CF98-1-7

AMOCO FABRICS AND FIBERS COMPANY
TECHNOLOGY CENTER
260 THE BLUFFS
AUSTELL, GA 30168
PHONE: 770/941-1711
FAX: 770/944-4745

April 28, 1998

The Consumer Product Safety Commission
4330 East West Highway
Bethesda, MD 20814

Flame Retardant Chemical Public Hearing, May 5-6, 1998

Honorable Commissioners:

Amoco Fabrics and Fibers Company is a producer of polypropylene fibers and yarns used in producing fabrics for a number of applications, including automotive, apparel, industrial, and home furnishing applications. We have occasionally experienced a phenomenon which we believe indirectly shows that certain components in some FR backcoatings when applied to polypropylene fabrics are migratory in nature and can migrate from the backcoating into the face fiber. We do not know the identity or the toxicity of the migratory component(s), only that migration does appear to occur.

The indirect evidence comes from the premature degradation of FR backcoated fabrics exposed to UV light. Polypropylene fibers, as most fibers, are subject to degradation from the UV rays in sunlight. The polymer molecules in the fiber are gradually broken down which leads to reduced fiber strength. Synthetic fiber producers routinely put additives into their fibers which inhibit the action of the UV light on the polymer. Fabrics made from properly stabilized fibers can withstand many years of direct sunlight exposure.

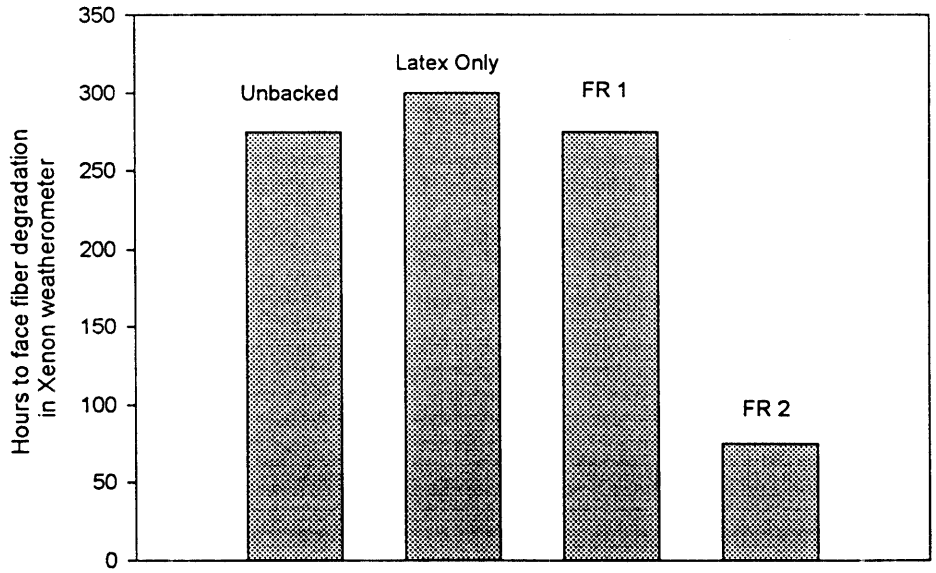
Over the past twenty (20) years, we have had customers (primarily automotive and marine fabric producers but also contract furniture fabric producers) report premature failure in accelerated UV testing of polypropylene fabrics which had been backcoated with an FR backcoating. It was also found that while some FR backcoatings exhibit this prodegrative action, others do not. Since the formulations of the FR backcoatings our customers use are often considered proprietary by them, we do not know which chemicals were used in the backcoatings, but data, such as shown in the Figure below, demonstrate the fact that the face fibers of some FR backcoated fabrics are not as stable as those which are not backcoated or where the backcoatings do not contain FR chemicals.

The fabric samples tested in the study reported in the Figure were all from the same roll of upholstered furniture fabric and the backcoatings used the same latex only with different FR chemicals added. The point of fiber degradation was determined to be when significant amounts of fiber could be removed from the fabric surface by applying Scotch tape to the fabric surface.

