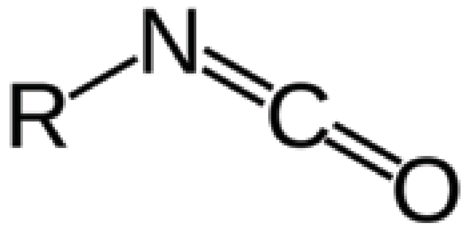
HEALTH IMPACTS



FORMALDEHYDE

EXPOSURE ROUTES
- INHALATION OF FUMES
- ABSORPTION THROUGH SKIN

SEVERE HEALTH ISSUES
- NERVOUS SYSTEM DAMAGE
- ENDOCRINE DISRUPTION
- NASAL CANCER
- NASOPHARYNGEAL CANCER
- LEUKEMIA
- SKIN SENSITIZER
- RESPIRATORY SENSITIZER



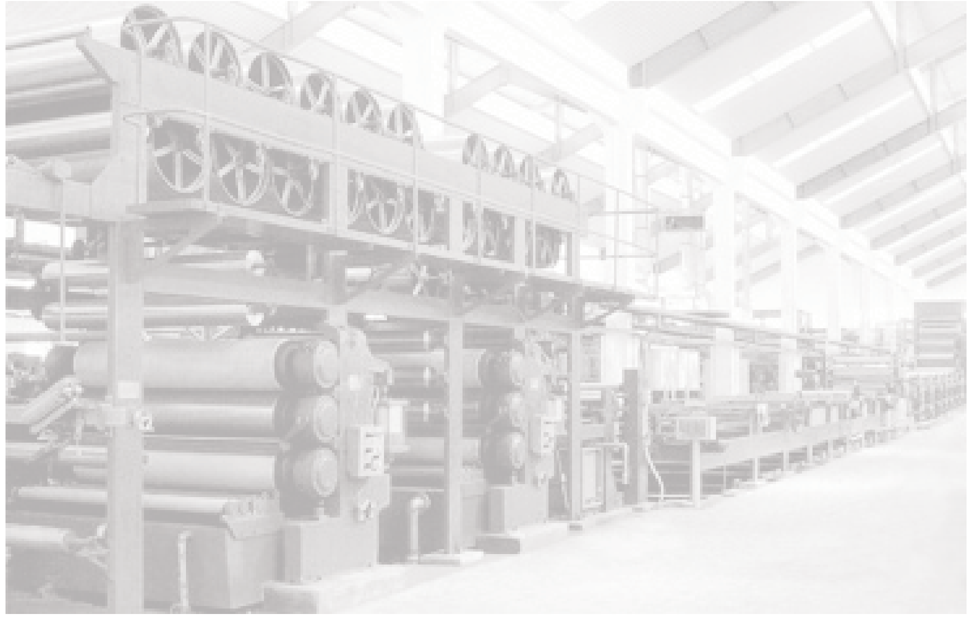
DIISOCYANATES

EXPOSURE ROUTES
- MAY BE APPLIED IN GARMENT FORM
- INCREASES EXPOSURE

SEVERE HEALTH ISSUES
- SKIN, EYE, AND RESPIRATORY IRRITANT
- RESPIRATORY SENSITIZER
- PRODUCES ASTHMA
- POSSIBLE CARCINOGEN

GOALS



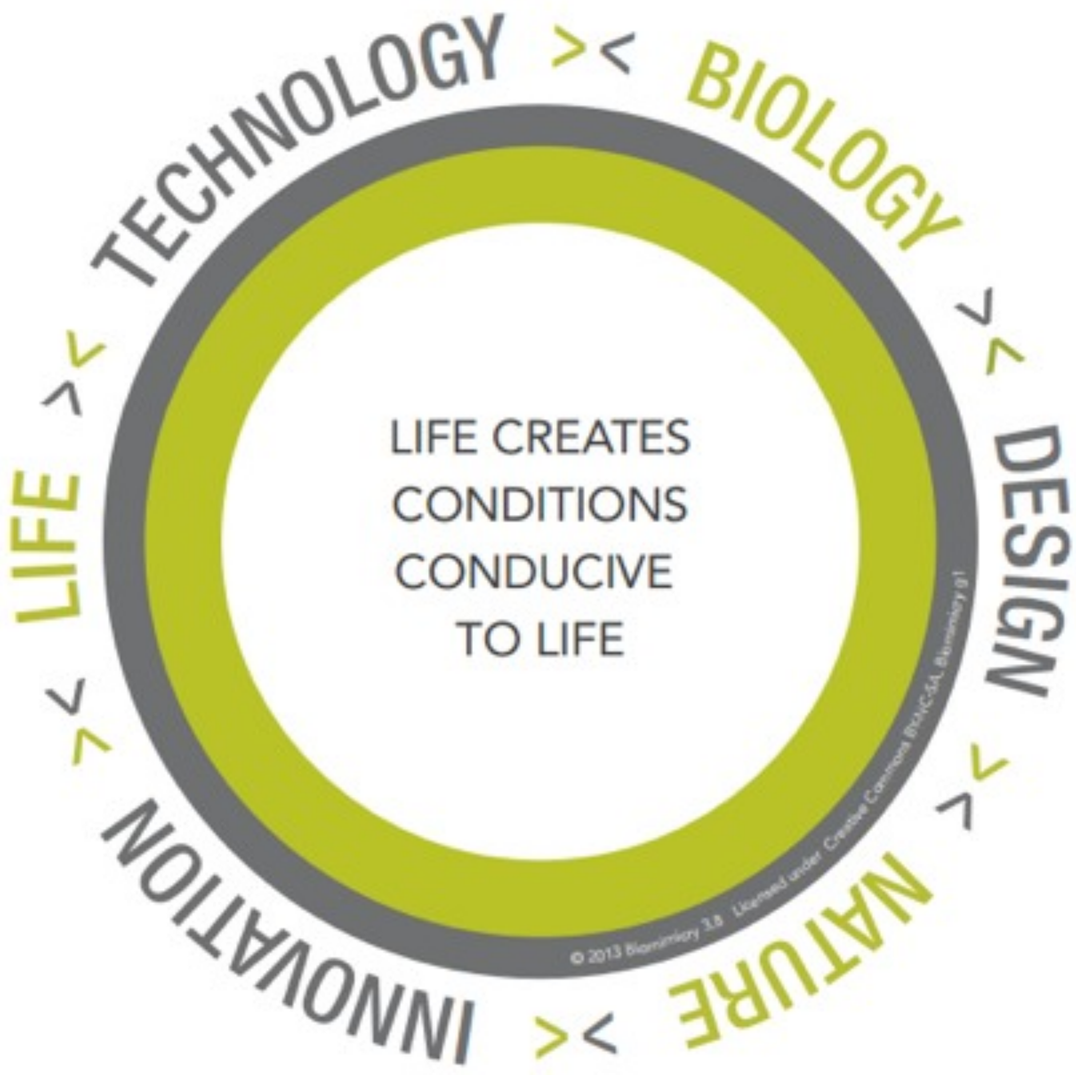


GOALS

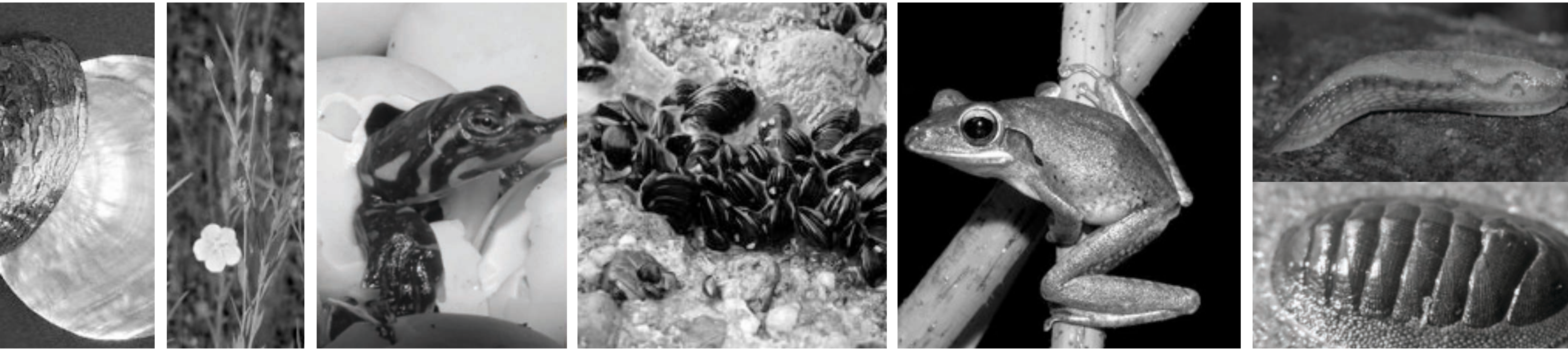
TO DETERMINE WHAT BIOLOGICALLY INSPIRED OPPORTUNITIES EXIST FOR LEVI STRAUSS & CO. TO MODIFY CURRENT CROSSLINKING TECHNOLOGIES USED TO IMPART WRINKLE-RESISTANCE AND WATER-REPELLENCY.

TO EVALUATE SOLUTIONS' HEALTH AND ENVIRONMENTAL IMPACTS RELATIVE TO CURRENT TECHNOLOGIES.

WHAT IS BIOMIMICRY?



BIOMIMICRY IS LEARNING FROM AND THEN EMULATING NATURAL FORMS, PROCESSES, AND ECOSYSTEMS TO CREATE MORE SUSTAINABLE DESIGNS



COVALENT INTERACTIONS

TRANSLATING BIOLOGY TO TEXTILES

NON-COVALENT INTERACTIONS

COORDINATION WITH METALS

STRUCTURAL FEATURES

12 EXAMPLES

COMMON THEMES

MULTIPLE BONDING TYPES

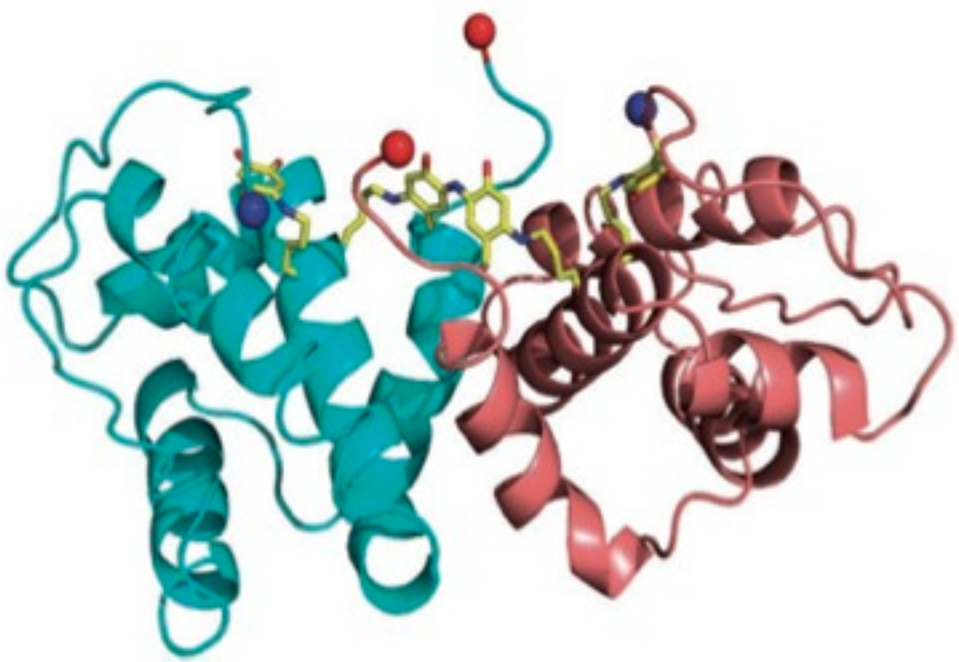
COVALENT + NONCOVALENT

CROSSLINKING + BONDS WITH CELLULOSE

STRATEGIES

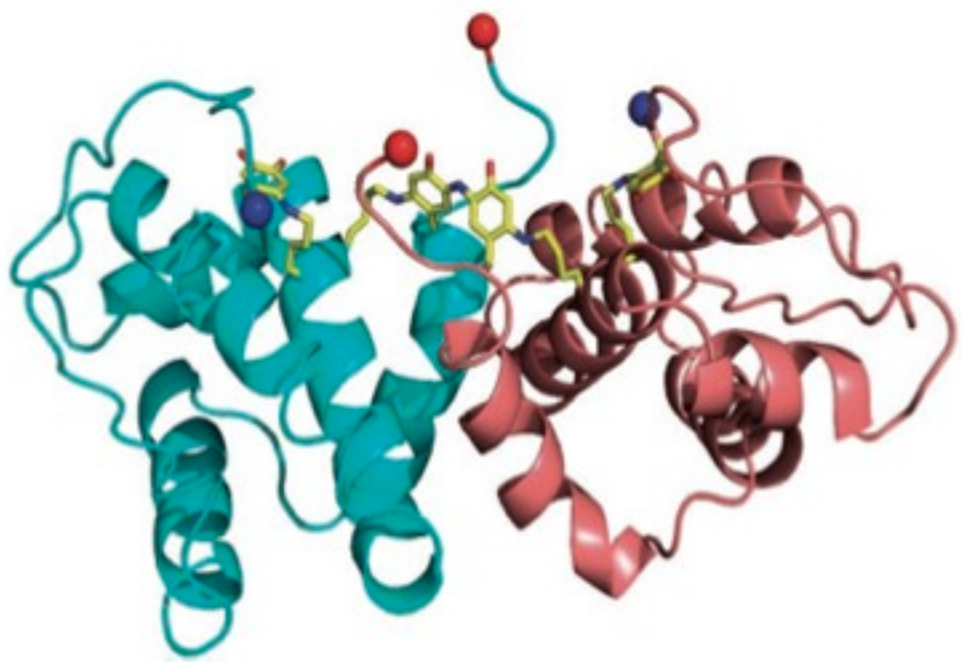
SOLUTIONS

RANASMURFIN

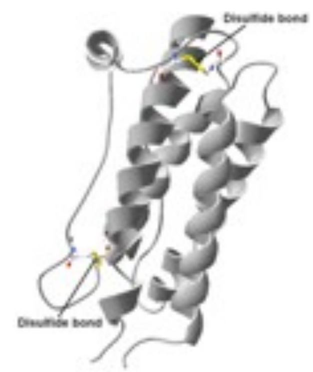


Oke, et al, 2008.

RANASMURFIN



Oke, et al, 2008.

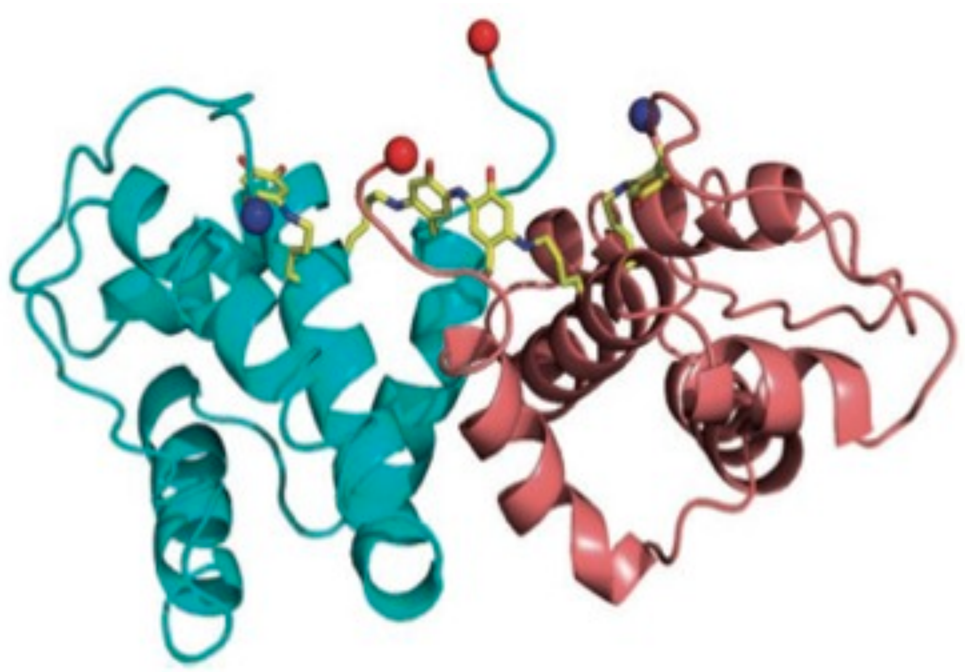


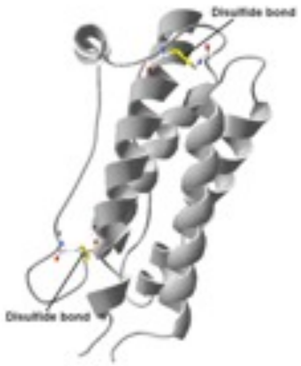
COVALENT INTERACTIONS

DISULFIDE BONDS

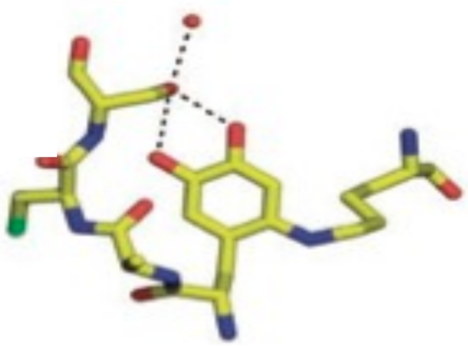
12 EXAMPLES | **COMMON THEMES** **MULTIPLE BONDING TYPES** | COVALENT + NONCOVALENT CROSSLINKING + BONDS WITH CELLULOSE | STRATEGIES | SOLUTIONS

RANASMURFIN





COVALENT INTERACTIONS
DISULFIDE BONDS

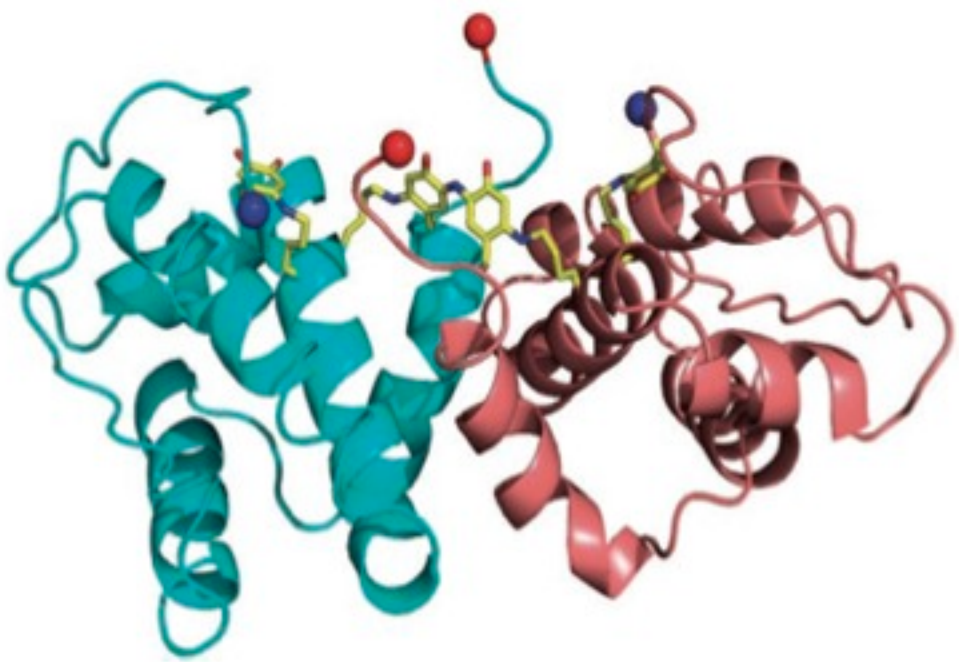


NON-COVALENT INTERACTIONS
HYDROGEN BONDS

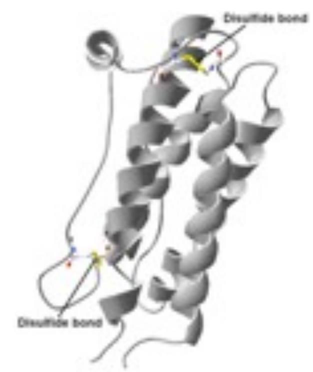
Oke, et al, 2008.

