

# Surface Film Technology

# The Air-Water Interface Represents an Important Target for Control of Immature and Adult Mosquitoes



## Surface Film Mode of Action : Surface Tension Reduction and Wetting

1. Entrapment and drowning of ovipositing females, resting males, and emerging adults.
2. Sinking and/or inactivation of eggs or egg rafts laid on surface.
3. Kills larvae and pupae by inhibiting orientation at the air-water interface and/or by wetting tracheal structures causing anoxia.

# Surface Films



## Registered

(EPA registered as mosquito  
larvicides and pupicides)

**Agnique® MMF**

**Arosurf® MSF**

## Experimental

(EPA approved as adjuvants  
in pesticide formulations)

**Alcohol Alcoxylate (X-A1)**

**Alcohol Alcoxylate Blend (X-A1/A2)**

## ALCOHOL ALKOXYLATES



Blends of C<sub>6</sub> - C<sub>11</sub> alcohols with 1 – 5 moles of ethylene and/or  
propylene oxide per mole of alcohol in the alcoxylate



### Type 1: Ethoxylated C<sub>9</sub> – C<sub>11</sub> Alcohols



Exempt from tolerance by the EPA when used as inert ingredients in pesticide  
formulations under 40 CFR 180.910 & 40 CFR 180.930

# Surface Film Bioassay Pans



# Surface Film / Surface Film - Larvicide Bioassays

**Test purpose:** Determined comparative acute kill efficacy of commercial and experimental surface films

**Test environment:** Glass pans – 33cm (L) x 22cm (W) x 5cm (D)

**Water quality/species:** 2000ml of freshwater (RO) for *Ae. aegypti*, *An. albimanus*, *An. quadrimaculatus*, and *Cx. quinquefasciatus*, and 10% and 25% artificial seawater for *An. albimanus* and *Oc. taeniorhynchus*, respectively (18.3°-26.7°C)

**Stages of development:** 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup> instar larvae and pupae

**Application rate:** 0.7gal / surface acre of surface films in technical or water-based formulations with or without lowest label rates of Abate®4-E or AQUABAC® xt applied with a glass pipette. Technical surface film / AQUABAC® xt formulations and all water-based formulations required vigorous shaking to maintain homogenous mixtures. Abate®4-E soluble in surface films.

**Test procedure:** Record % mortality at; 1, 3, 5, and/or 24hr posttreatment intervals; 10 larvae or pupae / pan (3 replications/test); larvae fed ground rabbit chow suspension

**Mortality Parameter:** No motion when prodded with a probe

# Comparative Efficacy of Surface Films Against Mosquito Larvae and Pupae

% Mortality of Mosquito Species at Indicated Hours Posttreatment										
Product*	Instar/ Pupae	<i>Ae. aegypti</i> (RO)			<i>Cx. quinquefasciatus</i> (RO)			<i>Oc. taeniorhynchus</i> (25%)		
		3	5	24	3	5	24	3	5	24
X-A1	1	93.3	100	----	30	53.3	100	100	----	----
	2	96.7	96.7	96.7	93.3	100	----	66.7	100	----
	3	83.3	100	----	93.3	100	----	80	90	100
	4	70	76.7	80	63.3	90	100	30	87.5	90
	P	93.3	93.3	100	56.7	86.7	100	100	----	----
X-A1/A2 (75%/25%)	1	63.3	100	----	36.7	66.7	100	100	----	----
	2	0	100	----	100	----	----	56.7	100	----
	3	50	100	----	86.7	100	----	90	100	----
	4	63.3	76.7	83.3	80	86.7	96.7	23.3	76.7	100
	P	96.7	100	----	60	96.7	100	100	----	----
Agnique®	1	30	33.3	70	0	0	3.3	0	0	10
	2	0	0	0	3.3	3.3	3.3	0	16.7	46.7
	3	0	0	13.3	0	20	70	0	0	0
	4	0	0	33.3	6.7	33.3	100	0	0	0
	P	53.3	93.3	100	20	60	90	96.7	100	----

\* Technical products applied at rate of ca. 0.7 gal/surface acre of water; 3 replications / test. Test water was reverse osmosis (RO) or 25% seawater (25%)..