The data in the Figure show that the fabric backcoated only with the latex and the fabric with FR formulation FR1 exhibited UV stability essentially the same at the fabric with no backcoating The UV stability of the fiber in the fabric with backcoating formulation FR 2 was greatly reduced.

Figure

Face Fiber Stability to UV Exposure
in Accelerated Light Testing



We do know that similar prodegrative effects have been seen in polypropylene fabrics when certain halogenated FR chemicals are incorporated in the fiber formulation during the fiber forming process. It is also known that there can be a chemical reaction between the active flame retarding agent and the UV light stabilizers in the fiber which renders the UV light stabilizers inactive. Migration of halogenated FR chemicals from the

backcoating into the face fiber where they react with the UV stabilizer could explain the reduced UV stability of the FR backcoated fabrics.

In summary, we have presented evidence that we believe shows some FR chemicals contained in FR backcoatings for fabrics are not locked into the latex but rather can migrate into the face fiber of the fabric. Since we do not know the identity of the migratory chemicals, we can not comment on their safety, but only on their migratory nature.

Sincerely,

Phil M. Stricklen

Phil M. Stricklen, Ph. D.
Research Associate
Amoco Fabrics and Fibers Co.

National Cotton Council OF AMERICA

1521 New Hampshire Avenue, NW • Washington, DC 20036
(202) 745-7805 • FAX (202) 483-4040

PRODUCERS • GINNERS • WAREHOUSEMEN • MERCHANTS • CRUSHERS • COOPERATIVES • MANUFACTURERS

1 May, 1998

Ms. Rockelle Hammond
Office of the Secretary
U.S. Consumer Product Safety Commission
Washington, DC 20207

Re: *Flame retardant chemicals (62 FR 13017; March 17, 1998)*

Dear Ms. Hammond:

These comments are submitted by the National Cotton Council (NCC) in response to CPSC's March 17, 1998 notice of public hearing and request for comments on flame retardant chemicals that may be suitable for use in upholstered furniture (63 FR 13017). NCC is the central trade organization of the American cotton industry. NCC members include producers of over 75% of the US cotton and cotton processing industries.

We have carefully reviewed the October 28, 1997 CPSC staff briefing package on regulatory options on upholstered furniture flammability. Two major areas of concern to our members are:

- The need for adequate toxicological testing by the chemical suppliers and well-defined approval methodology of flame retardant chemicals for use on upholstered furniture
- Consideration of environmental and worker health and safety issues for FR chemicals and their impact on small businesses

Toxicological testing and approval methodology

CPSC's review of the data and approval process of the flame retardant chemicals showed that the available toxicological data are incomplete and the approval methodology for fire retardant chemicals is inconsistent due to the lack of test data.

The toxicity testing of FR chemicals by the chemical suppliers should satisfy the requirements of the Federal Hazardous Substances Act (FHSA) and the EPA Toxic

Substances Control Act (TSCA). In addition, NCC suggests that CPSC consider the Organization for Economic Cooperation and Development (OECD), Screening Information Data Set (SIDS) set of basic tests that should be conducted on chemicals as a basis from approval under the CPSC administered FSHA. The SIDS criteria calls for the following testing for high production volume chemicals:

acute toxicity	mutagenicity
chronic toxicity	carcinogenicity
neurotoxicity	ecotoxicity
developmental or reproductive toxicity	environmental fate

This more complete data set would provide some confidence to both the textile and furniture manufacturer and the consumer that the chemicals used on FR-treated upholstered furniture will not present a human health or environmental risk.

Environmental, Health and Safety Issues for Textile Manufacturers

Very little if any FR-treated upholstered furniture fabrics are currently in production in the U.S. There are only three U.S. companies currently producing FR-treated cotton and cotton blend fabrics for any end use. This represents only about 0.2% of cotton and cotton blend fabrics produced in the U.S. The textile industry will essentially have to develop new processes for the almost infinite variety of currently available upholstery fabrics, depending upon weight, fiber types, fabric formation, and dyestuffs. This will necessitate large capital expenditures which many small textile businesses will not be able incur. It is uncertain whether the U.S. textile industry will produce many of these FR-treated fabrics or whether most will be produced outside of the United States.