TRANSLATING BIOLOGY TO TEXTILES

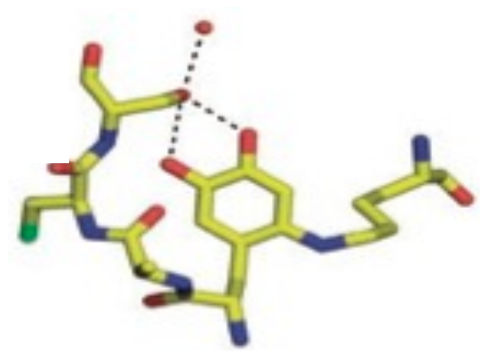
RANASMURFIN



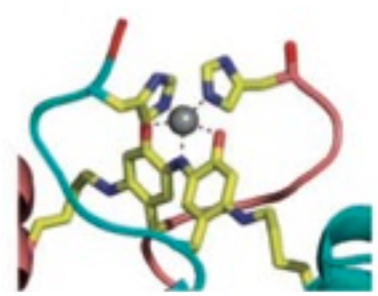
Oke, et al, 2008.



COVALENT INTERACTIONS
DISULFIDE BONDS



NON-COVALENT INTERACTIONS
HYDROGEN BONDS



ANCILLARY METALS
COORDINATION COMPLEXES

12 EXAMPLES

COMMON THEMES

MULTIPLE BONDING TYPES

COVALENT + NONCOVALENT

CROSSLINKING + BONDS WITH CELLULOSE

STRATEGIES

SOLUTIONS

BIOLOGICAL CROSSLINKING

TEXTILE CROSSLINKING

12 EXAMPLES | COMMON THEMES MULTIPLE BONDING TYPES | COVALENT + NONCOVALENT CROSSLINKING + BONDS WITH CELLULOSE | STRATEGIES | SOLUTIONS

BIOLOGICAL CROSSLINKING

MULTIPLE BONDING STRUCTURES

- COVALENT INTERACTIONS
- NON-COVALENT INTERACTIONS
- COORDINATION WITH METALS
- STRUCTURAL FEATURES

TEXTILE CROSSLINKING

12 EXAMPLES
COMMON THEMES
MULTIPLE BONDING TYPES
COVALENT + NONCOVALENT
CROSSLINKING + BONDS WITH CELLULOSE
STRATEGIES
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BIOLOGICAL CROSSLINKING

MULTIPLE BONDING STRUCTURES

- COVALENT INTERACTIONS
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TEXTILE CROSSLINKING

MULTIPLE BONDING STRUCTURES

- COVALENT INTERACTIONS
- NON-COVALENT INTERACTIONS + STRUCTURAL FEATURES

TRANSLATING BIOLOGY TO TEXTILES

12 EXAMPLES → **COMMON THEMES** / **MULTIPLE BONDING TYPES** → COVALENT + NONCOVALENT / CROSSLINKING + BONDS WITH CELLULOSE → STRATEGIES → SOLUTIONS

BIOLOGICAL CROSSLINKING

MULTIPLE BONDING STRUCTURES

- COVALENT INTERACTIONS
- NON-COVALENT INTERACTIONS
- COORDINATION WITH METALS
- STRUCTURAL FEATURES

MULTIPLE BONDING POINTS

TEXTILE CROSSLINKING

MULTIPLE BONDING STRUCTURES

- COVALENT INTERACTIONS
- NON-COVALENT INTERACTIONS + STRUCTURAL FEATURES

BIOLOGICAL CROSSLINKING

MULTIPLE BONDING STRUCTURES

- COVALENT INTERACTIONS
- NON-COVALENT INTERACTIONS
- COORDINATION WITH METALS
- STRUCTURAL FEATURES

MULTIPLE BONDING POINTS

TEXTILE CROSSLINKING

MULTIPLE BONDING STRUCTURES

- COVALENT INTERACTIONS
- NON-COVALENT INTERACTIONS + STRUCTURAL FEATURES

MULTIPLE BONDING POINTS

- TWO BONDING POINTS

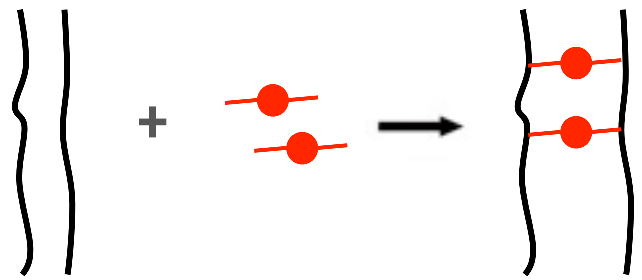
12 EXAMPLES | COMMON THEMES / MULTIPLE BONDING TYPES | COVALENT + NON-COVALENT / CROSSLINKING + BONDS WITH CELLULOSE | STRATEGIES | SOLUTIONS

TRADITIONAL CROSSLINKING

BIOMIMETIC CROSSLINKING

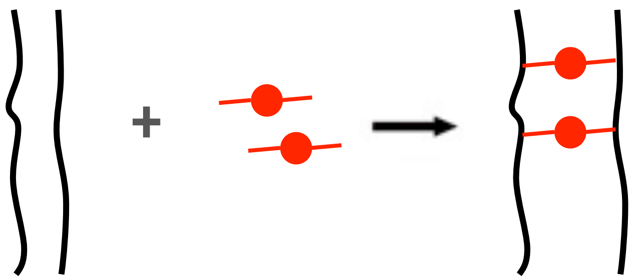
12 EXAMPLES | COMMON THEMES MULTIPLE BONDING TYPES | **COVALENT + NON-COVALENT CROSSLINKING + BONDS WITH CELLULOSE** | STRATEGIES | SOLUTIONS

TRADITIONAL CROSSLINKING



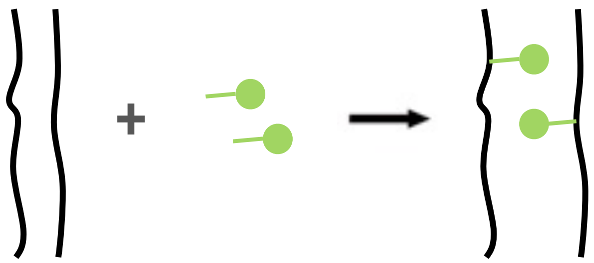
BIOMIMETIC CROSSLINKING

TRADITIONAL CROSSLINKING

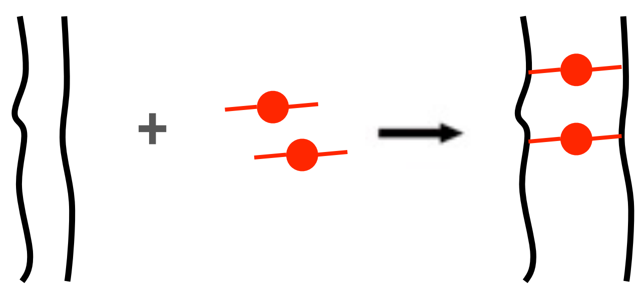


BIOMIMETIC CROSSLINKING

[1] BIND TO CELLULOSE

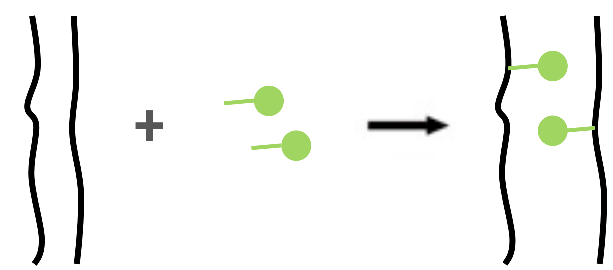


TRADITIONAL CROSSLINKING



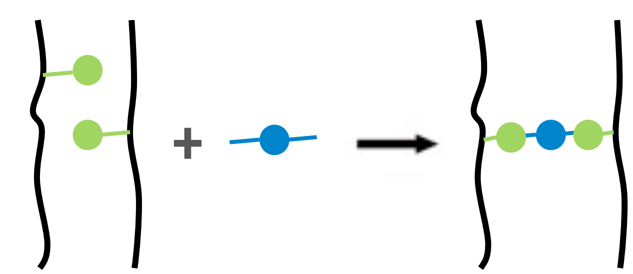
BIOMIMETIC CROSSLINKING

[1] BIND TO CELLULOSE

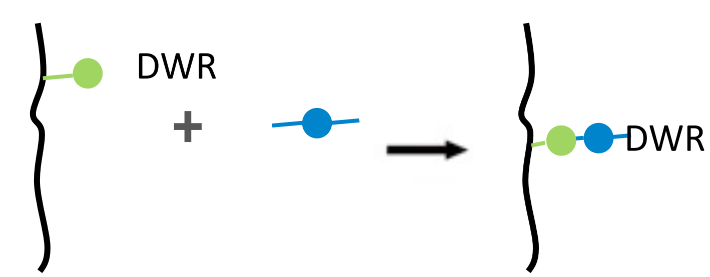


[2] PERFORM CROSSLINK

WRINKLE RESISTANCE



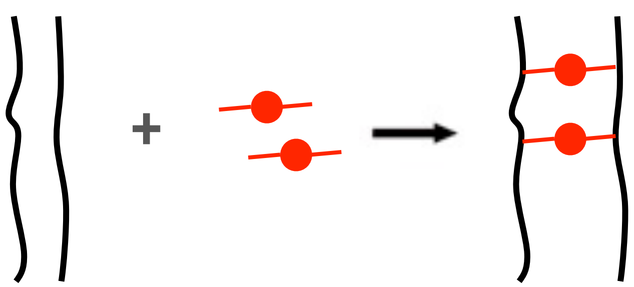
WATER REPELLENCY



TRANSLATING BIOLOGY TO TEXTILES

12 EXAMPLES → COMMON THEMES / MULTIPLE BONDING TYPES → COVALENT + NON-COVALENT / CROSSLINKING + BONDS WITH CELLULOSE → **STRATEGIES** → SOLUTIONS

TRADITIONAL CROSSLINKING



BIOMIMETIC CROSSLINKING

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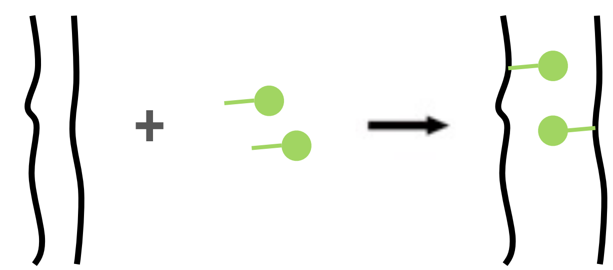
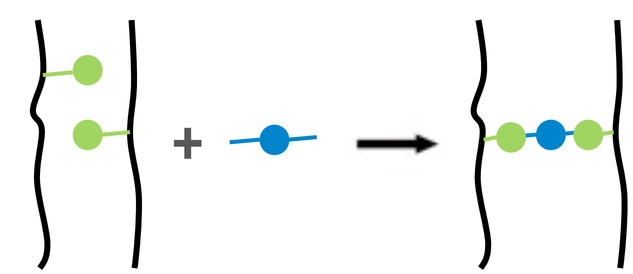
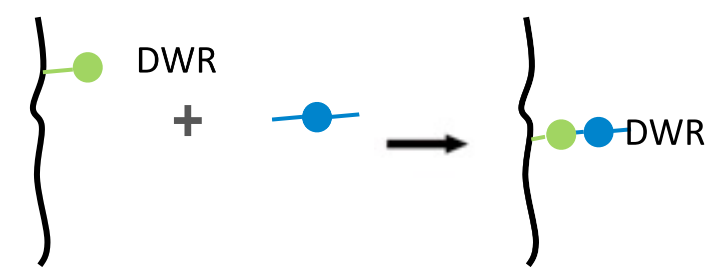


[2] PERFORM CROSSLINK

WRINKLE RESISTANCE

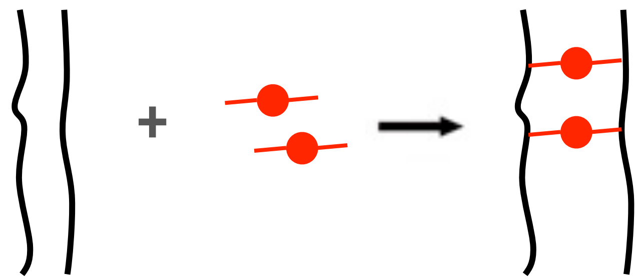


WATER REPELLENCY



12 EXAMPLES → COMMON THEMES / MULTIPLE BONDING TYPES → COVALENT + NON-COVALENT / CROSSLINKING + BONDS WITH CELLULOSE → STRATEGIES → **SOLUTIONS**

TRADITIONAL CROSSLINKING



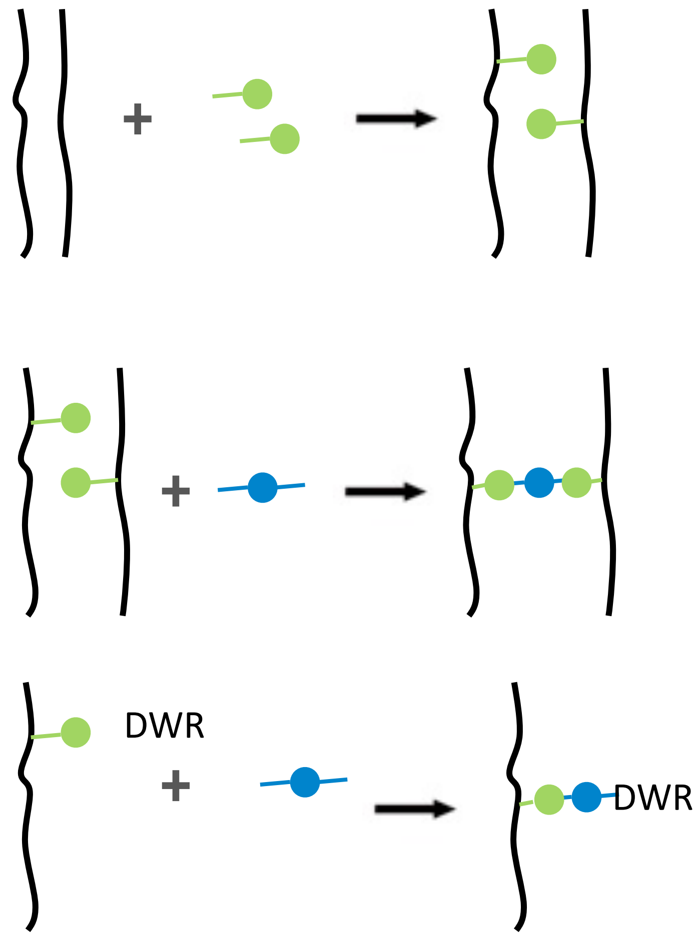
BIOMIMETIC CROSSLINKING

[1] BIND TO CELLULOSE

[2] PERFORM CROSSLINK

WRINKLE RESISTANCE

WATER REPELLENCY



PROCESS

YARN FORMATION

RAW COTTON

FIBER PREPARATION

SPINNING

FABRIC FORMATION

WARPING

SIZING → polyvinyl alcohol, polyacrylic acid, carboxymethyl cellulose

WEAVING

WET PROCESSING

PREPARATION

DYEING/PRINTING

FINISHING → may include DMDHEU, diisocyanates, perfluorinated acids, fluoropolymers, paraffin-based DWRs

FINISHING

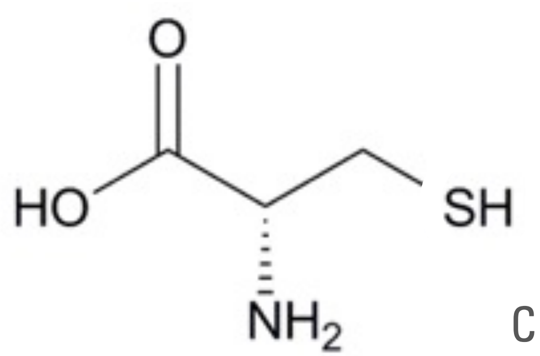
CUTTING

SEWING → for Levi's: DWR properties imparted here [garment form]