# Comparative Efficacy of Surface Films Against Mosquito Larvae and Pupae

% Mortality of Mosquito Species at Indicated Hours Posttreatment

Product*	Instar/ Pupae	<i>An. albimanus</i> (RO)			<i>An. albimanus</i> (10%)			<i>An. quadrimaculatus</i> (RO)		
		3	5	24	3	5	24	3	5	24
X-A1	1	0	0	23.3	100	----	----	0	0	100
	2	0	13.3	60	16.7	36.7	86.7	86.7	96.7	100
	3	100	----	----	86.7	100	----	86.7	100	----
	4	100	----	----	100	----	----	100	----	----
	P	100	----	----	100	----	----	100	----	----
X-A1/A2 (75%/25%)	1	0	0	16.7	0	0	50	0	0	100
	2	0	16.7	63.3	26.7	53.3	96.7	100	----	----
	3	100	----	----	90	100	----	46.7	100	----
	4	100	----	----	100	----	----	100	----	----
	P	100	----	----	100	----	----	100	----	----
Agnique®	1	0	10	10	0	0	0	0	0	0
	2	0	0	40	0	0	36.7	3.3	23.3	66.7
	3	23.3	56.7	90	26.7	60	100	16.7	70	100
	4	93.3	100	----	93.3	96.7	100	100	----	----
	P	100	----	----	100	----	----	100	----	----

\* Technical products applied at rate of ca. 0.7 gal/surface acre of water; 3 replications / test. Test water was reverse osmosis (RO) or 10% seawater (10%).

# Comparative Efficacy of Technical Surface Film Formulations Against Mosquito Larvae

Product Formulation Components	Application Rate*	Test #	% Larval Mortality at Indicated Hours Posttreatment <i>Cx. quinquefasciatus</i> (RO)					
			Instar (Days Old)		1	3	5	24
Aquabac®xt	0.25 pt/acre	T1	3	(5)	100	---	---	---
XA-1	0.7 gal/acre	T2	3	(5)	0	100	---	---
		T3	3	(5)	73	100	---	---
Aquabac® xt	0.25 pt/acre	T1	3	(5)	0	0	0	83.3
Agnique® MMF	0.7 gal/acre	T2	3	(5)	0	0	0	13.3
		T3	3	(5)	0	0	0	3.3
Abate® 4-E	0.5 fl.oz./acre	T1	3	(5)	76.7	100	---	---
XA-1	0.7 gal/acre	T2	3	(5)	23.3	50	60	100
		T3	3	(7)	3.3	96.7	100	---
Abate® 4-E	0.5 fl.oz./acre	T1	3	(5)	0	0	0	33.3
Agnique® MMF	0.7 gal/acre	T2	3	(5)	0	0	0	3.3
		T3	3	(7)	0	0	6.7	53.3

\*Aquabac or Abate applied at lowest label rates; surface films constant @ 0.7 gal/acre; 3 replications test. Test water was reverse osmosis (RO); Test water ranged from ca. 18.3°C-26.7°C.



# Comparative Efficacy of Water-Based Surface Film Formulations Against Mosquito Larvae and Pupae

Product Formulation Components	Application Rate*	Instar (5Day)/Pupae	% Larval / Pupal Mortality at Indicated Hours Posttreatment <i>Oc. taeniorhynchus</i> (25% Seawater)			
			1	3	5	24
Aquabac®xt	0.25 pt/acre	3	0	66.7	90	100
RO Water	49.97 gal/acre	P	0	0	0	0
XA-1	0.7 gal/acre	3	13.3	46.7	56.7	100
RO Water	49.3 gal/acre	P	0	100	---	---
Agnique® MMF	0.7 gal/acre	3	0	0	0	0
RO Water	49.3 gal/acre	P	56.7	96.7	100	---
Aquabac®xt	0.25 pt/acre	3	20	53.3	66.7	100
XA-1	0.7 gal/acre	P	13.3	100	---	---
RO Water	49.27 gal/acre					
Aquabac®xt	0.25 pt/acre	3	0	10	30	86.7
Agnique® MMF	0.7 gal/acre	P	33.3	90	100	---
RO Water	49.27 gal/acre					

\*Water-based formulations applied at total application rate of 50.0 gal/acre; Aquabac applied at lowest label rate; surface films constant @ 0.7 gal/acre; 3 replications / test. Test water was 25% artificial seawater (Instant Ocean®); Test water ranged from ca. 18.3°C-26.7°C.