These changes will also trigger changes in environmental (EPA) and workplace (OSHA) regulatory requirements which will add to the cost of doing business. CPSC needs to consider these costs and requirements, as well as the cumulative impact of incremental increases in regulatory costs, in their determination of the economic and technological feasibility of any regulation that is promulgated.

In their analysis of the costs of a potential new regulation CPSC staff did not consider the additional costs incurred to produce FR-treated upholstery fabrics. In addition, CPSC did not do an analysis to determine if the potential new regulation will have a significant impact on a substantial number of small entities as is required by the Regulatory Flexibility Act.

Some of the environmental, health and safety regulations for flame retardant textile processes are:

<u>OSHA (workplace)</u>

- Process Safety Management Standard (29 CFR 1910.119) (if ammonia or other listed chemicals are used in the process)
- Hazard Communication Standard (29 CFR 1910.1200) (MSDS, training)
- PEL for ammonia (29 CFR 1910.1000 Table Z-1); Formaldehyde (29 CFR 1910.1048); other chemicals (29 CFR 1910.1000). This includes monitoring, control, recordkeeping
- Safety and Health Management Program (training, etc.)

Furthermore, the textile industry has concerns with the dermal affects of handling these materials throughout processing. Worker practices, training and personal protective equipment could be required.

EPA (environmental)

- (Air) Clean Air Act (42 US Code 7401 et seq.)
    - NAAQS for O_3 (because of VOCs)
    - Hazardous Air Pollutant (HAP); MACT standard for textile finishing
    - Chemical Accident Prevention, Section 112(r) (40 CFR 68)
    - Federal Permits ("Title V" permit) (40 CFR 70)
    - State Air Permits

- (Water) Clean Air Act (33 US Code 1251 et seq.)
    - NPDES permits (40 CFR 122) (for effluents including metals, COD, BOD, TSS)
    - State Water Permits

- (Solid Waste) RCRA (42 US Code 6901 et seq.)
    - If the product is a hazardous waste or produces hazardous waste a state solid waste permit could be required

- Emergency Planning and Community Right-to-Know (42 US Code 11001 et seq.)
    - Toxic Release Inventory (TRI) (40 CFR 372)

We appreciate the Consumer Product Safety Commission's consideration of these comments. Please do not hesitate to call us if you have any questions or need additional information.

Sincerely,

Phillip J. Wakelyn, Ph.D.
Senior Scientist, Environmental Health and Safety

Patty Adair
Manager, Standards and Workplace/Consumer Regulations

Attachments:

1. Flame Retardants Buyers' Guide. *American Dyestuff Reporter* 87(1) 13-29 (1998).
2. Cotton and Flammability. *American Dyestuff Reporter* 87(2) 13-21 (1998).

Flame Retardants Buyers' Guide

ADR's Annual Listing Of Current Flame Retardant Suppliers To Textile Wet Processing Areas