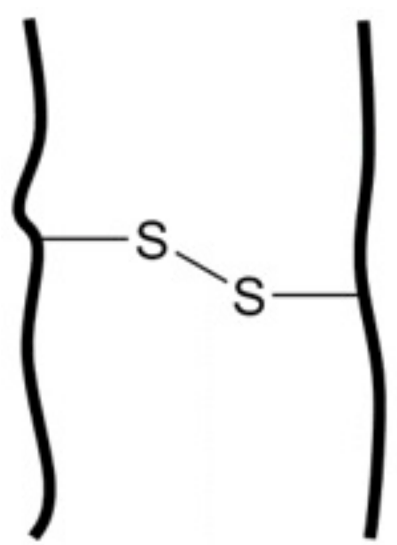
CURING

FINISHED GOODS

DISULFIDE BONDS STABILIZE PROTEIN STRUCTURE BY CROSSLINKING PEPTIDE CHAINS



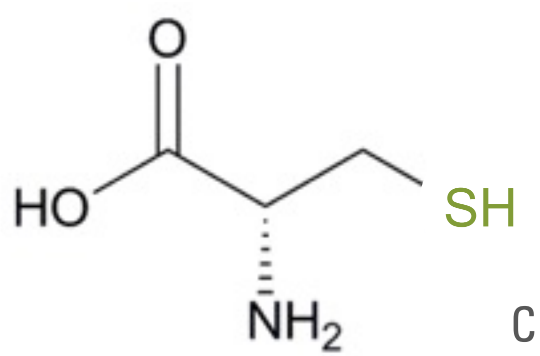
CYSTEINE



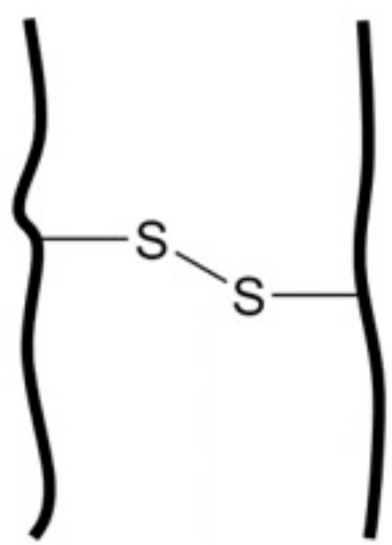
PROTEIN

CROSSLINKING: DISULFIDE BONDS

DISULFIDE BONDS STABILIZE PROTEIN STRUCTURE BY CROSSLINKING PEPTIDE CHAINS



CYSTEINE



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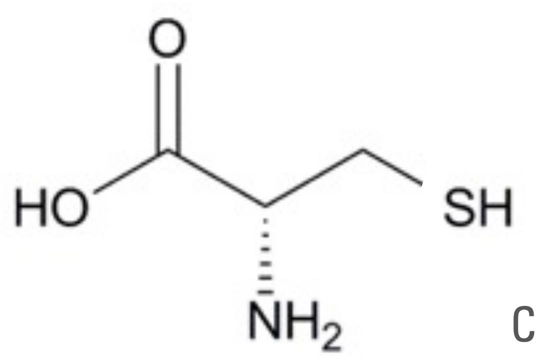
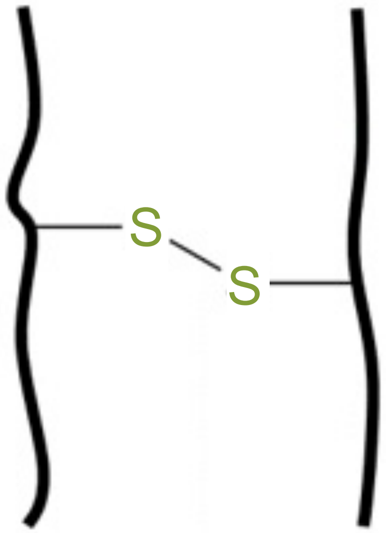


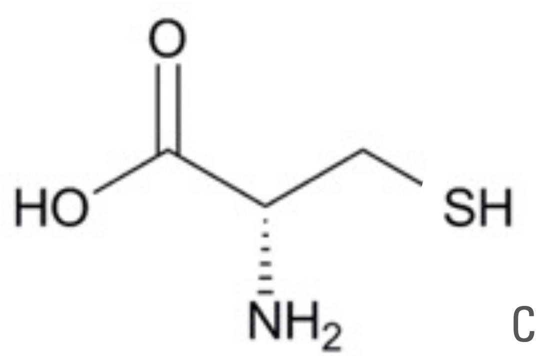
CYSTEINE



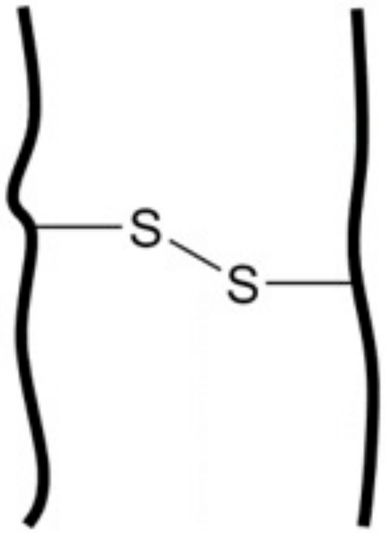
PROTEIN

CROSSLINKING: DISULFIDE BONDS

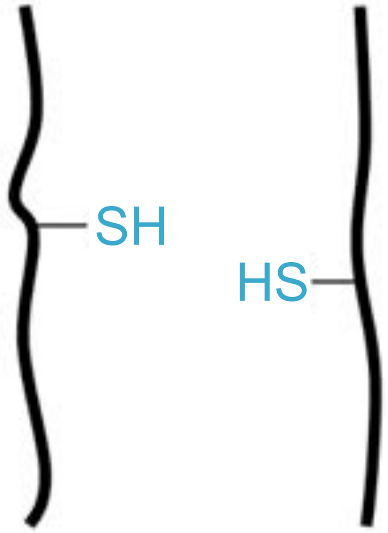
DISULFIDE BONDS STABILIZE PROTEIN STRUCTURE BY CROSSLINKING PEPTIDE CHAINS



CYSTEINE

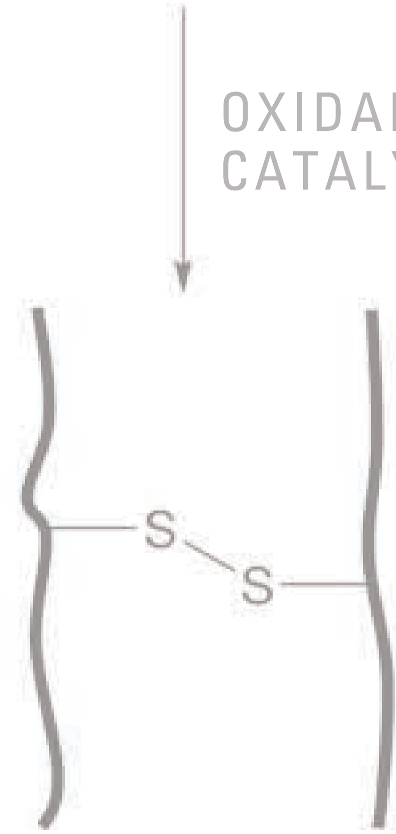


PROTEIN



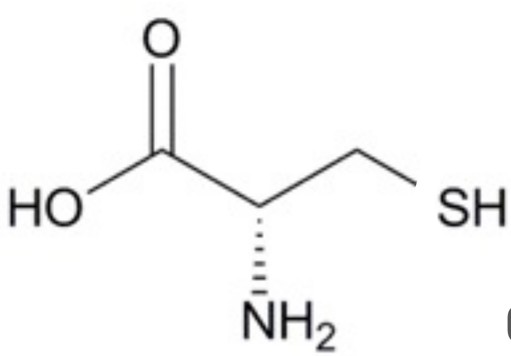
ATTACH THIOL GROUPS TO CELLULOSE FIBER

OXIDANT, CATALYST

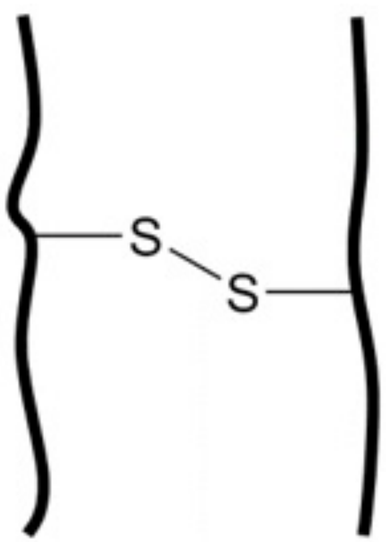


CROSSLINKING: DISULFIDE BONDS

DISULFIDE BONDS STABILIZE PROTEIN STRUCTURE BY CROSSLINKING PEPTIDE CHAINS



CYSTEINE



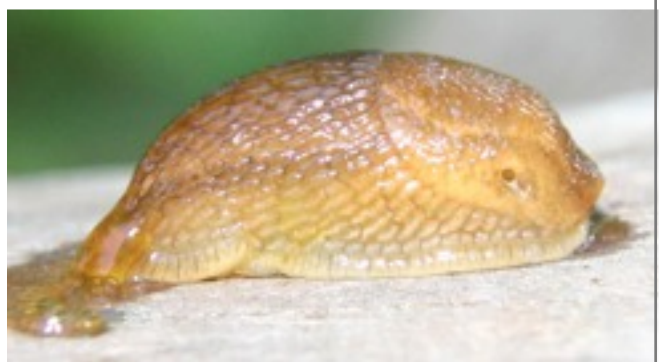
PROTEIN

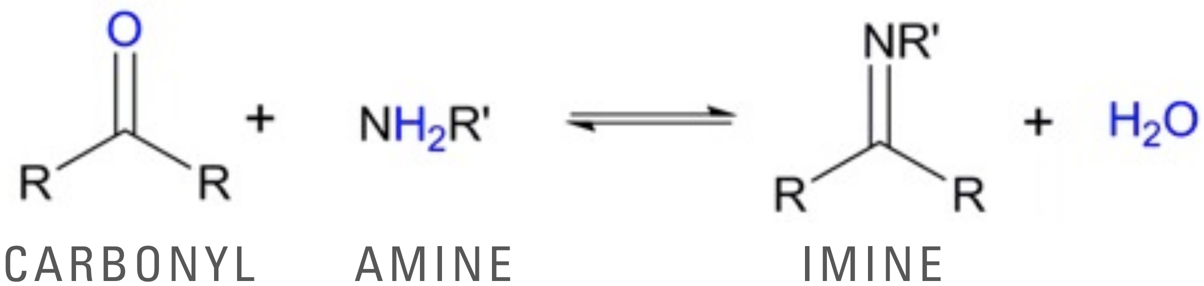
ATTACH THIOL GROUPS TO CELLULOSE FIBER

OXIDIZE TO FORM DISULFIDE BOND

CROSSLINKING: IMINE + AMINE BONDS

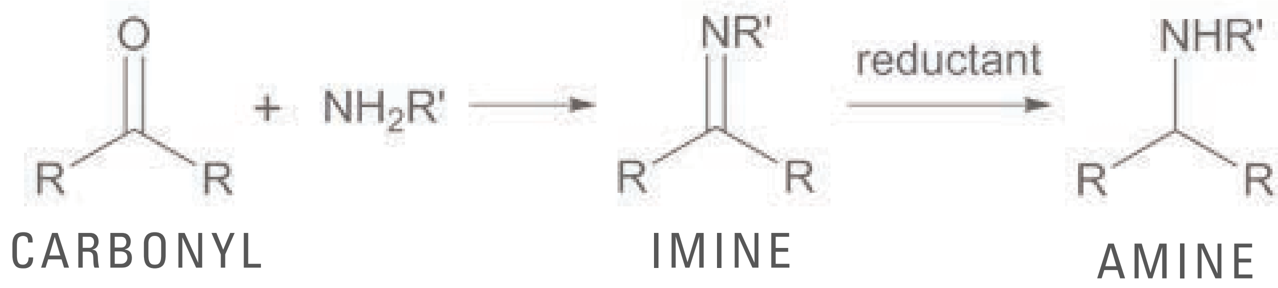
INSPIRED BY THE SLUG, ARION SUBFUSCUS





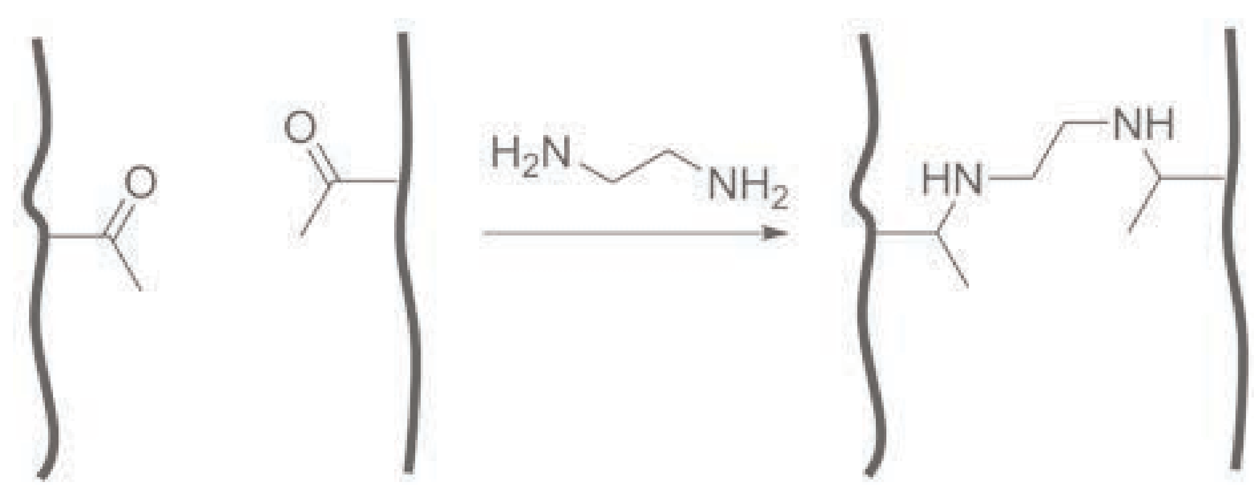
IMINE BOND CONTRIBUTES TO STIFFNESS OF MUCUS SECRETIONS

REDUCTIVE AMINATION PRODUCES A MORE STABLE BOND



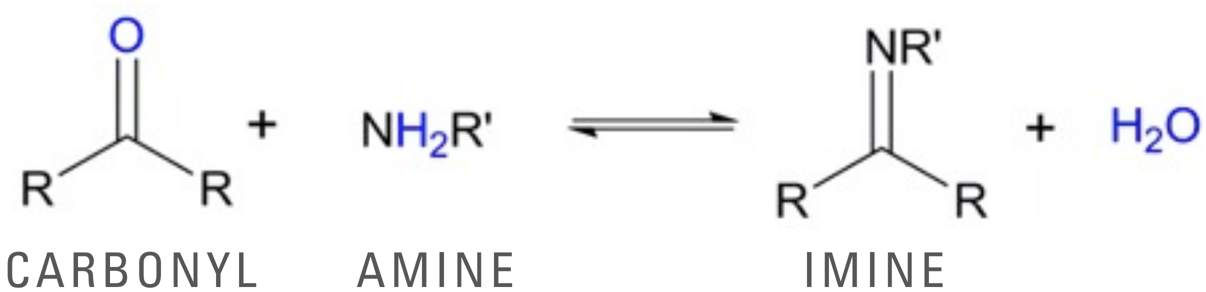
ATTACH CARBONYL GROUPS

CROSSLINK WITH DIAMINE



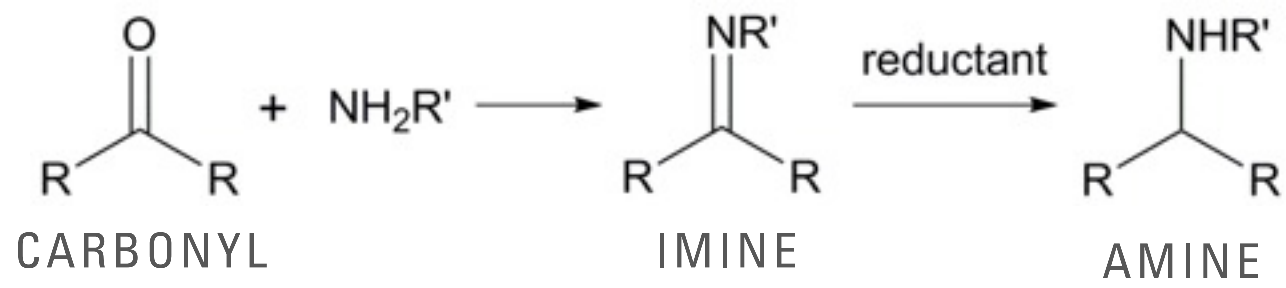
CROSSLINKING: IMINE + AMINE BONDS

INSPIRED BY THE SLUG, ARION SUBFUSCUS



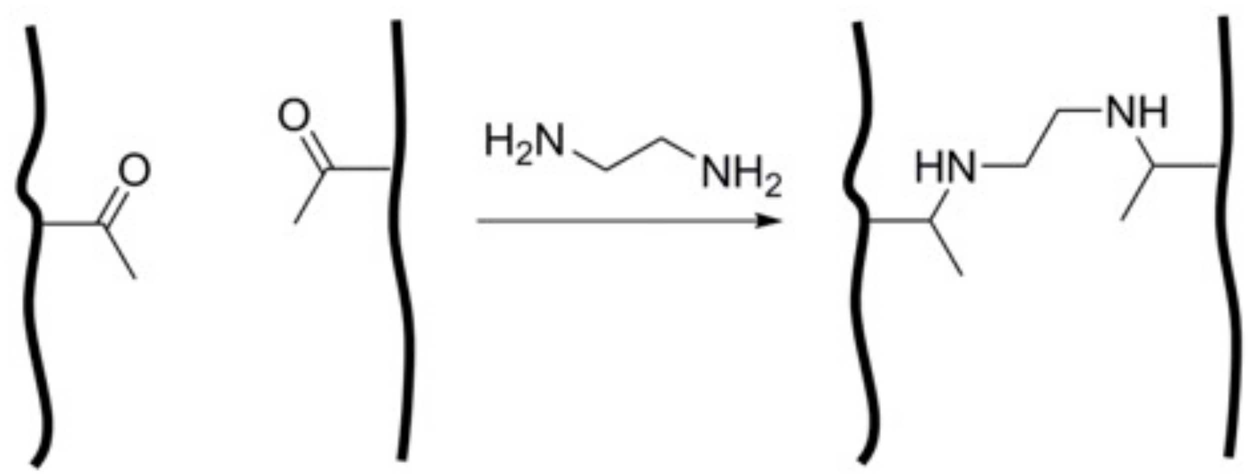
IMINE BOND CONTRIBUTES TO STIFFNESS OF MUCUS SECRETIONS

REDUCTIVE AMINATION PRODUCES A MORE STABLE BOND



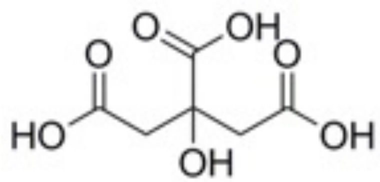
ATTACH CARBONYL GROUPS

CROSSLINK WITH DIAMINE

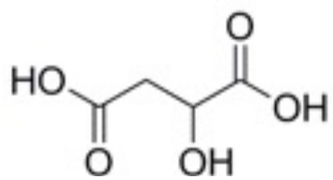


LINKING TO COTTON: POLY[CARBOXYLIC ACIDS]