# Comparative Efficacy of Water-Based Surface Film Formulations Against Mosquito Larvae and Pupae

Product Formulation Components	Application Rate*	Instar (5Day)/Pupae	% Larval / Pupal Mortality at Indicated Hours Posttreatment <i>Oc. taeniorhynchus</i> (25% Seawater)			
			1	3	5	24
Abate®4-E	0.5 fl.oz./acre	3	50	100	---	---
RO Water	49.99 gal/acre	P	0	0	0	0
XA-1	0.7 gal/acre	3	16.7	100	---	---
RO Water	49.3 gal/acre	P	0	100	---	---
Agnique® MMF	0.7 gal/acre	3	0	0	0	66.7
RO Water	49.3 gal/acre	P	0	100	---	---
Abate®4-E	0.5 fl.oz./acre	3	0	100	---	---
XA-1	0.7 gal/acre	P	3.3	100	---	---
RO Water	49.29 gal/acre					
Abate®4-E	0.5 fl.oz./acre	3	26.7	100	---	---
Agnique® MMF	0.7 gal/acre	P	6.7	100	---	---
RO Water	49.29 gal/acre					

\*Water-based formulations applied at total application rate of 50.0 gal/acre; Abate applied at lowest label rate; surface films constant @ 0.7 gal/acre; 3 replications / test. Test water was 25% artificial seawater (Instant Ocean®); Test water ranged from ca. 18.3°C-26.7°C.

# Joint-Action Surface Film Formulations

VectoBac® 12AS  
Aquabac®xt  
+ Altosid® LL  
NyGuard™ IGR  
Abate® 4-E

X – A1  
X – A1 / A2

+

±

Suspending ± Water  
Agents



# Gelgrade® Technology

# Gelgrade® Controlled-Delivery Bioremediation and Pollution Management Systems



## Classes of Biodegradable Contaminants

Aromatics

PCBs

Alcohols

Detergents

Ketones

Phenols

Pesticides

Petroleum Hydrocarbons

Polynuclear Aromatic Hydrocarbons

Animal Fats and Greases

Chlorinated Solvents

Carbohydrates

Phthalates

# Examples of Gelgrade® Superabsorbent Polymer Matrices

1. Starch grafted sodium polyacrylate
2. Starch-g-poly (2-propenamide-co-propenoic acid, sodium salt)
3. Starch-g-poly (2-propenamide-co-propenoic acid, mixed sodium and aluminum salt)
4. Hydrolyzed starch-polyacrylonitrile
5. Potassium polyacrylate/polyacrylamide copolymer
6. Sodium polyacrylate
7. Potassium polyacrylate

# Gelgrade<sup>®</sup> Contaminant-Reducing Agents

## Microbial Agents

(Bacteria or  
Fungi)

## Nutrient Agents

(Macronutrients/  
Micronutrients)

## Film-Forming Agents

(Surfactants/Surface  
Active Agents)

### Microbial Agents

#### BACTERIA (Genera)

Myobacterium

Micrococcus

Acetobacter

Anthrobacter

Flavobacterium

Thiobacillus

Brevibacterium

Acinebacter

Achromobacter

Corynebacterium

Methylococcum

Aeromonas

Norcardia

Bacterium

Moraxella

Pseudomonas

Alcaligenes

Beijerinckia

#### FUNGI (Genera)

Candida Aspergillus

### Nutrient Agents

Ammonium Chloride  
Diammonium Phosphate

### Film-Forming Agents

Sorbitan Monooleate  
Ethoxylated Isostearyl Alcohol

# Gelgrade® Controlled-Delivery Compositions: Bioremediation Bioassays

Target Contaminant



No. 2 Diesel Fuel



Aquatic Habitat

Terrestrial Habitat

**Gelgrade® Starch Grafted  
Sodium Polyacrylate (SGSP)  
Granules and Powders**

(Encapsulation, Slow Release, and Bioreactor Matrices)

**Contaminant-Reducing Agents**



Bacteria (a blend of gram positive  
and negative *Pseudomonas* spp.)

ABR® Diesel

ABR® Hydrocarbon

Nutrients (a blend of  
macronutrients and  
micronutrients)

Bi-Chem® Accelerator II Special

## Petroleum Hydrocarbon Biodegradation

No. 2 Diesel Fuel

+

ABR® Diesel Blend Bacteria  
(Sybron Chemicals, Inc.)

+

Electron Acceptors

+

Bi-Chem® Accelerator II  
Special Nutrient Blend  
(Sybron Chemicals, Inc.)



Carbon Dioxide

+

Water

+

Waste Products

+

ABR® Diesel  
Blend Bacteria



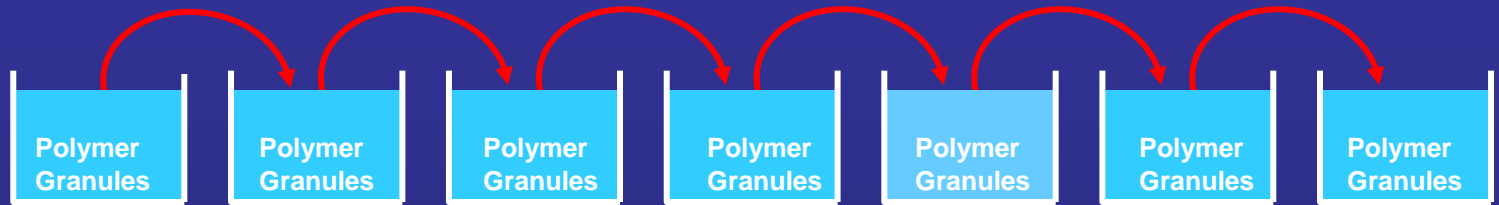
# Starch-Grafted Sodium Polyacrylate Granules and Powders