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
Albright & Wilson Americas **P.O. Box 4439** **Glen Allen, VA 23060** **(800) 446-3700**						
Antiblaze® N	Cyclic phosphonate ester	Liquid	Polyester, coatings for most fibers	3-6	MVSS 302, NFPA 701 Children's sleepwear	N/A
Antiblaze® NT	Cyclic phosphonate ester	Liquid	Polyester, coatings for most fibers	3-6	MVSS 302. NFPA 701	N/A
Antiblaze 37	Organic phosphonate blend	Liquid	Most fibers, Synthetics and Blends	3-6	MVSS 302. NFPA 701	N/A
Amgard RD-1	Organic Phosphorus blend	Liquid	Most fibers, Synthetics and Blends	4-12	MVSS 302 NFPA 701	N/A
Amgard® FSD	Ammonium polyphosphate blend	Liquid	Cellulose, blends, most Synthetics	5-15	MVSS 302 NFPA 701	N/A
Amgard® LR2	Ammonium polyphosphate blend	Liquid	Cellulose and blends	5-15	NFPA 701, Leach resistant,	N/A
Amgard® LR4	Ammonium polyphosphate	Powder	Coatings for most fibers	5-30	MVSS. NFPA 701 Leach resistant	N/A
Amgard® TFR1	Organic phosphonic acid	Liquid	Cellulose and blends	25-40	NFPA 701, Durable	N/A
Amgard® TR	Ammonium polyphosphate blend	Liquid	Cellulose and blends	5-10	NFPA 701 Non durable	N/A
All are designed to meet Federal, National, State and Local standards. Information available on request.						
American Fire Retardant Corp. **9337 Bond Avenue** **EL Cajon, CA 92021** **(619) 390-6888** **Fax: (619) 390-6889** **110 Brush Rd.** **Broussard, LA 70518** **Fax: (318) 837-1699**						
Firextra®1000	Inorganic phosphonated esters	Liquid	Cellulosic,blends most synthetics, wood, paper	5-15	NFPA701,MVSS302, FAA 25.853(b), and others	N/A
Fiberix® 2000	Polyphosphate-nitrogen compound	Liquid	Cellulosic, blends most synthetics.	6-16	NFPA 701, MVSS 302, FAA 25.853(b),	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
(American Fire Retardant, Continued)						
					soil repellant, and others	
Fiberix® 2000V	Polyphosphate-nitrogen compound	Liquid	Cellulosic, blends most synthetics,	6-16	NFPA 701. MVSS 302, FAA 25 853(b), soil repellant, anti-bacterial, and others	N/A
Firextra® 238	Acrylic polymer compound	Liquid	Woods. thatch. wall coverings	N/A	ASTM E-84. NFPA 701	N/A
These and others that are designed to meet various Federal, National, State, Local and International protocols. Information available on request.						
Apex Chemical Corp of S.C. 1905 New Cut Rd. Spartanburg, SC 29303						
Apex Flameproof #1279	Inorganic salts	Liquid	Cellulosic fibers and blends	10-20	MVSS 302, California, New York City, Boston	N/A
" #311	Inorganic salts	Powder	Paper and paper products, and cellulosics	10-20	Tappi 461SU-72, NFPA-701 and 702 NBS-PS-46-1	N/A
" #1027	Inorganic salts	Powder	Cellulosic; non yellowing in heat exposure	7-20	CS 191-53 NFPA-701, CS 191-53 (Rev.)	N/A
" #736	Inorganic salts	Liquid	Diversified blends, cellu-losics and synthetics	approx 10	California Registration C-72, New York City Calendar #838-68-SM, CS 191-53, MV55-302, CPAI-34, NFPA-701 and NFPA 702	N/A
" #925	Inorganic salts	Liquid	Flame retard ant-water repellent combinations Calendar #838-68-SM	10-20	California Registration #C-72-2, MVSS-302 NFPA-701, MVSS, 302, New York City	N/A
" #1945	Organic phosphate	Liquid	Polyester cotton and polyester	10-20	CPAI-84, NFPA-701 MVSS-302 Calif. Reg. #C-72-7	N/A
" #1951	Inorganic salts	Liquid	Cellulosics syn-thetic blends	10-20	California Registration #C-72.11; NFPA-701, CPAI-84; MVSS-302	N/A
Apex Flameproof #344-HC	Halogenated com-pound/ antimony oxide	Aqueous dispersion	Cellulosics and synthetic blends	10-30	CPAI-84, NFPA-701 and 702, MVSS-302	N/A