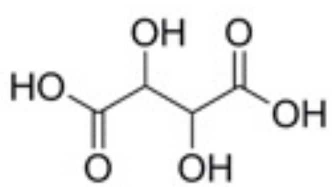
POLY[CARBOXYLIC ACIDS] ARE COMMONLY FOUND IN NATURE



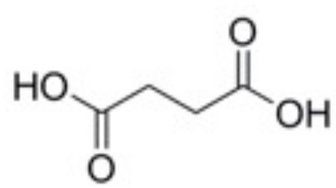
CITRIC ACID



MALIC ACID

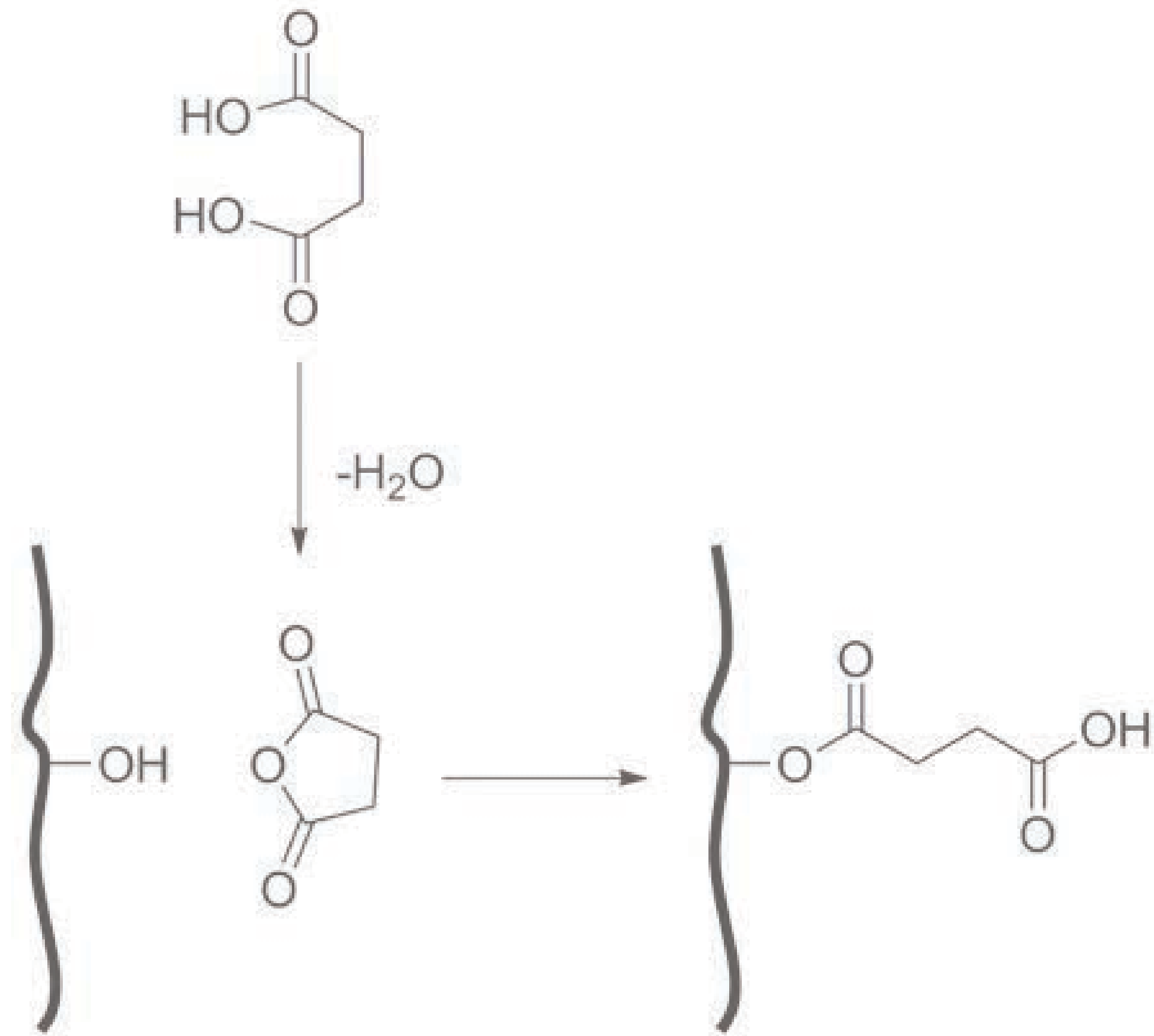


TARTARIC ACID



SUCCINIC ACID

POLY[CARBOXYLIC ACIDS] HAVE BEEN SHOWN TO BIND TO CELLULOSE THROUGH CYCLIC ANHYDRIDE INTERMEDIATE



LINKING TO COTTON: POLY[CARBOXYLIC ACIDS]

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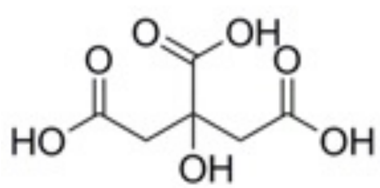
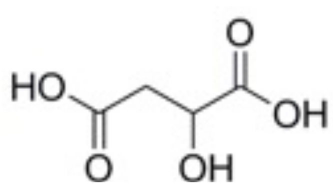
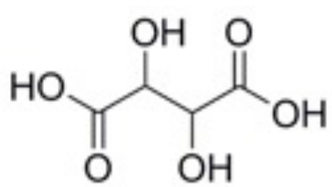


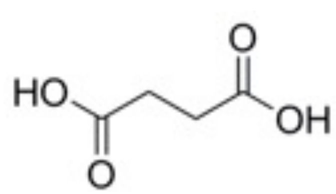
CITRIC ACID



MALIC ACID



TARTARIC ACID



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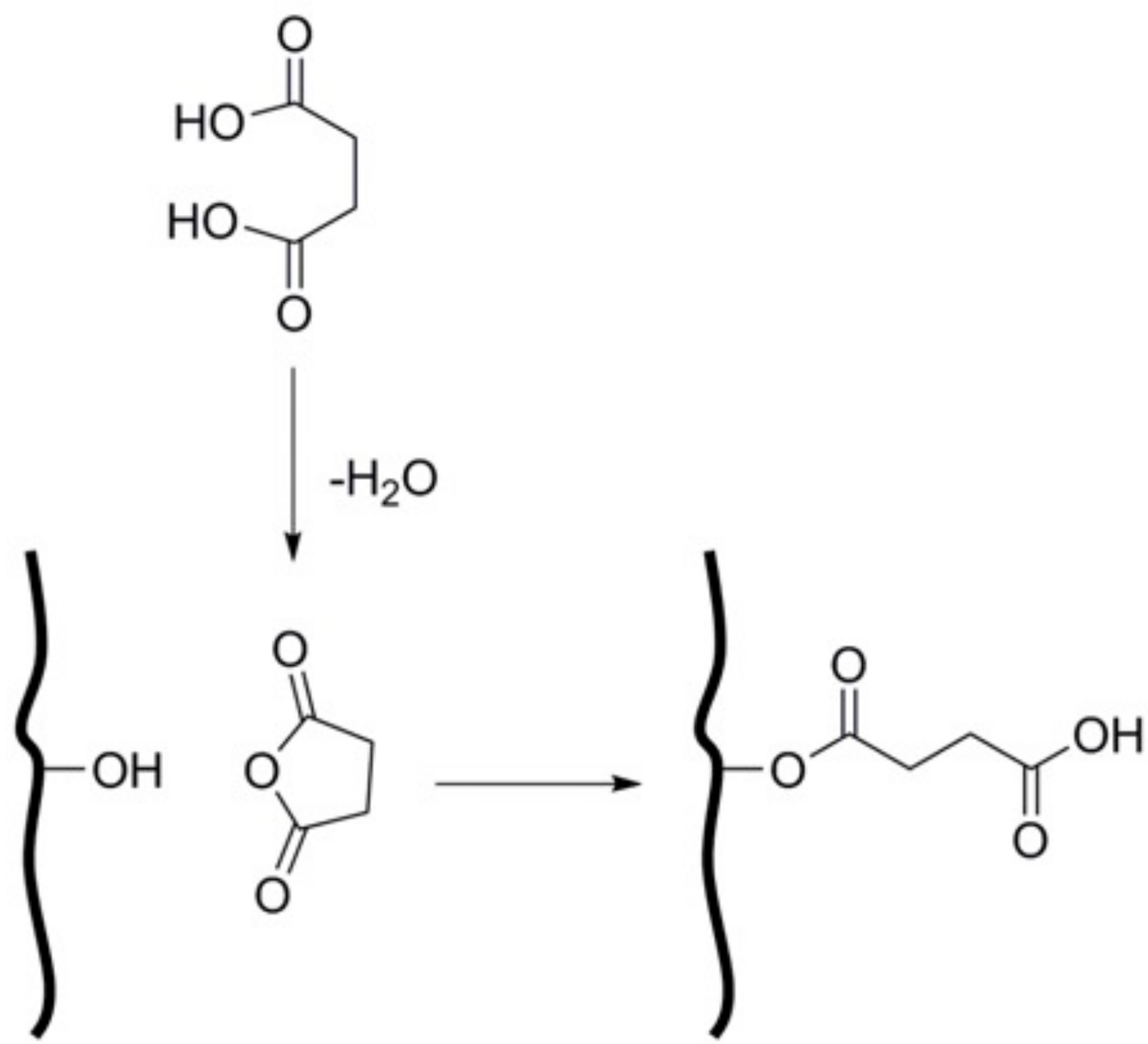
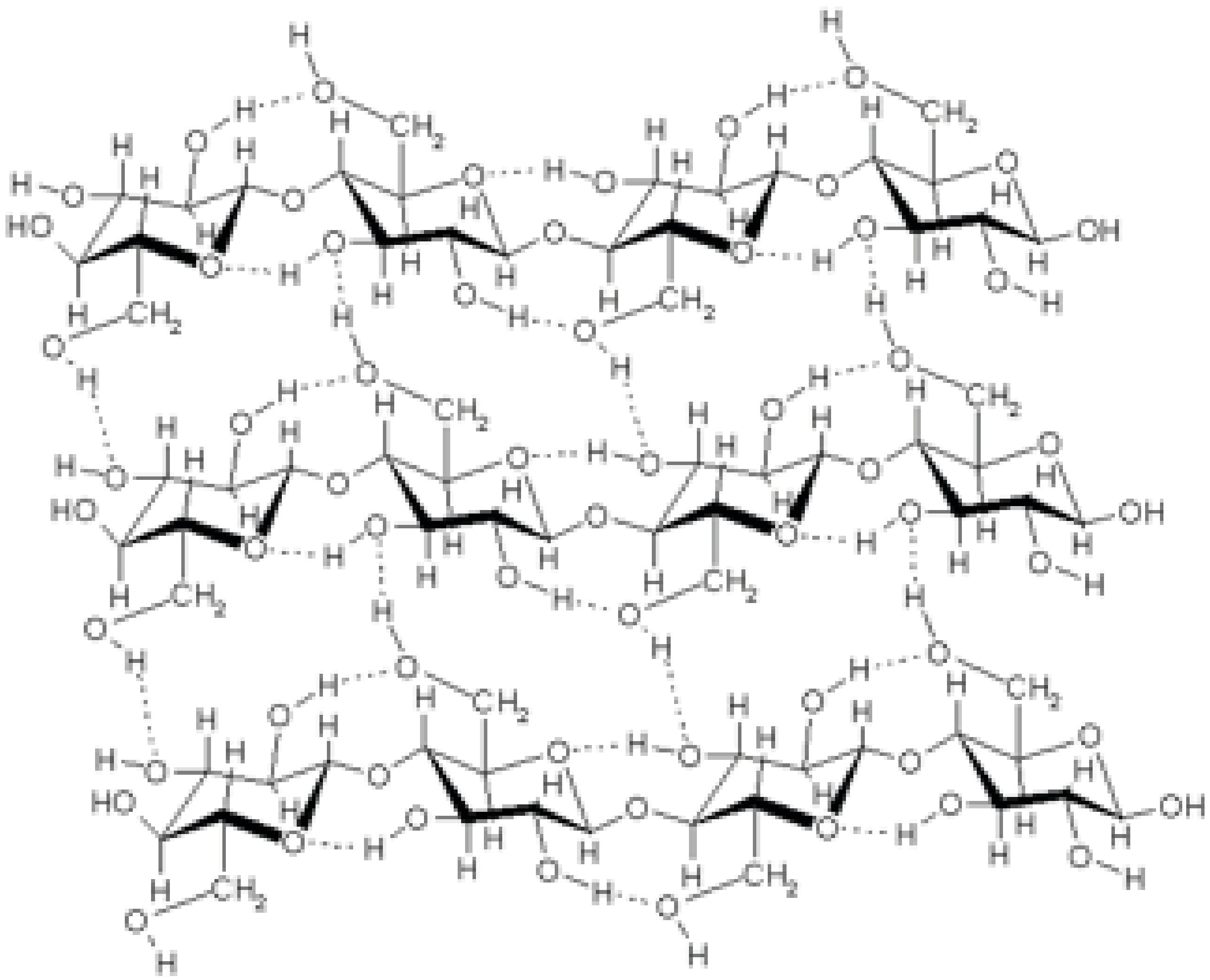


LINKING TO COTTON



BIOLOGICAL ORIGINS

WOOD CELL WALL

- HIGH NUMBER OF HYDROGEN BONDS
- STRUCTURAL INTEGRATION

INDUSTRY PRECEDENT

USE OF POLYMERS

- CURRENTLY COAT FIBERS AND BLEND POLYESTERS

MOTIVATION

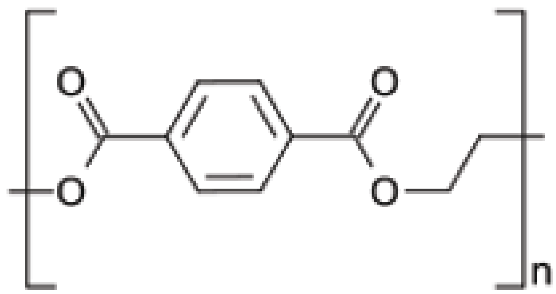
FUNCTIONALIZE CELLULOSE

- BETTER CROSSLINKING HANDLES
- COATING PROCESS
- COAT FIBER OR FABRIC WITH NON-COVALENTLY BOUND POLYMER FOR BETTER CROSSLINKING

LINKING TO COTTON: POLYMER WEAVE

CROSSLINK TO BLENDED POLYESTER

- LS & CO. OFTEN USES PET
- BLENDED POLYESTER MAY PROVIDE CROSSLINKING SITES

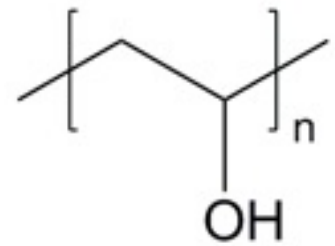


POLYETHYLENE TEREPHTHALATE, THE MOST COMMON POLYESTER IN TEXTILES

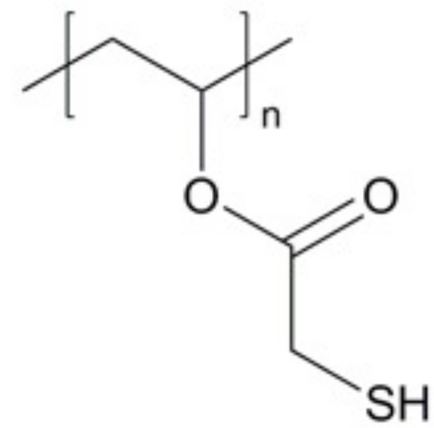
LINKING TO COTTON: POLYMER COATING

COAT FIBERS OR FABRIC WITH MORE CROSS-LINKABLE POLYMER

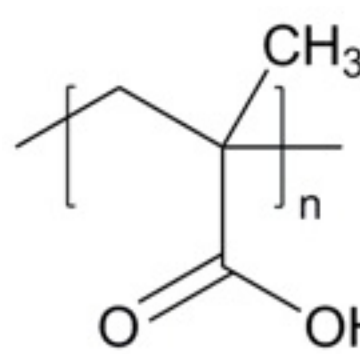
- POLYMERS ALREADY COATED ON FIBERS DURING SIZING
- MODIFIED SIZES OR NEW POLYMERS MAY PROVIDE CROSSLINKING SITES



POLY[VINYL ALCOHOL]



THIOLATED PVA

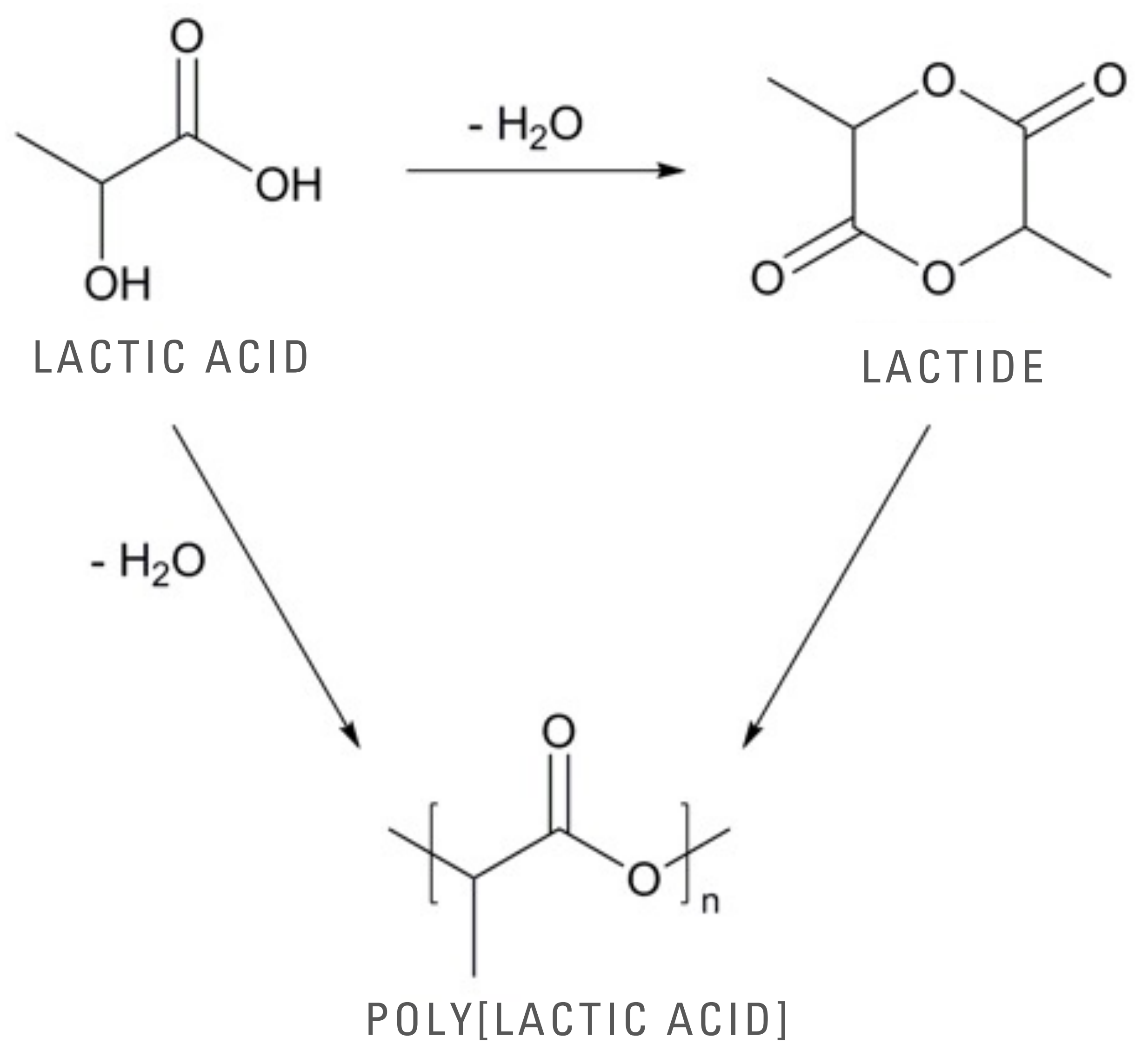


POLY[METHACRYLIC ACID]

LINKING TO COTTON: IN SITU POLYMERIZATION

COAT FIBERS OR FABRIC WITH MORE CROSS-LINKABLE POLYMER

- ENABLES APPLICATION IN FABRIC OR GARMENT FORM
- PREVIOUS USE IN TEXTILE INDUSTRY FOR DIFFERENT FUNCTIONALITIES [EG. LEVI'S REVEL LINE, CONDUCTIVE FABRICS, ETC.]