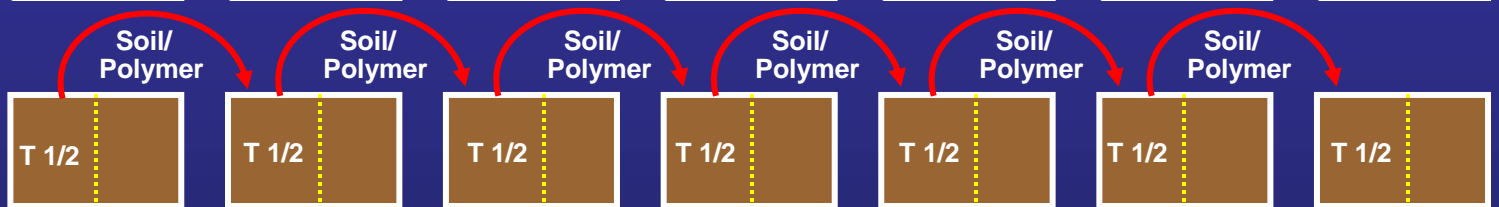
# Gelgrade® Polymer - Transfer Bioassays

## Bioremediation Evaluations

**Aquatic  
(25-26C)**



**Terrestrial  
(25-26C)**



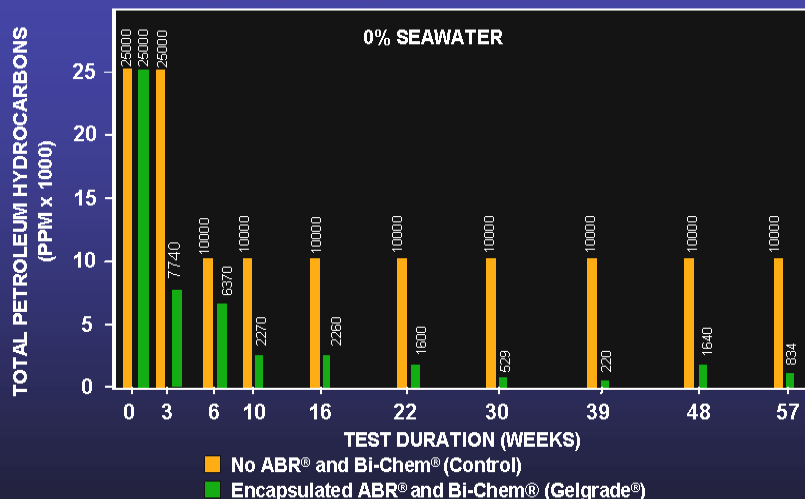
**Aquatic**

**Terrestrial**

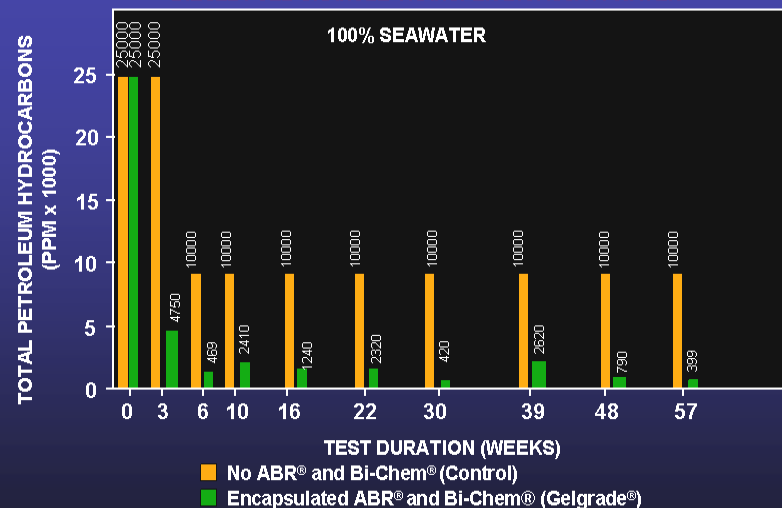
Test Chambers:	Pyrex Dishes (125 x 65 mm)	Pyrex Pans (33 x 23 x 5 cm)
No. Replications:	3	3
Habitat Type:	0%,50%,100% Seawater (500ml)	Soil (3371g)
Contaminant Type:	No. 2 Diesel Fuel	No. 2 Diesel Fuel
Contaminant Amount:	25000/10000 PPM	25000/10000 PPM
Remediation Agents:	ABR® Diesel (9577)	ABR® Diesel (9577)
	Bi-Chem® Accelerator (9546)	Bi-Chem® Accelerator (9546)
ABR® Rates:	Label (4.6 x 10 <sup>5</sup> CFU Granules)	Label (4.6 x 10 <sup>5</sup> CFU Granules)
BiChem® Rates:	Label (Granules)	Label (Granules)
Transfer Interval:	Granules (3,6,10,16,22,30,39,48,57 Wks)	Powder (3,6,10 Wks)
TPH Analyses:	Q BioChem (Water @ Transfers)	Q BioChem (Soil @ Transfers)