" #351	Halogenated com-pound/phosphate	Liquid	Cellulosics and synthetic blends, urethane foams	10-30	CPAI-84. NFPA-701 and 702, MVSS-302	N/A
" #353	Halogenated compound	Aqueous dispersions	Cellulosics and synthetic blends	10-30	CPAI-84, NFPA-701 and 702, MVSS-302	N/A
" #364	Halogenated com-pound/antimony oxide	Aqueous dispersions	Synthetic blends	10-30	CPAI-84, NFPA-701 and 702. MVSS-302	N/A
" #2080	Organic phosphorus compound	Liquid	Cotton, polyester/cotton	20%	NFPA-701	N/A
" #334	Organic halogen compound	Liquid	Polyester	25	NFPA-701, NS5852	N/A
" #1510	Organic halogen compound	Liquid	Nomex, nylon, polyester	5-10	NFPA-701, BS5852	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
(Apex, Continued)						
" #333	Organic halogen	Liquid	Cellulosic fibers and blends	3-10	NFPA-701, MVS5S-302, BS5852	N/A
Apex Flameproof #344-HC	Dispersion of antimony oxide and DBDPO	Viscous white liquid	Both synthetic and natural fibers	5-50	All recognized standards	
" #345	Blend of DBDPO and antimony oxide	Powder	Both synthetic and natural fibers	5-50	All recognized standards	N/A
" Backote 308	Organic halogen compounds	Liquid	Polyester, cotton, polyester blends	2 oz/yd²	NFPA-701 MVSS2-302. CPAI-84 BS 5852	N/A
" #1525	Organic phosphate	Clear liquid	Polyester	5-25	NFPA 701, BS 5852	N/A
" #377	Organic halogen	Liquid	Nomex, nylon. polyester	10-50	NFPA 701, BS 5852	N/A
Apollo Chemical Corp. P.O. Box 2176 Burlington, NC 27216 (336) 226-1161						
Barfire OTF-New	Self-emulsiflable halogenated compound	White liquid	Polyester, polyester blends	5-15	NFPA 701, UFAC, MVSS 302. CALIF. REG C120.00	N/A
" RE	Organic phosphate	Clear liquid	Polyester cotton	5-30	NFPA 701, MVSS 302 UFAC, CALIF. REG. C120.01	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
(Apollo, Continued)						
PCR	Halogenated	Clear liquid	Polyester, cotton rayon, nylon blends	5-50	NFPA 701, MVSS 302, UFAC, NFPA 702 CALIF. REG C120.02	N/A
Bolger & O'Heam P.O. Box 355 Fall River, MA 02724						
Flameout FR-8	Complex salt blend	liquid	Cellulosics and synthetic blends	15-35	NFPA-701, MVSS-302	
Flameout 44	Antimony organo-halogen compound	liquid	all fibers	10-30	All flammability standards	
Flameout II Special	Organic phosphonated ester	liquid	Cellulosics and synthetic blends	15-45	NFPA-701, Boston 1x-1, CPA 1-84, MVSS-302, FAA 25-853(B)	
Flameout PC-1	Modified organic phosphonated ester	liquid	all fibers	15-35	FAA 25-853(B), NFPA-701, MVSS-302, CPA 1-84	
Flameout N-15	Organic nitrogen compound	liquid	nylon	10-20	NFPA-701, CPA 1-84, CS191-5903, MVSS-302 FAA 25-853(B)	
Flameout NW	inorganic salts	liquid	Cellulosics and synthetic blends	10-20	NFPA-701, CPA 1-84, MVSS-302	
Chemonic Industries Inc, P.O. Box 9601 Greensboro, NC 27429 1-800-255-0438						
Pyron 125	Phosphonate Ester	Clear Liquid	Polyester	1-10	NFPA 701, MVSS 302	N/A
Pyron 5588	Proprietary Compound	Clear Liquid	Polyester, Jet dyeing applications	1-5	NFPA 701, MVSS 302	N/A
Pyron C-21C	Proprietary Compound	White Liquid	Cotton Poly cotton, Rayon	10-30	NFPA 701, MVSS 302	N/A
Pyron 95-L	Organic and Inorganic Salts	Clear Liquid	Natural, Synthetic & Blends	10-30	Standards not requiring washing, dry cleaning, or bleaching.	N/A
Pyron FR-65	Dispersion of Decabromodi-phenyl Oxide & Antimony Trioxide	White Liquid	Natural, Synthetic Blends	5-25	NFPA 701, MVSS 302	N/A
Chemrez FR-1099	Flame Retardant Acrylic Polymer	Clear Liquid	Polyester. Polypropylene, Vertical Blinds. Pleated Shades	10-40	NFPA 701, MVSS 302	N/A
Chemrez VR-7	Acrylic/Decabro-modiphenyl Oxide Blend	White Liquid	All Fibers, Pigment Pad Dyeing, Vertical Blinds	20-80	NFPA 701, MVSS 302	N/A