TECHNICAL EVALUATION FRAMEWORK

INNOVATION	ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY

TECHNICAL EVALUATION FRAMEWORK

INNOVATION	ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY
DISRUPTION OF INFRASTRUCTURE	CHEMICAL SUPPLY	SPECIAL MANUFACTURE	LIMITED AVAILABILITY	WIDE AVAILABILITY

TECHNICAL EVALUATION FRAMEWORK

INNOVATION	ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY
DISRUPTION OF INFRASTRUCTURE	CHEMICAL SUPPLY	SPECIAL MANUFACTURE	LIMITED AVAILABILITY	WIDE AVAILABILITY
	FABRIC APPLICATION	NEW PROCESS	MODIFY EXISTING PROCESS	USES EXISTING PROCESS

TECHNICAL EVALUATION FRAMEWORK

INNOVATION	ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY
DISRUPTION OF INFRASTRUCTURE	CHEMICAL SUPPLY	SPECIAL MANUFACTURE	LIMITED AVAILABILITY	WIDE AVAILABILITY
	FABRIC APPLICATION	NEW PROCESS	MODIFY EXISTING PROCESS	USES EXISTING PROCESS
	CROSSLINKING STEP	NEW EQUIPMENT	NEW CHEMICALS, SOLVENTS	HEAT OR AIR CURED

TECHNICAL EVALUATION FRAMEWORK

INNOVATION	ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY
DISRUPTION OF INFRASTRUCTURE	CHEMICAL SUPPLY	SPECIAL MANUFACTURE	LIMITED AVAILABILITY	WIDE AVAILABILITY
	FABRIC APPLICATION	NEW PROCESS	MODIFY EXISTING PROCESS	USES EXISTING PROCESS
	CROSSLINKING STEP	NEW EQUIPMENT	NEW CHEMICALS, SOLVENTS	HEAT OR AIR CURED
ROBUSTNESS	CONTROLLABLE CROSSLINKING	TOO REACTIVE OR UNREACTIVE	SPECIAL CONDITIONS OR EXTRA CHEMICALS	ADD CATALYST, REAGENT, HEAT

TECHNICAL EVALUATION FRAMEWORK

INNOVATION	ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY
DISRUPTION OF INFRASTRUCTURE	CHEMICAL SUPPLY	SPECIAL MANUFACTURE	LIMITED AVAILABILITY	WIDE AVAILABILITY
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	CROSSLINKING STEP	NEW EQUIPMENT	NEW CHEMICALS, SOLVENTS	HEAT OR AIR CURED
ROBUSTNESS	CONTROLLABLE CROSSLINKING	TOO REACTIVE OR UNREACTIVE	SPECIAL CONDITIONS OR EXTRA CHEMICALS	ADD CATALYST, REAGENT, HEAT
	RESILIENCE DURING MANUFACTURING	**LIKELY PROBLEMS**	**POSSIBLE PROBLEMS**	**NO FORESEEABLE PROBLEMS**

TECHNICAL EVALUATION FRAMEWORK

INNOVATION	ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY
DISRUPTION OF INFRASTRUCTURE	CHEMICAL SUPPLY	SPECIAL MANUFACTURE	LIMITED AVAILABILITY	WIDE AVAILABILITY
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ROBUSTNESS	CONTROLLABLE CROSSLINKING	TOO REACTIVE OR UNREACTIVE	SPECIAL CONDITIONS OR EXTRA CHEMICALS	ADD CATALYST, REAGENT, HEAT
	RESILIENCE DURING MANUFACTURING	LIKELY PROBLEMS	POSSIBLE PROBLEMS	NO FORESEEABLE PROBLEMS
	RESILIENCE DURING CONSUMER USE	LIKELY PROBLEMS	POSSIBLE PROBLEMS	NO FORESEEABLE PROBLEMS

TECHNICAL EVALUATION FRAMEWORK

INNOVATION		ADDITIONAL RESEARCH NEEDED	MAJOR HURDLES ANTICIPATED	MINOR HURDLES ANTICIPATED	OPTIMIZATION ONLY
DISRUPTION OF INFRASTRUCTURE	CHEMICAL SUPPLY		SPECIAL MANUFACTURE	LIMITED AVAILABILITY	WIDE AVAILABILITY
	FABRIC APPLICATION		NEW PROCESS	MODIFY EXISTING PROCESS	USES EXISTING PROCESS
	CROSSLINKING STEP		NEW EQUIPMENT	NEW CHEMICALS, SOLVENTS	HEAT OR AIR CURED
ROBUSTNESS	CONTROLLABLE CROSSLINKING		TOO REACTIVE OR UNREACTIVE	SPECIAL CONDITIONS OR EXTRA CHEMICALS	ADD CATALYST, REAGENT, HEAT
	RESILIENCE DURING MANUFACTURING		LIKELY PROBLEMS	POSSIBLE PROBLEMS	NO FORESEEABLE PROBLEMS
	RESILIENCE DURING CONSUMER USE		LIKELY PROBLEMS	POSSIBLE PROBLEMS	NO FORESEEABLE PROBLEMS
SIDE EFFECTS	EFFECTS ON FABRIC		REQUIRES PROBLEM CHEMICALS	POSSIBLE NEED FOR PROBLEM CHEMICALS	NO FORESEEABLE PROBLEMS

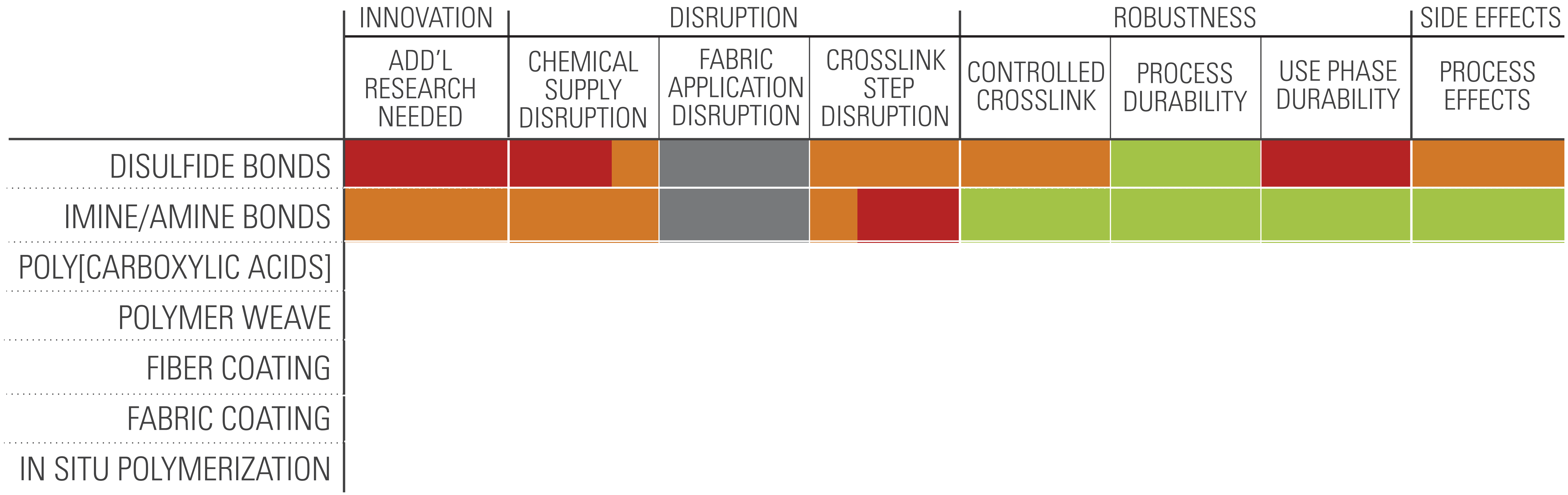
TECHNICAL EVALUATION COMPARISON

	INNOVATION	DISRUPTION			ROBUSTNESS			SIDE EFFECTS
	ADD'L RESEARCH NEEDED	CHEMICAL SUPPLY DISRUPTION	FABRIC APPLICATION DISRUPTION	CROSSLINK STEP DISRUPTION	CONTROLLED CROSSLINK	PROCESS DURABILITY	USE PHASE DURABILITY	PROCESS EFFECTS
DISULFIDE BONDS								
IMINE/AMINE BONDS								
POLY[CARBOXYLIC ACIDS]								
POLYMER WEAVE								
FIBER COATING								
FABRIC COATING								
IN SITU POLYMERIZATION								

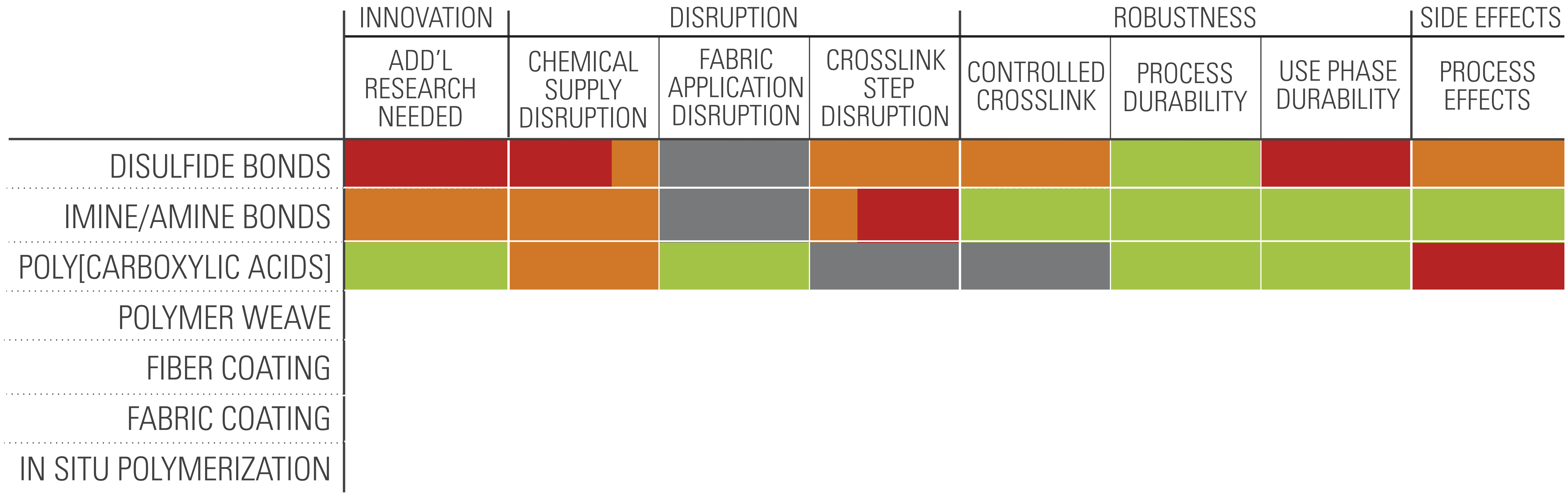
TECHNICAL EVALUATION COMPARISON

	INNOVATION	DISRUPTION			ROBUSTNESS			SIDE EFFECTS
	ADD'L RESEARCH NEEDED	CHEMICAL SUPPLY DISRUPTION	FABRIC APPLICATION DISRUPTION	CROSSLINK STEP DISRUPTION	CONTROLLED CROSSLINK	PROCESS DURABILITY	USE PHASE DURABILITY	PROCESS EFFECTS
DISULFIDE BONDS								
IMINE/AMINE BONDS								
POLY[CARBOXYLIC ACIDS]								
POLYMER WEAVE								
FIBER COATING								
FABRIC COATING								
IN SITU POLYMERIZATION								