# Controlled Delivery of Bacteria and Nutrients in Simulated Aquatic or Terrestrial Habitats from Superabsorbent Polymer Granules or Powder

**DIESEL FUEL GRANULE-TRANSFER BIOASSAY: WATER**



**DIESEL FUEL GRANULE-TRANSFER BIOASSAY: WATER**



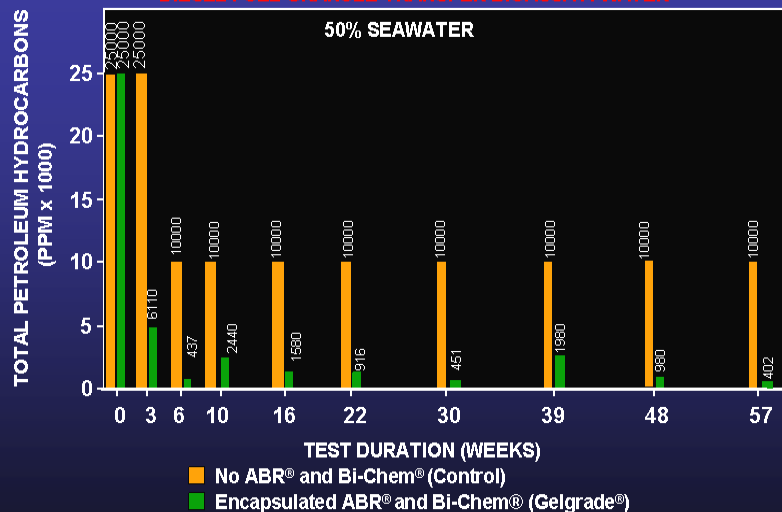
## **GELGRADE® MIXTURE**

40.4% SGSP + 59.0% ABR® Diesel + 0.6% Release Regulator  
 37.3% SGSP + 62.1% Bi-Chem® Accelerator II + 0.6% Release Regulator

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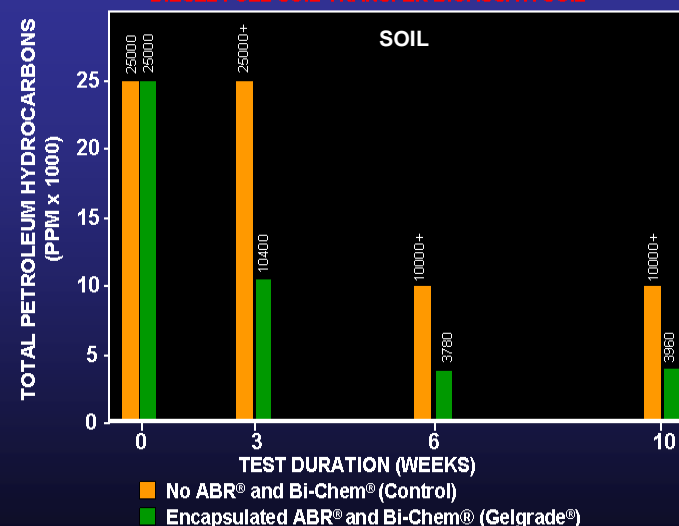
**DIESEL FUEL GRANULE-TRANSFER BIOASSAY: WATER**



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40.4% SGSP + 59.0% ABR® Diesel + 0.6% Release Regulator  
 37.3% SGSP + 62.1% Bi-Chem® Accelerator II + 0.6% Release Regulator