Ciba Specialty Chemical Consumer Care Division 4090 Premier Drive P.O. Box 2444 High Point, NC 27261-2444						
Pyrovatex CP-New	Dialky Phosphorus Carboxyl Amide	Liquid	Cotton	20-40	All recognized standards	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
Dover Chemical Corp. **P.O. Box 40** **Dover, OH 44622** **(800)321-8805**						
Doversperse™ 3	70% Chlorinated Paraffin (Liquid)	Aqueous Liquid Emulsion (65% solids)	Cellulosics	5-30	NFPA 701 MVSS 302	N/A
" A 1	70% Chlorinated (Paraffin Resinous)	Aqueous Solid Dispersion (65% solids)	Cellulosics Polyester	5-30	"	N/A
Paroil™ 170	70% Chlorinated Paraffin	Liquid	Cellulosics	5-30	"	N/A
Chlorez™ 700	70% Chlorinated - Paraffin	Solid Powder	Cellulosics Polyester	5-30	"	N/A
Doverguard™ 8207-A	Bromine and Chlorine (60% total)	Liquid	Nylon Cellulosics Polyester	5-30	"	N/A
" 8208-A	Bromine and Chlorine (59% total)	Liquid	Nylon Cellulosics Polyester	5-30	"	N/A
" 8307-A	Bromine, Chlorine & Phosphorous, (52% total)	Liquid	Nylon Cellulosics Polyester	5-30	"	N/A
" 8410	Bromine 57%	Liquid	Nylon Cellulosics Polyester	5-30	"	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
(Dover, Continued)						
" 8426	Bromine 42%	Liquid	Nylon Cellulosics Polyester	5-30	"	N/A
" 9119	Bromine and Chlorine (66% total)	Liquid	Nylon Cellulosics Polyester	5-30	"	N/A
" 9122	Bromine, Chlorine & Phosphorous, (36% total)	Liquid	Nylon Cellulosics Polyester	5-30	"	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
Eagle Systems Corporation **340 Beamer Road** **Calhoun, GA 30701** **(706) 629-1044**						
Aqueous Dispersions: Eagleban F/R P-44	DBDPO + AO 2:1	Liquid	All	15-35	All flammability standards	N/A
" F/R P-53	DBDPO	Liquid	Synthetics	10-20	All	N/A
" FIR P-64	DBDPO + AO 5:1	Liquid	Flocked fabrics and Synthetics	10-20	All	N/A
" F/R P-66	Brominated Aliphatic	Liquid	Polyester, Nylon	3-10	All	N/A
" F/R P-75	Brominated Aliphatic + AO	Liquid	All	15-35	All	N/A
" F/R P-99	Low particle size Antimony Oxide	Liquid				N/A
" 5531	Low particle size version of P-44	Liquid	All	15-35	All	N/A
" SP-100	Lower cost form of P-44	Liquid	All	15-35	All	N/A
Emulsions And Solutions Eagleban F/R N-22	Brominated aromatic + colloidal Antimony Oxide	Liquid	Synthetics	15-35	All	N/A
" F/R N-24	Halogenated aliphatic + colloidal Antimony Oxide	Liquid	Synthetics	15-35	All	N/A
" CPA-2000E	Halogen + Phosphorous Organic	Liquid	Synthetics	3-10	All	N/A
" FIR P-50	Organic Phosphate	Liquid	Latexes	5-20	All	N/A
" FR-P Series	Organic Phosphate	Liquid	Cellulosics and blends	10-20	All	N/A
Eastem Color & Chemical Co. **35 Livingston Street** **Providence, RI 02904**						
Ecco Flameproof WN-17	Blend of inorganic bromo/Phosphate	Clear liquid	Cellulosic, wool blends	5-10	NFPA 701, MVSS 302	N/A
" LB-2	Blend of inorganic ammonium salts	Clear liquid	Cellulosics, blends	5-10	NFPA 701, MVSS 102	"
" CPE	Blend of inorganic bromo/phosphate	Clear liquid	Cellulosics, Polyester	10-15	NFPA 701, MVSS 302	"
" PE-100	Organo phosphate/ester	Clear liquid	polyester-durable	2-5	NFPA 701, MVSS 302	"
Eccogard SF-10	Nitrogen condensate	Clear liquid	polyester-durable blends	10-40	NFPA 701, MVSS 302	"
" W-2	Organic ester/phosphate	Clear liquid	Acrylic-durable nylon, polypropylene	5-10	NFPA 701, MVSS 302	"
Eccogard BV-46	Halogenated organic resin compound	Emulsion	Synthetics and blends	10-40	NFPA 701, MVSS 302	N/A
Eccogard BV-17	Halogenated organic resin compound	Emulsion	Synthetics and blends	10-40	NFPA 701, MVSS 302	"
Eccogard CCP	Organo-phosphate ester	Liquid	Cellulosics and durable blends	10-40	NFPA 701, MVSS 302	"