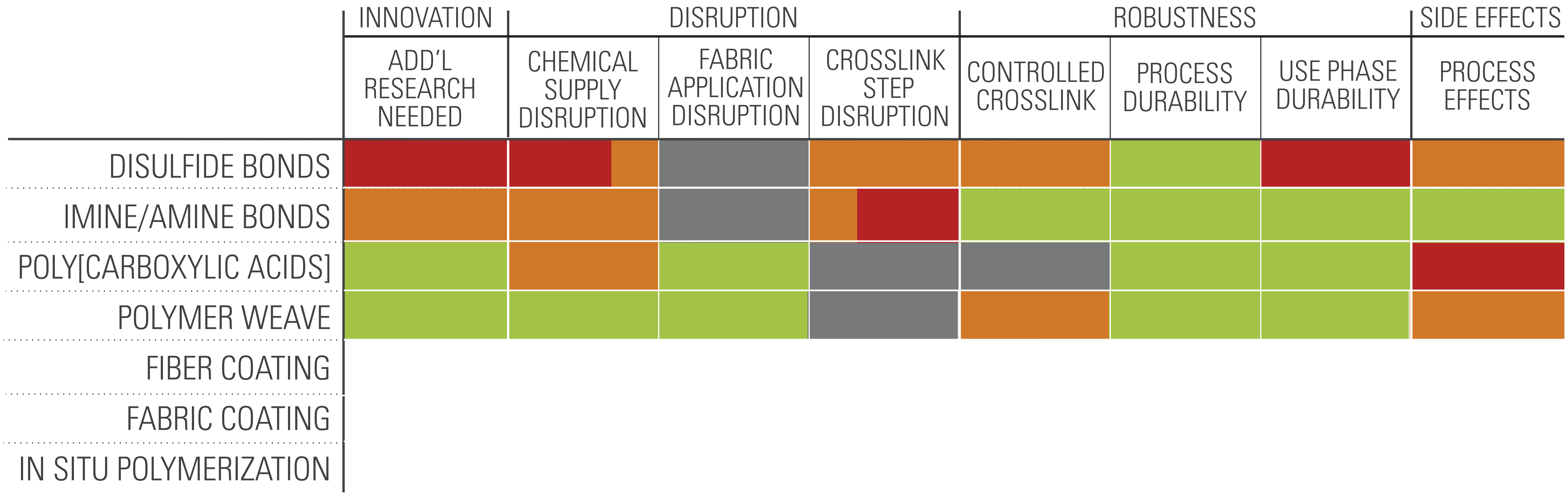
TECHNICAL EVALUATION COMPARISON



TECHNICAL EVALUATION COMPARISON



TECHNICAL EVALUATION COMPARISON



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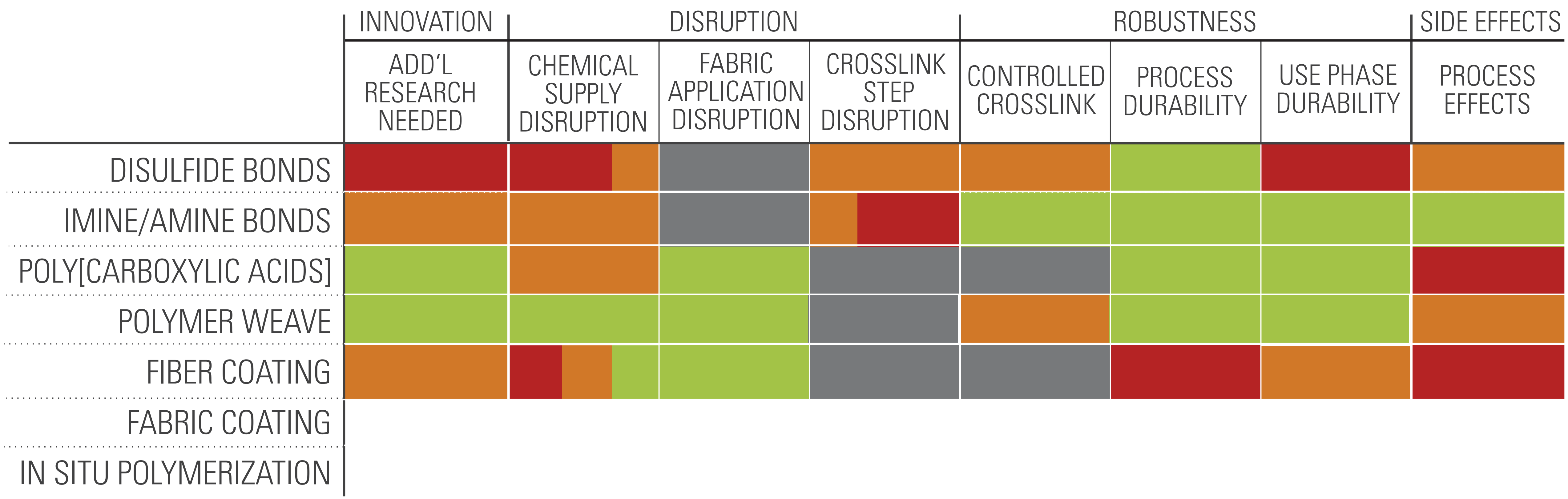
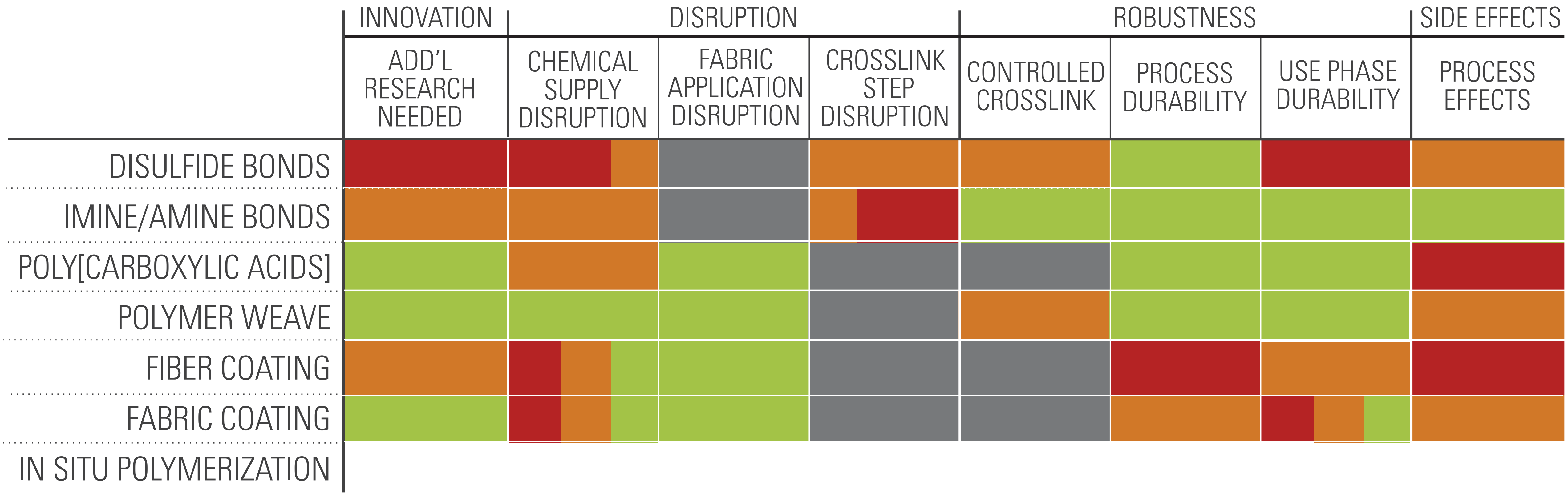
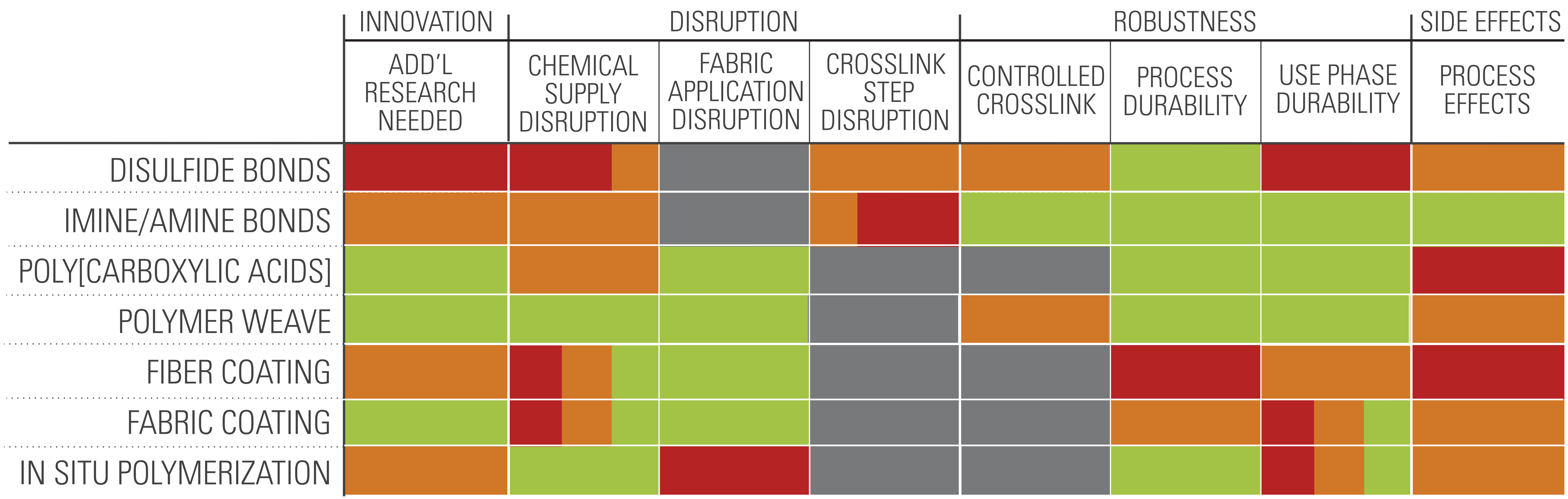


TECHNICAL EVALUATION COMPARISON



TECHNICAL EVALUATION COMPARISON



HEALTH EVALUATION FRAMEWORK

	SCOPE			DATA COLLECTION + PRIORITIZATION				OUTCOME
	INPUTS	USE	DEGREDATION	LISTS	PRIMARY LIT	ANALOGS	MODELED DATA	
GREENSCREEN				2	1 [comprehensive]	3	3	benchmark score
ADAPTED EVAL				1	2 [as needed]	3	3	relative rank

HEALTH EVALUATION FRAMEWORK

	GROUP I HUMAN					GROUP II + II* HUMAN									E TOX		FATE		PHYS	
	C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
							sgl	rep	sgl	rep										
SINGLE CHEMICAL EVALUATION																				

HEALTH EVALUATION FRAMEWORK

SINGLE CHEMICAL EVALUATION

GROUP I HUMAN					GROUP II + II* HUMAN										E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

CHEMICAL HAZARD COMPARISON

GROUP I HUMAN					GROUP II + II* HUMAN										E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

HEALTH EVALUATION FRAMEWORK

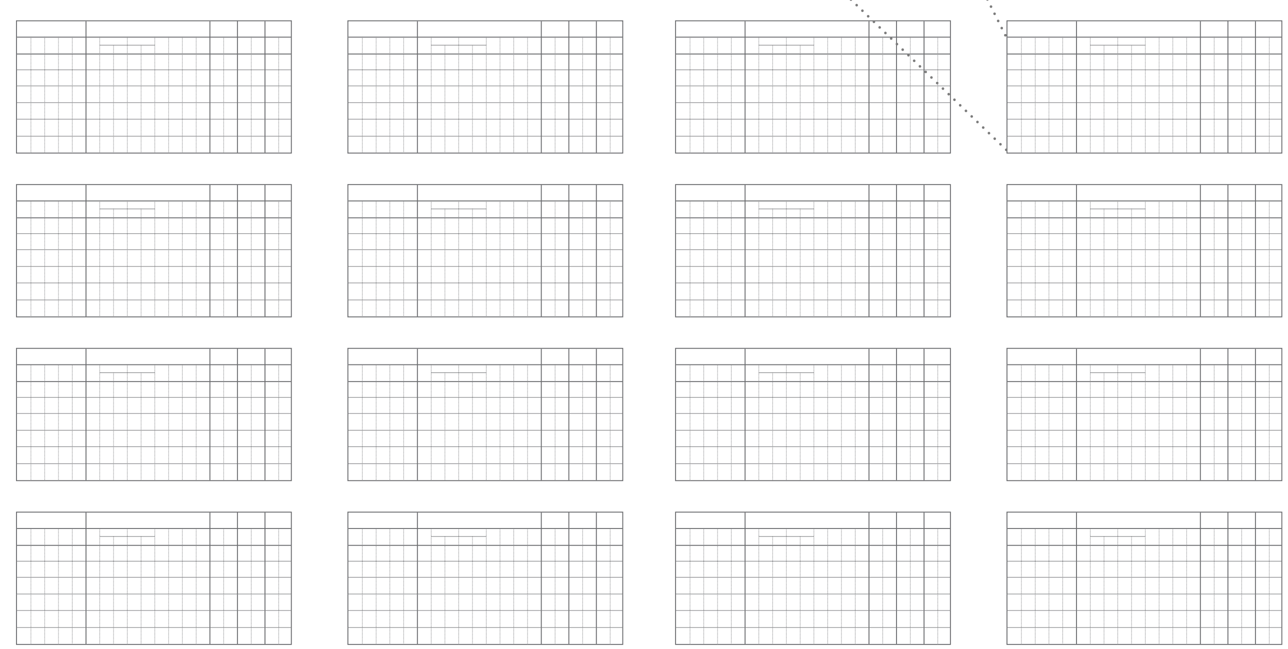
SINGLE CHEMICAL EVALUATION

GROUP I HUMAN					GROUP II + II* HUMAN									E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

CHEMICAL HAZARD COMPARISON

GROUP I HUMAN					GROUP II + II* HUMAN									E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

SYSTEMS HAZARD COMPARISON



HEALTH EVALUATION FRAMEWORK

BM 1	MEETS GREENSCREEN BENCHMARK 1 CRITERIA FOR AT LEAST ONE ENDPOINT; MUST BE ELIMINATED.

HEALTH EVALUATION FRAMEWORK

BM 1	MEETS GREENSCREEN BENCHMARK 1 CRITERIA FOR AT LEAST ONE ENDPOINT; MUST BE ELIMINATED.
	PROBABLE HIGH HAZARD FOR GROUP 1 HUMAN AND ECOTOXICITY ENDPOINTS; VERY HIGH GROUP II/II* ENDPOINTS; AVOID.

HEALTH EVALUATION FRAMEWORK

BM 1	MEETS GREENSCREEN BENCHMARK 1 CRITERIA FOR AT LEAST ONE ENDPOINT; MUST BE ELIMINATED.
	PROBABLE HIGH HAZARD FOR GROUP 1 HUMAN AND ECOTOXICITY ENDPOINTS; VERY HIGH GROUP II/II* ENDPOINTS; AVOID.
	POTENTIAL HAZARD FOR GRP I HUMAN AND ECOTOX ENDPOINTS; KNOWN HIGH HAZARD FOR GRP II/II* HUMAN ENDPOINTS; HIGH PHYSICAL HAZARD.

HEALTH EVALUATION FRAMEWORK

BM 1	MEETS GREENSCREEN BENCHMARK 1 CRITERIA FOR AT LEAST ONE ENDPOINT; MUST BE ELIMINATED.
	PROBABLE HIGH HAZARD FOR GROUP 1 HUMAN AND ECOTOXICITY ENDPOINTS; VERY HIGH GROUP II/II* ENDPOINTS; AVOID.
	POTENTIAL HAZARD FOR GRP I HUMAN AND ECOTOX ENDPOINTS; KNOWN HIGH HAZARD FOR GRP II/II* HUMAN ENDPOINTS; HIGH PHYSICAL HAZARD.
	REASONABLE SUSPICION FOR CONCERN; MORE RESEARCH IS NECESSARY.

HEALTH EVALUATION FRAMEWORK

BM 1	MEETS GREENSCREEN BENCHMARK 1 CRITERIA FOR AT LEAST ONE ENDPOINT; MUST BE ELIMINATED.
	PROBABLE HIGH HAZARD FOR GROUP 1 HUMAN AND ECOTOXICITY ENDPOINTS; VERY HIGH GROUP II/II* ENDPOINTS; AVOID.
	POTENTIAL HAZARD FOR GRP I HUMAN AND ECOTOX ENDPOINTS; KNOWN HIGH HAZARD FOR GRP II/II* HUMAN ENDPOINTS; HIGH PHYSICAL HAZARD.
	REASONABLE SUSPICION FOR CONCERN; MORE RESEARCH IS NECESSARY.
	SUITABLE SUBSTITUTION BASED ON AVAILABLE DATA.

HEALTH EVALUATION FRAMEWORK

BM 1	MEETS GREENSCREEN BENCHMARK 1 CRITERIA FOR AT LEAST ONE ENDPOINT; MUST BE ELIMINATED.
	PROBABLE HIGH HAZARD FOR GROUP 1 HUMAN AND ECOTOXICITY ENDPOINTS; VERY HIGH GROUP II/II* ENDPOINTS; AVOID.
	POTENTIAL HAZARD FOR GRP I HUMAN AND ECOTOX ENDPOINTS; KNOWN HIGH HAZARD FOR GRP II/II* HUMAN ENDPOINTS; HIGH PHYSICAL HAZARD.
	REASONABLE SUSPICION FOR CONCERN; MORE RESEARCH IS NECESSARY.
	SUITABLE SUBSTITUTION BASED ON AVAILABLE DATA.
	NO DATA AVAILABLE.

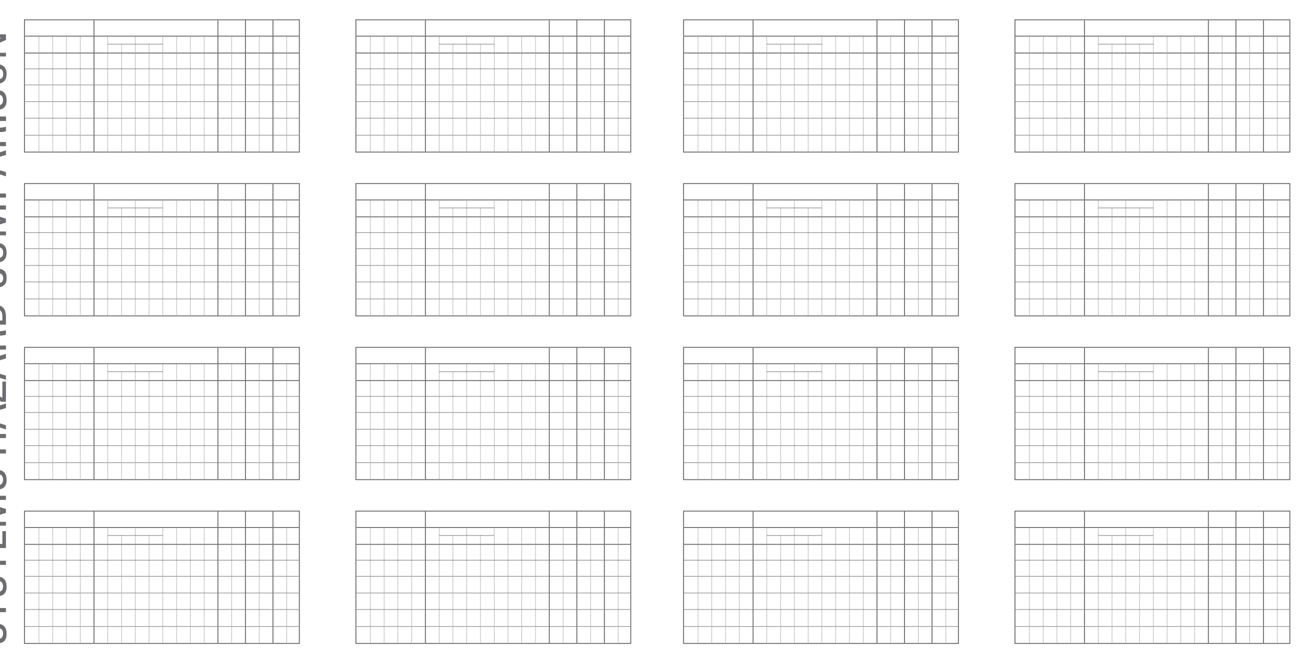
HEALTH EVALUATION FRAMEWORK

SINGLE CHEMICAL EVALUATION

GROUP I HUMAN					GROUP II + II* HUMAN									E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

GROUP I HUMAN					GROUP II + II* HUMAN									E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