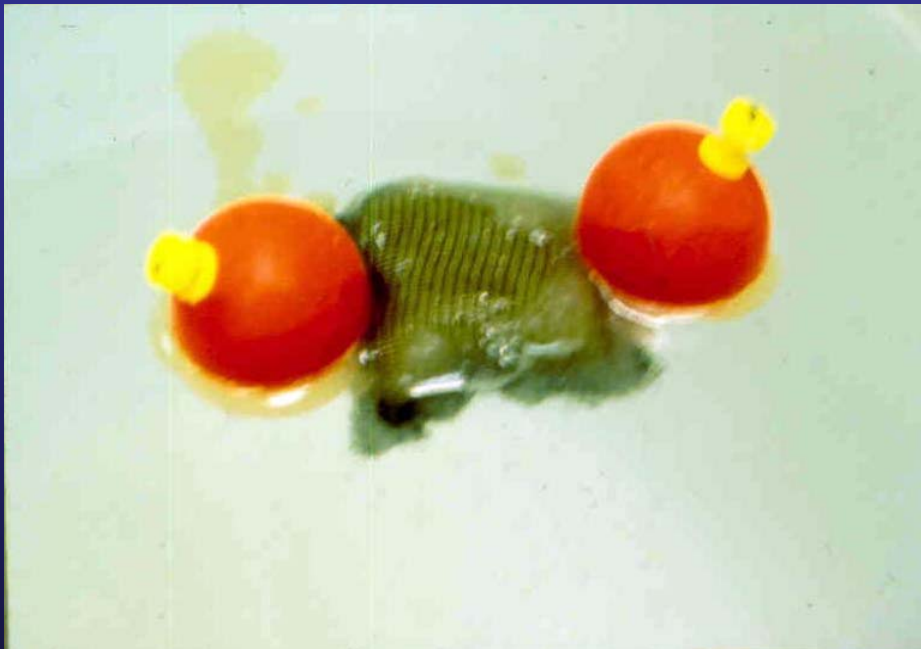
**DIESEL FUEL SOIL-TRANSFER BIOASSAY: SOIL**



## **GELGRADE® MIXTURE**

40.4% SGSP + 59.0% ABR® Diesel + 0.6% Release Regulator  
 37.3% SGSP + 62.1% Bi-Chem® Accelerator II + 0.6% Release Regulator

# Controlled Delivery of Gelgrade® Film-Forming Compositions



# **Lubrisorb® Technology**

# **Lubrisorb® Entrapment, Encapsulation, and Controlled-Delivery Lubricant Technology for Friction and Wear Management**

## **LUBRISORB®**

**Lubricant**   **Superabsorbent**

### **Superabsorbent Polymers**

Starch grafted sodium polyacrylate

Starch g-poly (2-propenamide-co-2-propenoic acid, sodium salt)