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
(Eastem, Continued)						
Eccogard WS-2	Organo-phosphate ester	Liquid	Cellulosics and durable blends	10-40	NFPA 701, MVSS 302	"
Eccogard A-10	Organo-phosphate ester	Liquid	Nylon, urethanes, gortex	5-10	NFPA 701, MVSS 302	"
Eccogard C-75	Organo-phosphate ester	Liquid	Cellulosics	20-45	NFPA 701, MVSS 302 CFR 1610, 1615 and 1616	"
Emco Services, Inc. P.O. Box 2191 Taunton, MA 02780 (508) 823 8852 Fax (508) 824-6735						
Flame Out II	Organo Nitrogen Phosphanated Ester	Liquid	All Fabrics	10-45	NFPA #701 Boston 1X-1 ASTM E-84	N/A
" PE-60	Halogenated Organic Compound	Liquid	Polyester	5-25	NFPA #701 British Std 5852	N/A
" PE-19	Cyclic Phosphorus Compound	Liquid	Polyester	10-35	NFPA 701 British Std 5852	"
" CA-43	Antimony Organo-Halogen Compound	Liquid	All Fabrics	10-50	CPAI-84, NFPA 701 British Std 5852	"
" CO	Polymeric Borated Phosphonate	Liquid	Cellulosics and Blends	30-40	NFPA 701	"
" 21	Complex Polymer Electrolyte	Liquid	Chintz and Teflon Treated Fabrics	50	NFP 701	"
" 95	Non-salt Organo-Phosphonated Ester	Liquid	Cellulosics and Polyesters	35	NFPA 701	"
" 35	Non-Antimony Organic Halogen Compound	Liquid	Cellulosics and Synthetic Blends	50	Antileach British Std 5852 NFP 701. CPA 1-84	"
" 6	Antimony Organic Halogen Compound	Liquid	All Textile Fabrics	50	Antileach British Std 5852 NFPA 701, CPAI-84	"
Flameout FR-8	Complex salt blendd	Liquid	Cellulosics and Synthetic Blends	15-35	NFPA 701, MVSS-302	N/A
Flameout II Special	Organic Phosphonated ester	Liquid	Cellulosics and Synthetic Blends	15-45	NFPA 701, Boston 1X-1 CPAI-84, MVSS-302, FAA 25-853 (B)	N/A
Flameout NW	Inorganic Salts	Liquid	Cellulosics and Synthetic Blends	10-20	NFPA 701, CPAI-84, MVSS-302	"
Flameout PC-1	Modified Organic Phosphonated ester	Liquid	All Fibers	15-35	FAA 25-853 (B), NFPA 701, MVSS-302, CPAI-84	"
Flameout 44	Antimony Organo-Halogin Compound	Liquid	All Fibers	10-30	All Flammability Standards	"
Flameout N-15	Organic Nitrogen Compound	Liquid	Nylon	10-20	NFPA 701, CPAI-84, CS191-5903, MVSS-302, FAA 25-853 (B)	"
" 279-7	Modified Organlc Halogen	Liquid	Nylon	50	NFPA 701	"
" 82	Non-Salt Organo-Phosphate Ester	Liquid	Cellulosics and Synthetic Blends	30	NFPA 701 Boston 1X-1 STME-84	"