SYSTEMS HAZARD COMPARISON



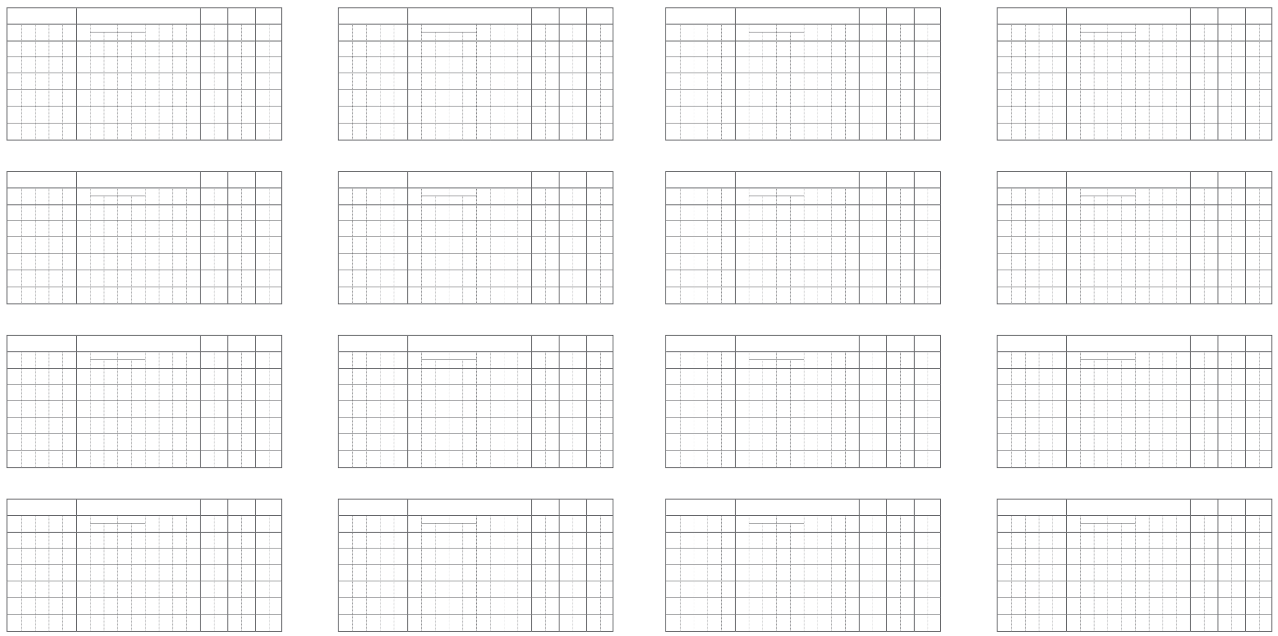
HEALTH EVALUATION FRAMEWORK

SINGLE CHEMICAL EVALUATION

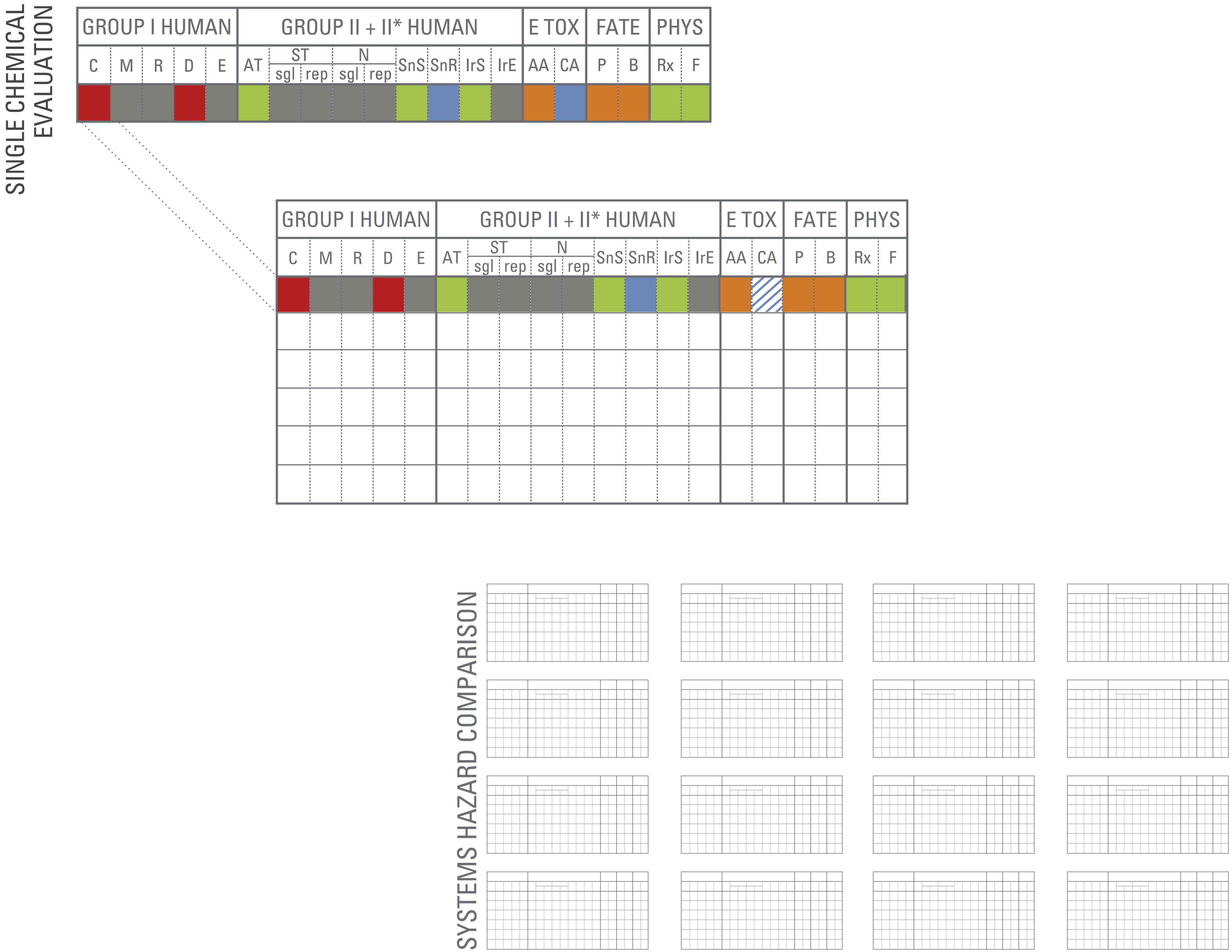
GROUP I HUMAN					GROUP II + II* HUMAN										E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

GROUP I HUMAN					GROUP II + II* HUMAN										E TOX		FATE		PHYS	
C	M	R	D	E	AT	ST		N		SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
						sgl	rep	sgl	rep										

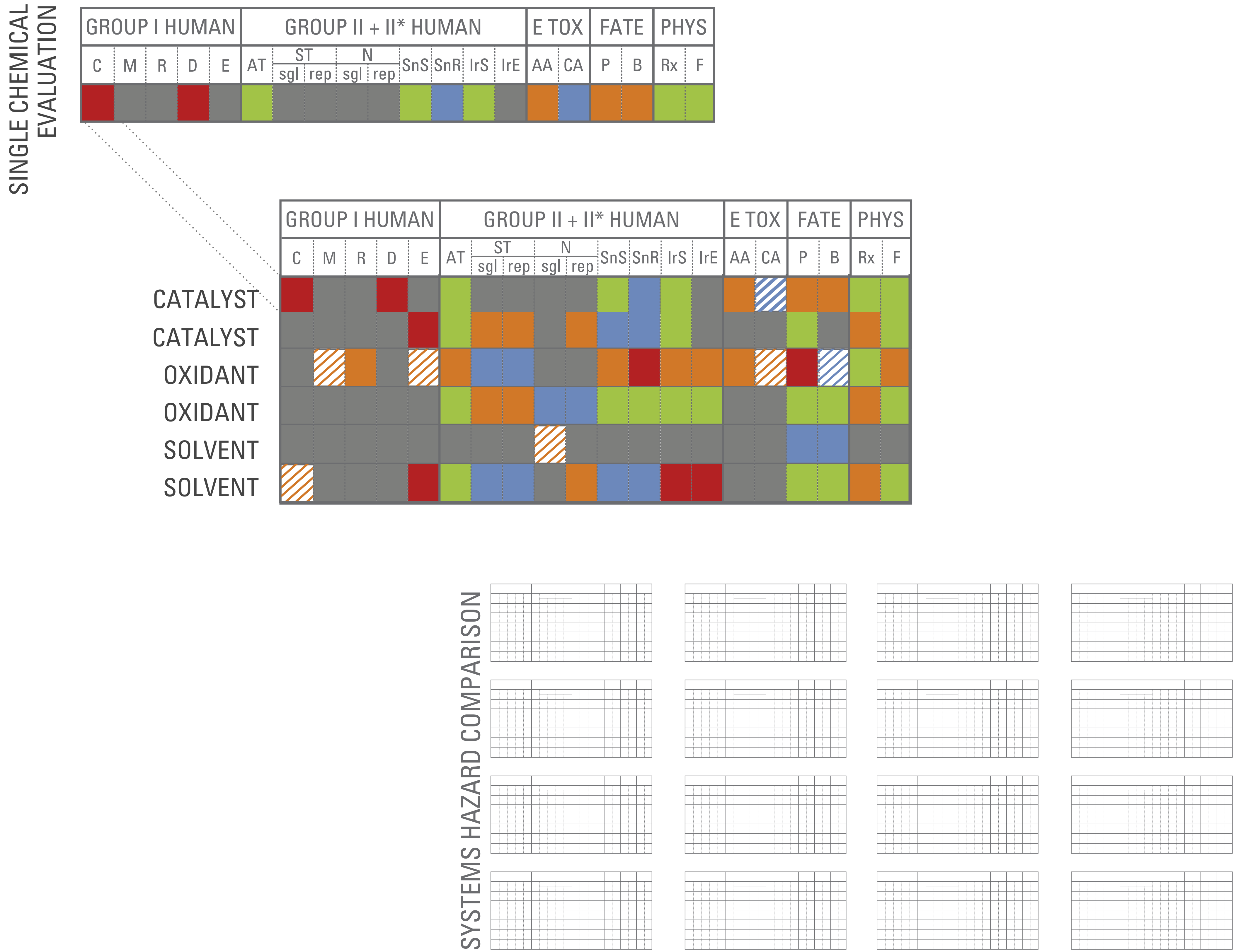
SYSTEMS HAZARD COMPARISON



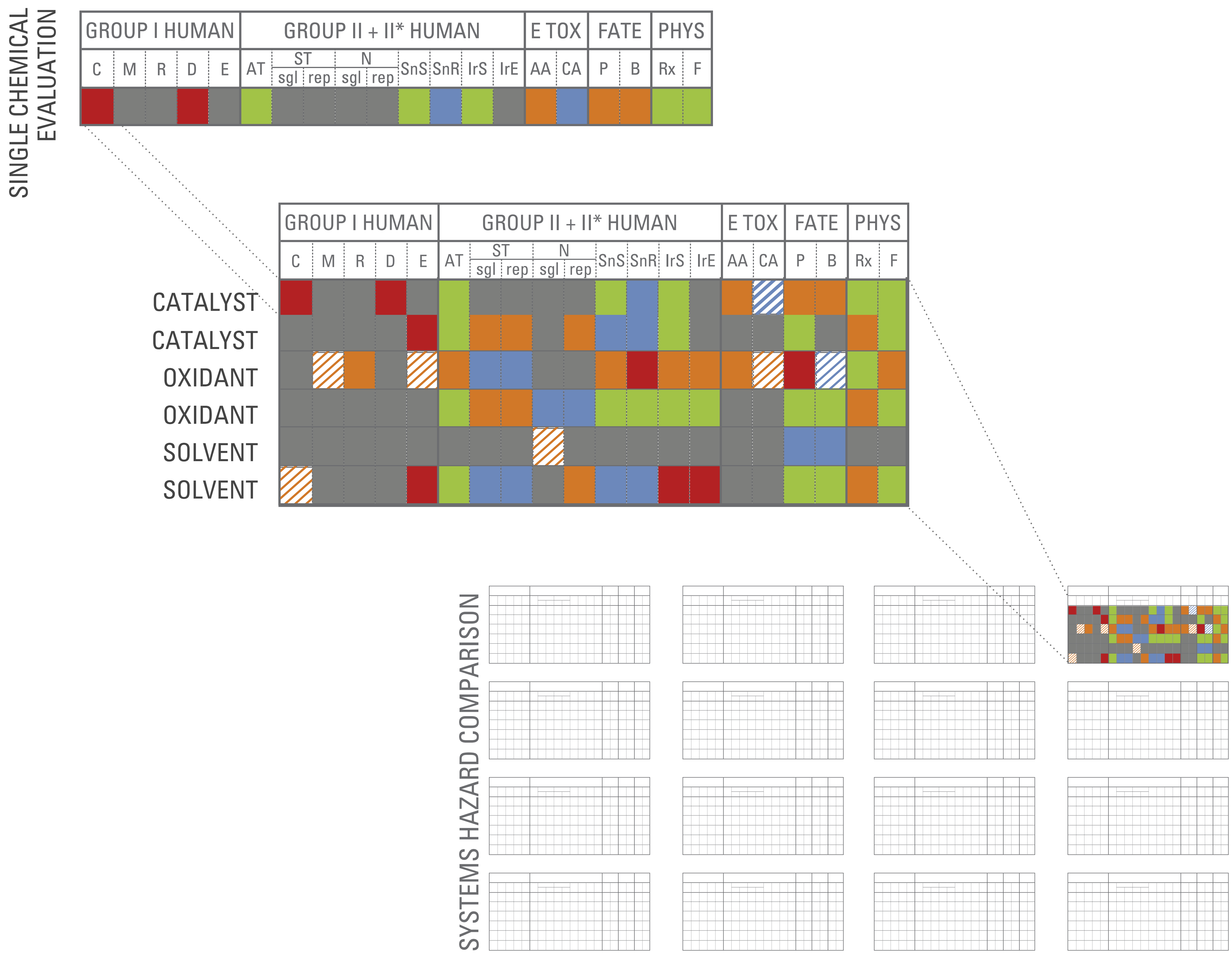
HEALTH EVALUATION FRAMEWORK



HEALTH EVALUATION FRAMEWORK



HEALTH EVALUATION FRAMEWORK

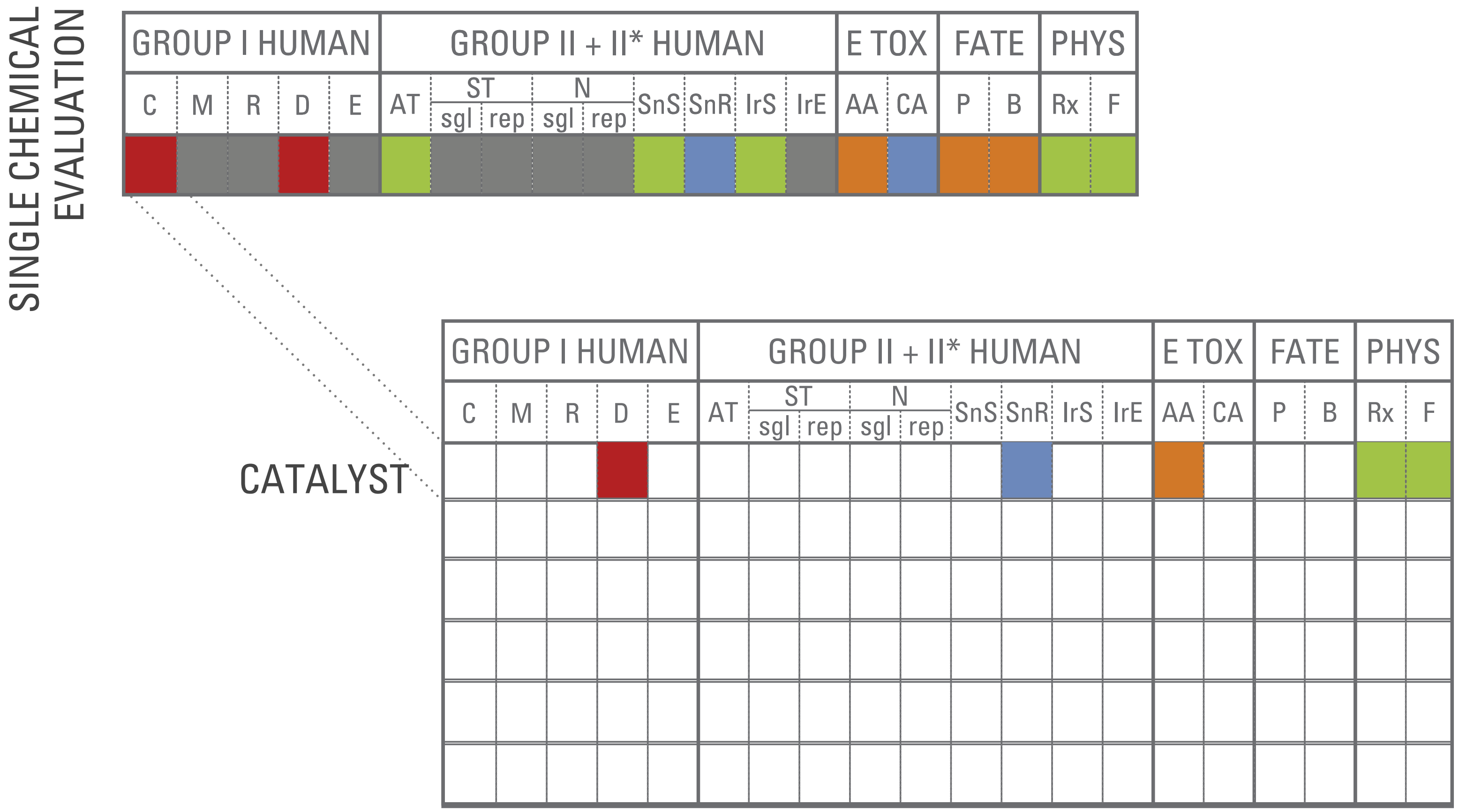


HEALTH EVALUATION FRAMEWORK

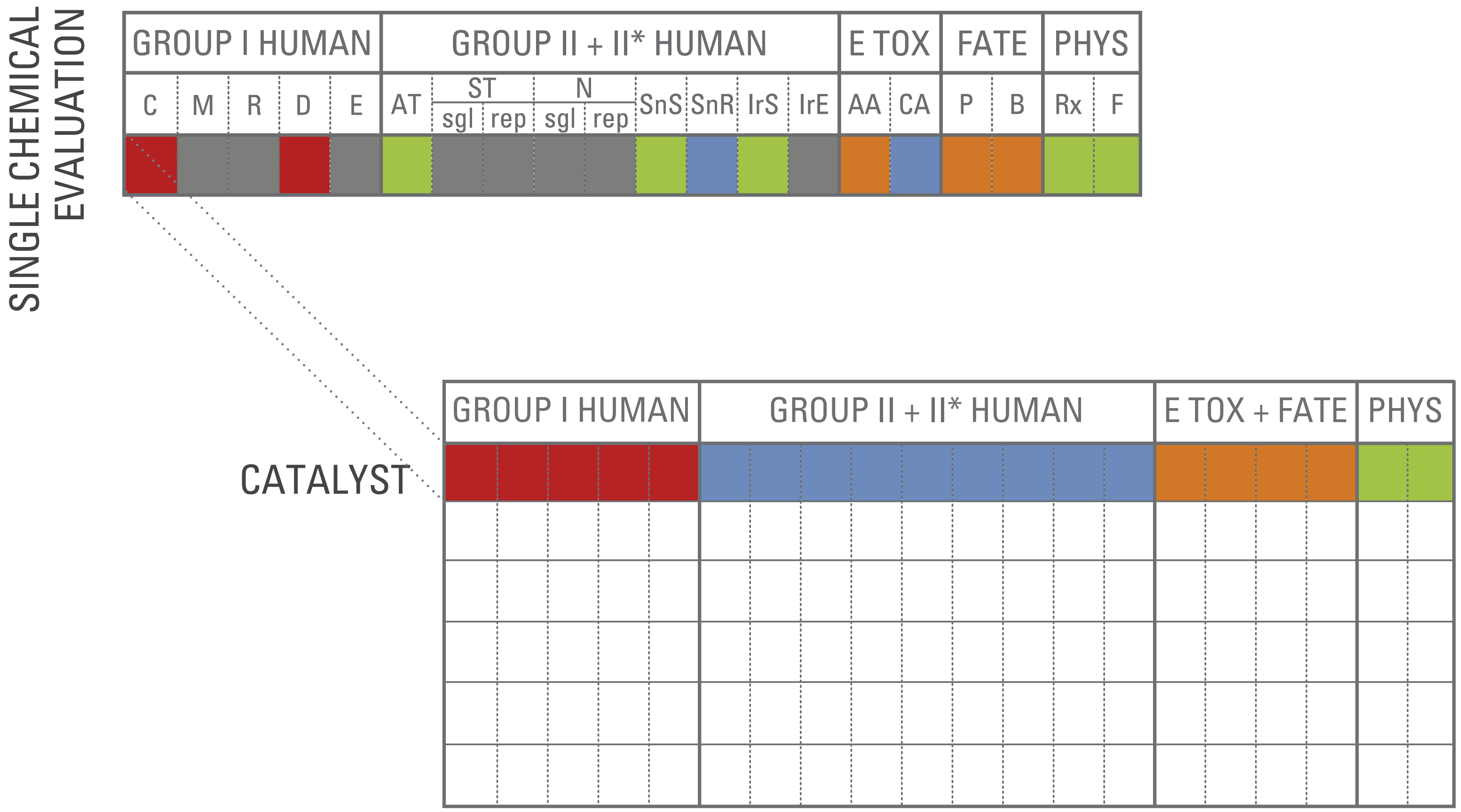
	GROUP I HUMAN					GROUP II + II* HUMAN									E TOX		FATE		PHYS	
							ST		N											
	C	M	R	D	E	AT	sgl	rep	sgl	rep	SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F
SINGLE CHEMICAL EVALUATION																				