Starch acrylonitrile copolymer

Crosslinked potassium polyacrylate/  
polyacrylamide copolymer or terpolymer

Crosslinked polyacrylamide copolymer

Acrylic acid polymer, sodium salt

Poly-2-propenoic acid, sodium salt

Potassium polyacrylate, lightly crosslinked

Poly (sodium acrylate) homopolymer

Copolymer of acrylamide and sodium acrylate

### **Solid and Liquid Lubricants**

#### **Solid**

Graphite  
Carbon  
Talc  
Mica  
Metals

Molybdenum Disulfide

#### **Liquid**

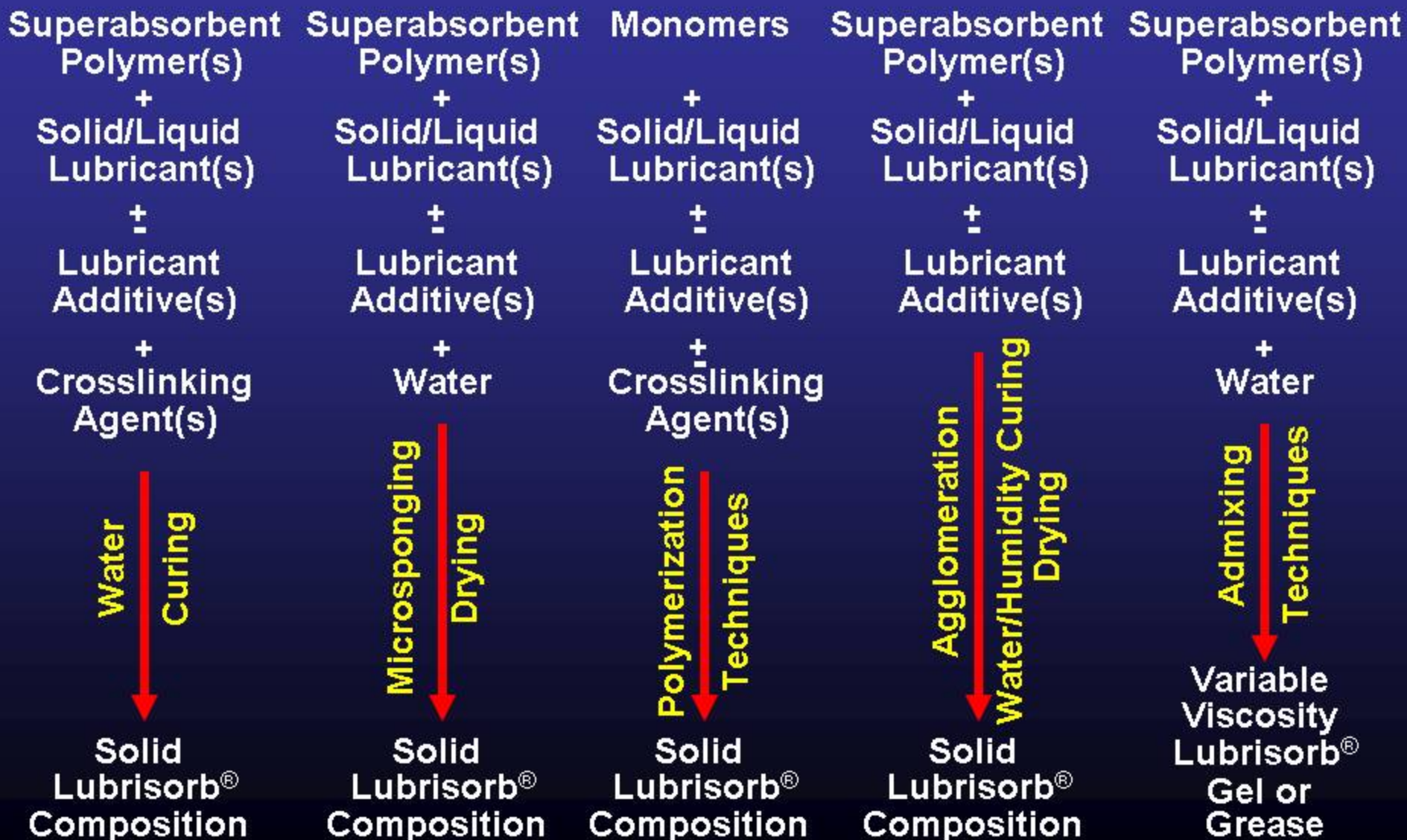
Vegetable Oils  
Petroleum Oils  
Plasticizers  
Water

### **Lubricant Additives**

Antioxidants  
Rust Inhibitors  
Anti-Wear Compounds  
Extreme Pressure Additives  
Viscosity Index Improvers  
Foam Inhibitors  
Detergents  
Dispersants



# Lubrisorb® Fabrication Techniques



# **Lubrisorb<sup>®</sup> Matrix Compositions**

**Granules**

**Coatings**

**Pellets**

**Sheets**

**Powders**

**Composites**

**Extrusions**

**Gels**

**Films**

**Greases**

## **Stimuli Eliciting Delivery of Lubricants from Lubrisorb<sup>®</sup> Compositions**

**pH**

**Chemicals**

**Pressure**

**Compression**

**Friction**

**Humidity / Water**

**Temperature**

**Electrical Charge**



# Lubricants Evaluated in Lubrisorb® Compositions in Laboratory Friction-Reduction Tests<sup>1</sup>

## Solid

Graphite (-325 mesh)  
Carbon (-325 Mesh)

## Liquid

Water  
Citrate Esters  
Royco® 481 Oil  
Arosurf® 66-E2  
Marvel® Mystery Oil

<sup>1</sup> Short, intermittent, and extended term stress tests conducted with solid and variable-viscosity superabsorbent polymer-based compositions at 135 or 271 ft-lbs of force at 3450 RPM.