GROUP I HUMAN					GROUP II + II* HUMAN									E TOX		FATE		PHYS	
						ST		N											
C	M	R	D	E	AT	sgl	rep	sgl	rep	SnS	SnR	IrS	IrE	AA	CA	P	B	Rx	F

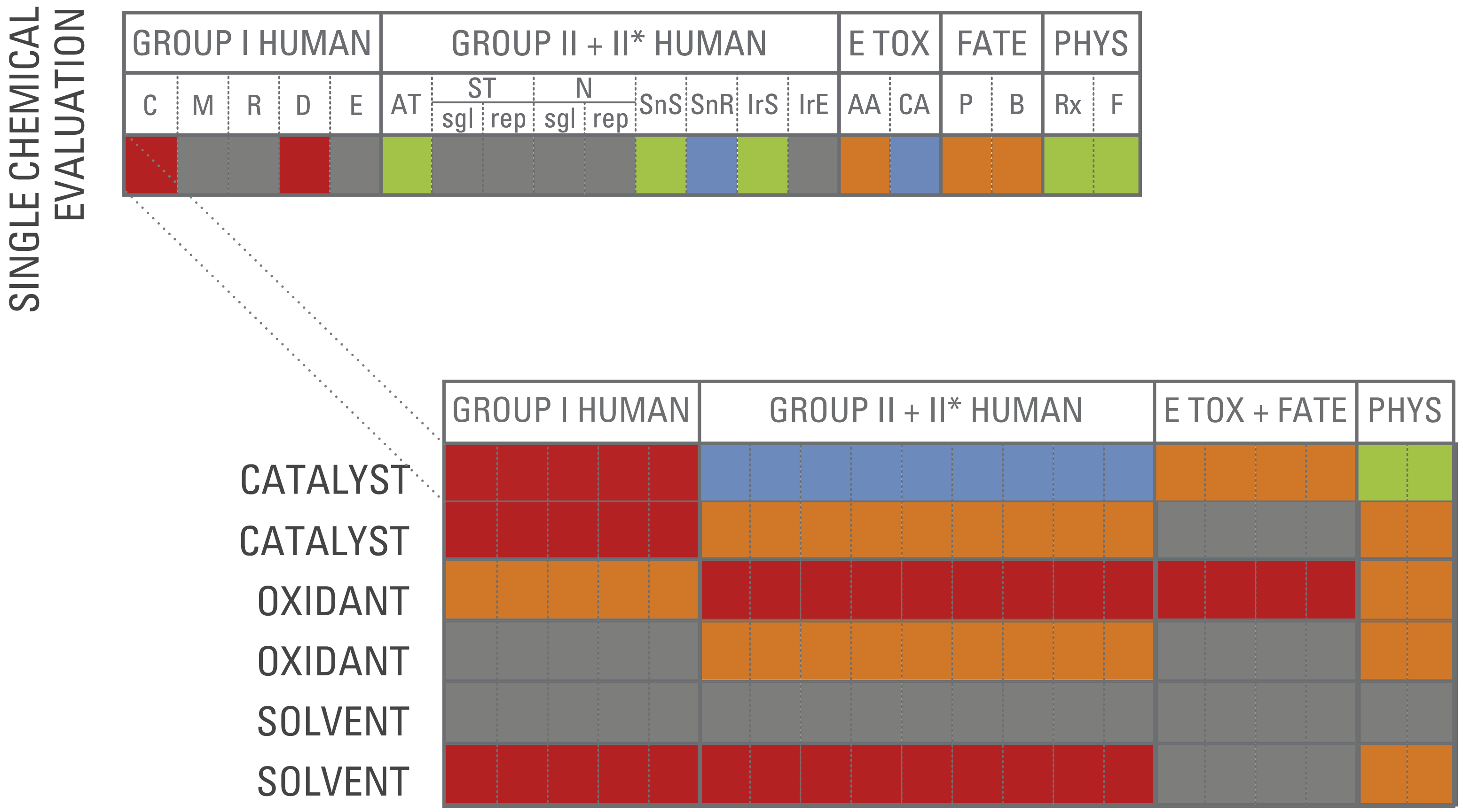
HEALTH EVALUATION FRAMEWORK



HEALTH EVALUATION FRAMEWORK



HEALTH EVALUATION FRAMEWORK



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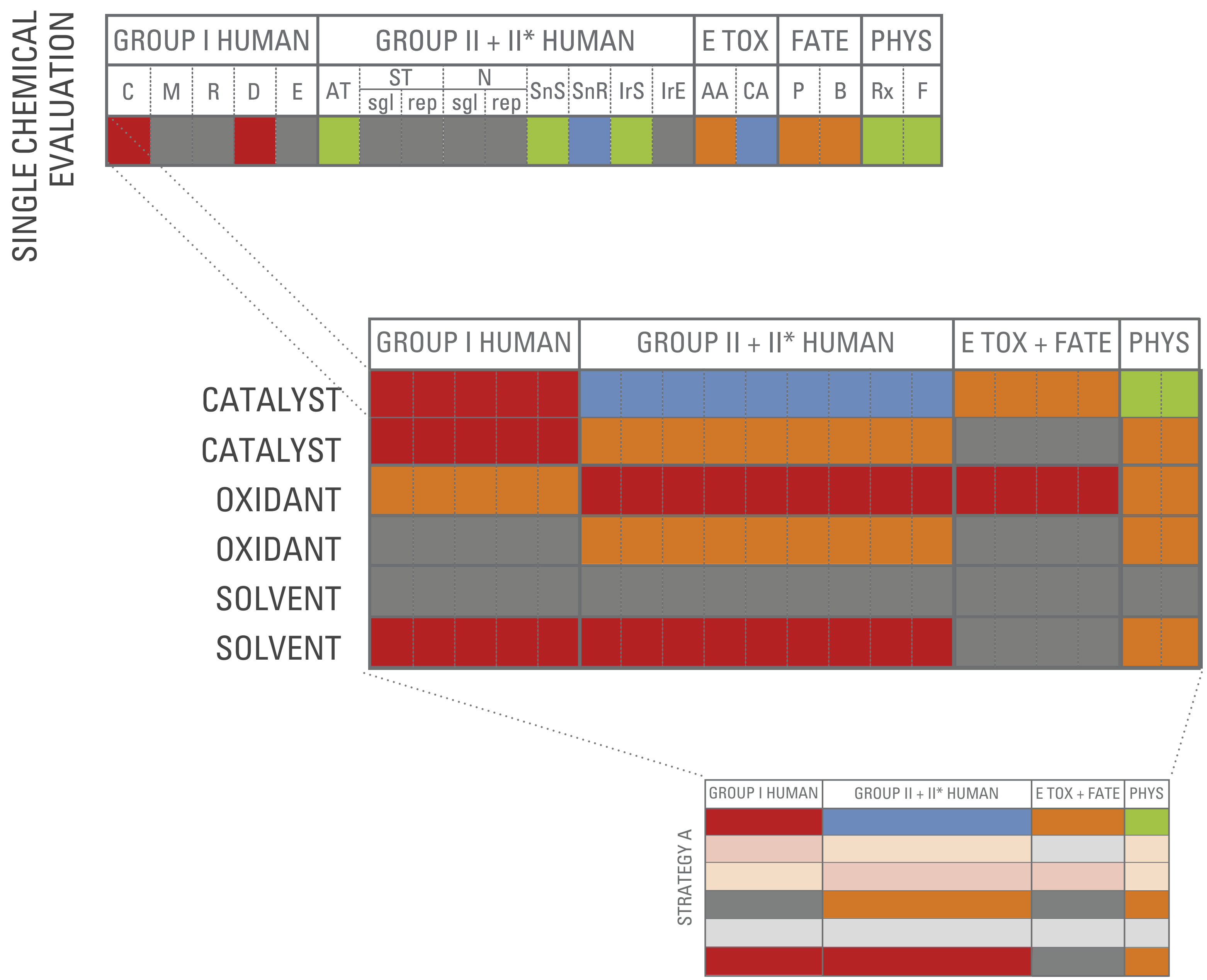
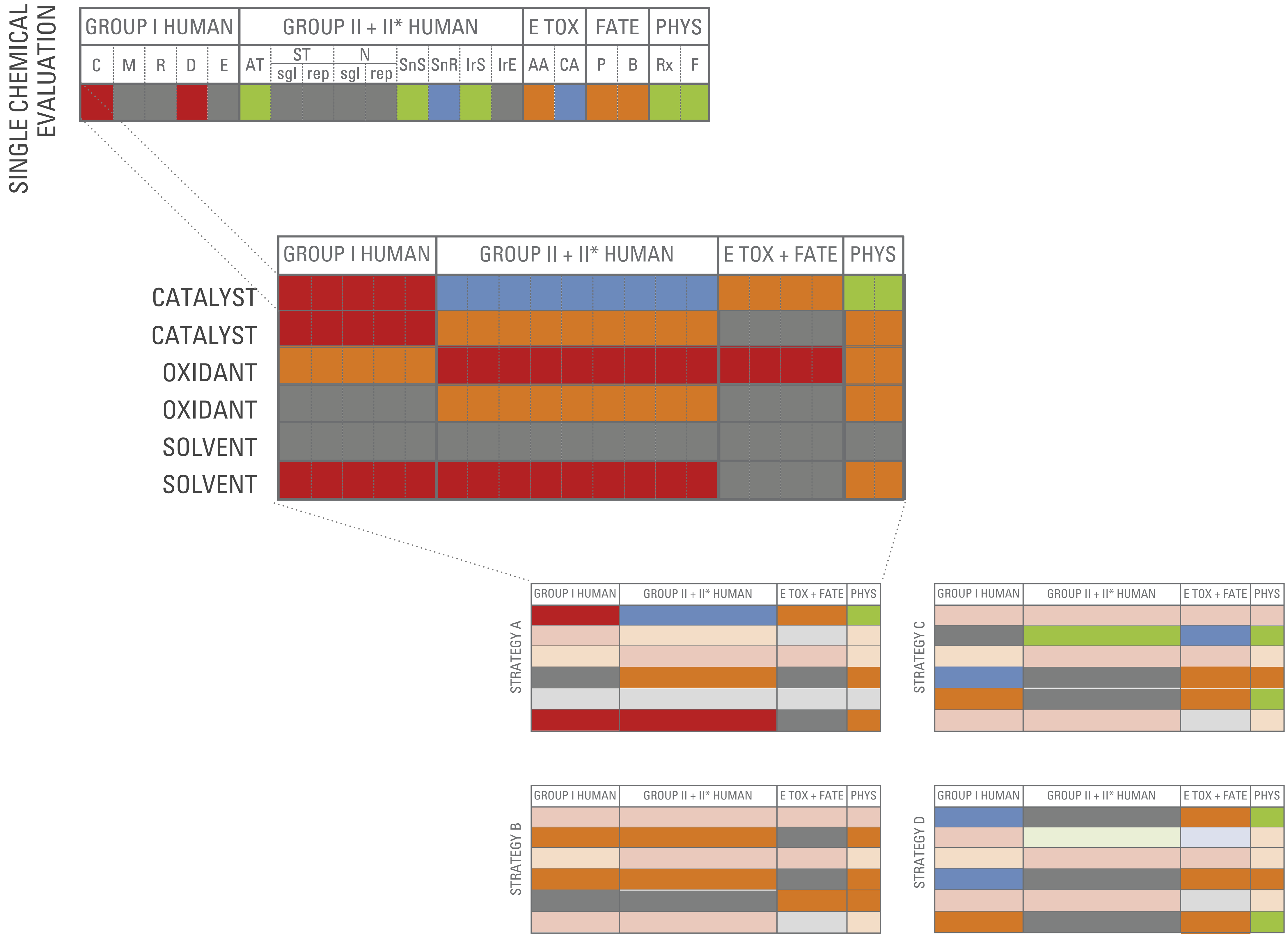
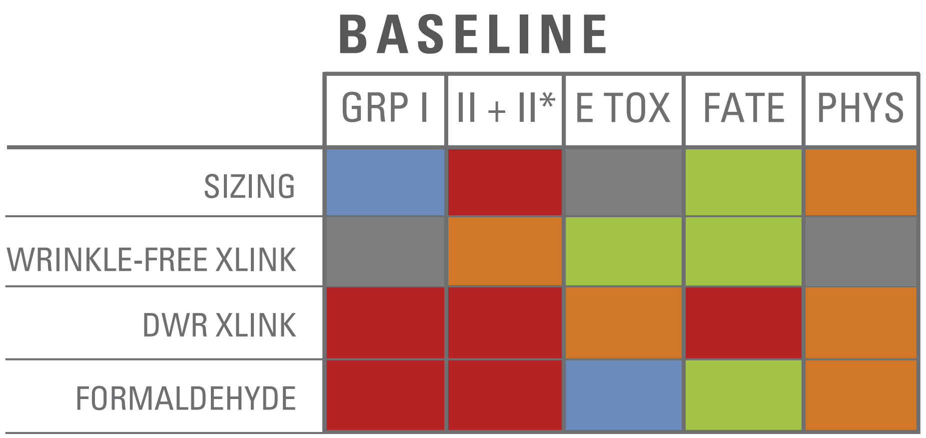


HEALTH EVALUATION FRAMEWORK



HEALTH EVALUATION GREATEST HITS



HEALTH EVALUATION GREATEST HITS

BASELINE

	GRP I	II + II*	E TOX	FATE	PHYS
SIZING					
WRINKLE-FREE XLINK					
DWR XLINK					
FORMALDEHYDE					

DISULFIDE BONDS

	GRP I	II + II*	E TOX	FATE	PHYS
OXIDANT					
CATALYST					
CATALYST SUPPORT					
HEAT SOURCE					

IMINE BONDS

	GRP I	II + II*	E TOX	FATE	PHYS
XLINK					
REDUCTANT					
CATALYST					

POLY ACIDS

	GRP I	II + II*	E TOX	FATE	PHYS
CARBOXYLIC ACID					
THIOLATING AGENT					
CATALYST					

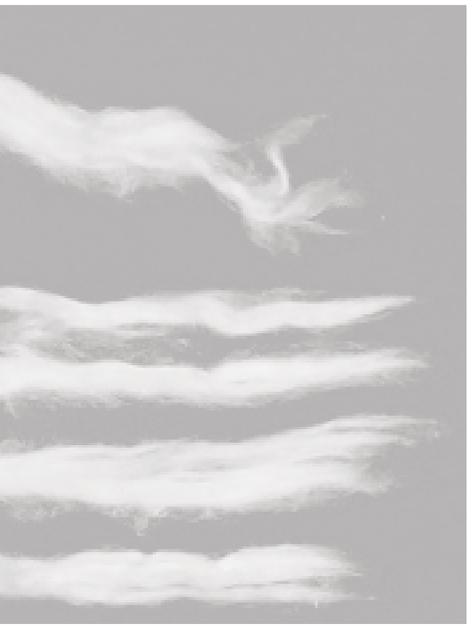
POLY THIOLATION

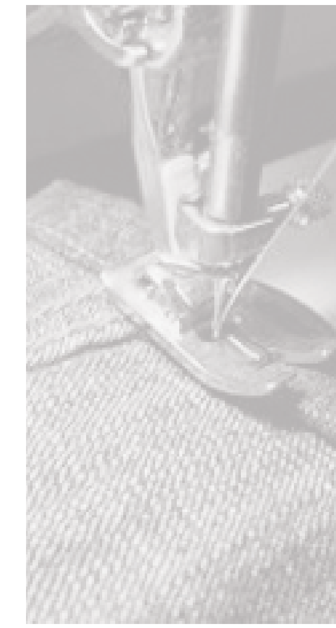
	GRP I	II + II*	E TOX	FATE	PHYS
POLYMER					
THIOLATING AGENT					
CATALYST					
REDUCTANT					
THIOLATED POLYMER					

POLY COATING

	GRP I	II + II*	E TOX	FATE	PHYS
MONOMER					
CATALYST					
STRENGTHENER					
FIBER					
SOLVENT					
FUNCTIONALIZER					

CONCLUSIONS





TEXTILE CROSSLINKING CAN BE CONSIDERED IN TWO PARTS: LINKAGE WITH CELLULOSE AND CROSSLINKING.

CONCLUSIONS

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TECHNICAL AND HEALTH EVALUATION FRAMEWORKS CAN BE APPLIED TO CURRENTLY PROPOSED AND FUTURE SOLUTIONS.

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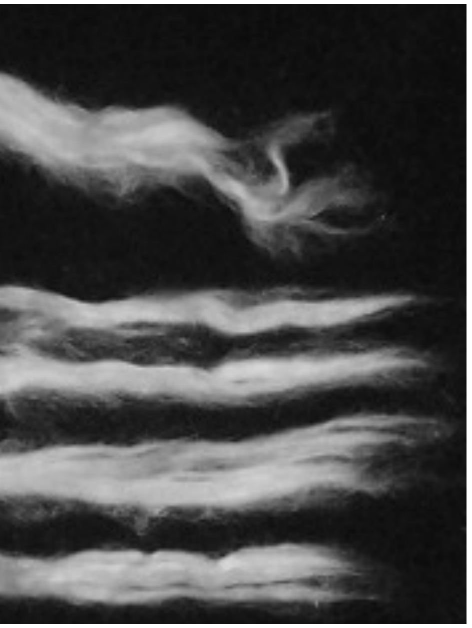
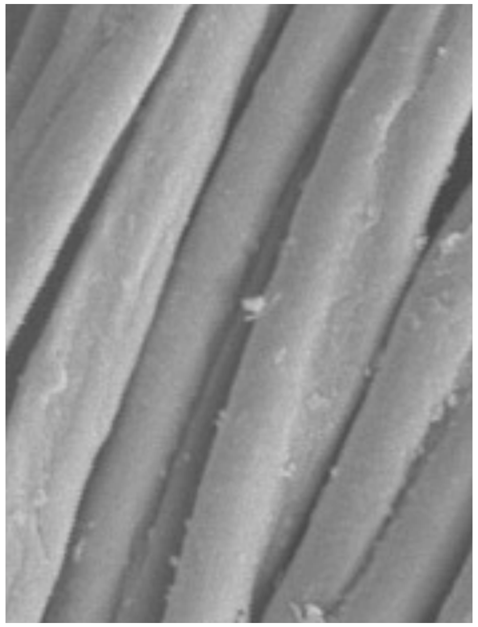
TECHNICAL AND HEALTH EVALUATION FRAMEWORKS CAN BE APPLIED TO CURRENTLY PROPOSED AND FUTURE SOLUTIONS.

CONCLUSIONS FROM FRAMEWORKS ARE COMPLEX AND NUANCED, AND THERE IS OFTEN A TRADEOFF BETWEEN PERFORMANCE AND HEALTH CONSIDERATIONS




THANK YOU