# Lubrisorb® Compositions

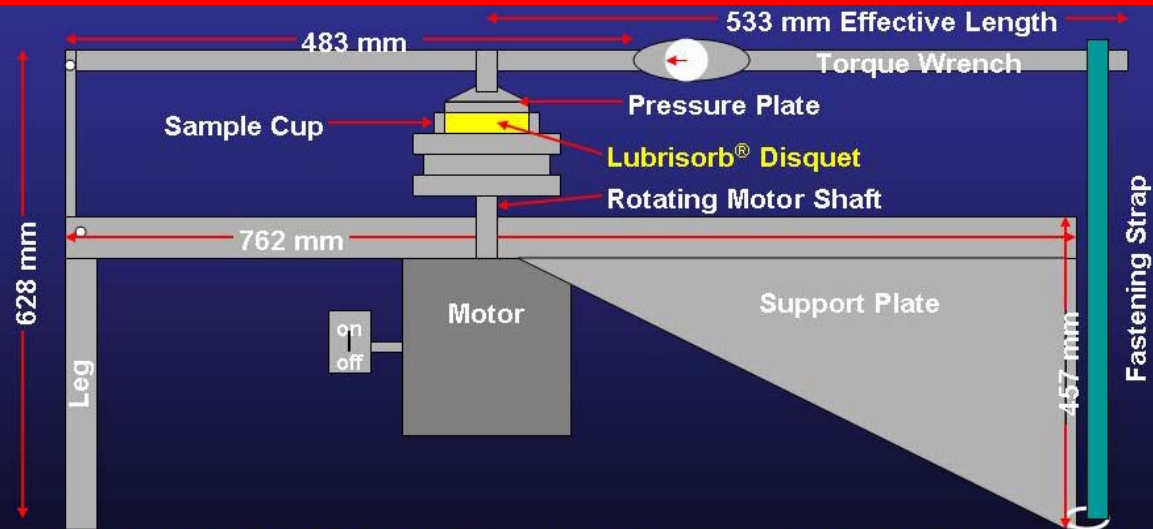
## Solids



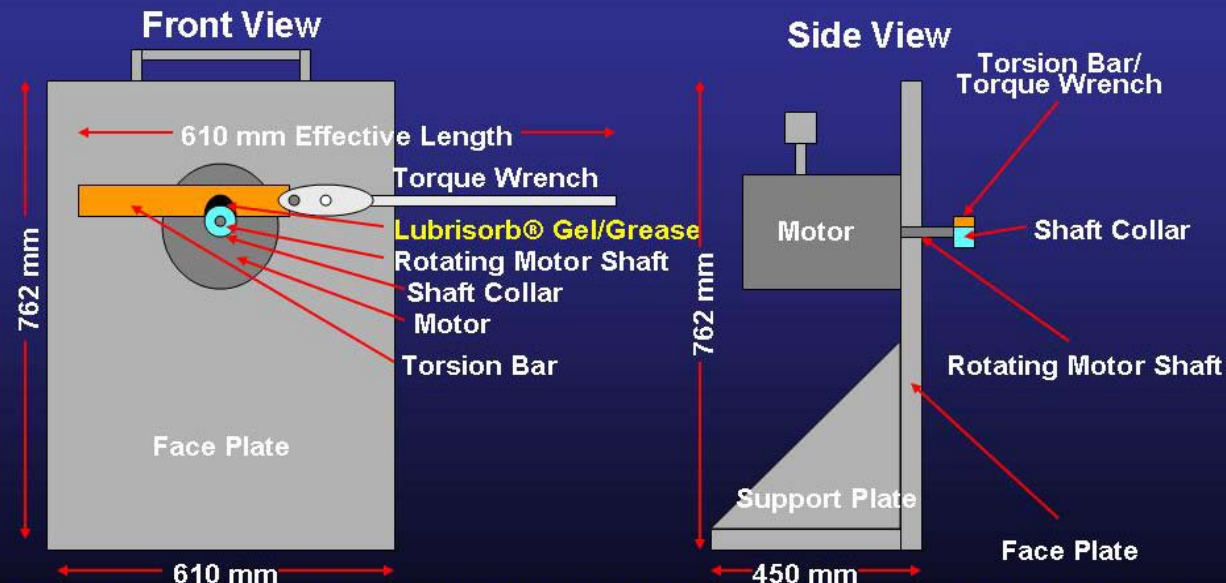
## Greases



# Apparatus for Testing Friction-Reduction by Lubrisorb® Disquets or Greases <sup>1</sup>



<sup>1</sup> Solid and/or liquid lubricant compositions were fabricated into disquets. Each disquet was ca. 32-35 X 8-10mm (ca. 5-9g). Disquets contained ca. 25-50% (w/w) lubricant(s) and 50-75% (w/w) superabsorbent polymer(s).



<sup>1</sup> Solid and/or liquid lubricants were formulated into gels/greases. Tests conducted using 0.15g gel/grease per run. Gels/grease contained ca. 10% (w/w) lubricant(s), 0.2-0.3% (w/w) superabsorbent polymer, and 89.7-89.8% (w/w) water.

# **Lubrisorb® Stress Tests: Conclusions**

- 1. Lubrisorb® disquets and variable-viscosity gels or greases were effective in lubricating an aluminum surface or shaft that was subjected to 136 or 271 ft/lbs of force at 3450 RPM for 15 sec. to 15 min. in a series of short, intermittent or extended-duration stress tests.**
- 2. The structural integrity of several types of Lubrisorb® disquets was not significantly affected by friction, compression, decompression, and shear produced during the tests.**
- 3. Lubrisorb® gels or greases provided significantly better short-term lubrication of a metal shaft than lubricants that were not formulated with a superabsorbent polymer.**