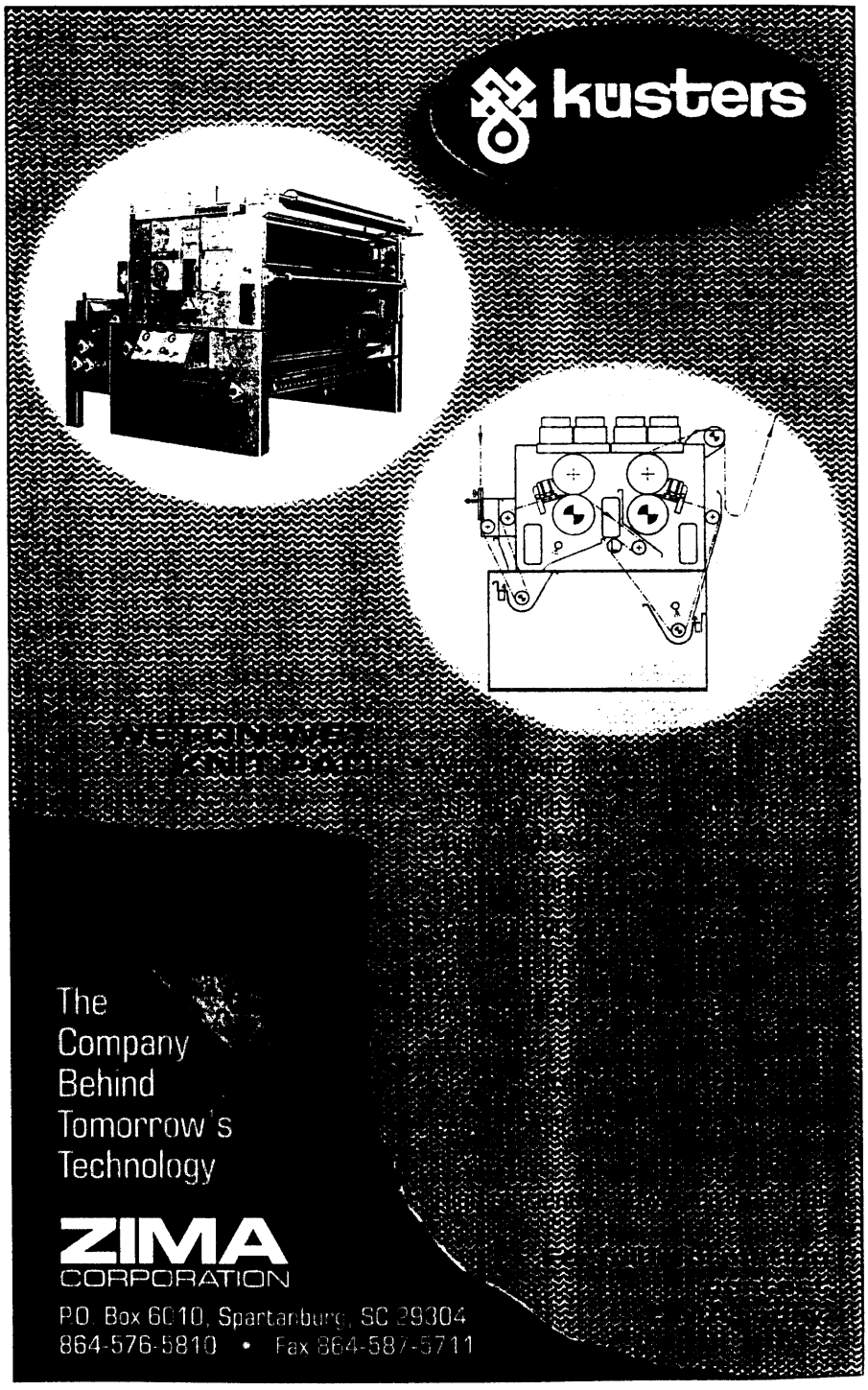
Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
(Emco, Continued)						
• 93	Ammonium Polyphosphate	Liquid	Cellulosics and Synthetic Blends	20-40	NFPA 701	"
• 80	Non-Salt Organo Phosphate Ester	Liquid	Cellulosics and Synthetic Blends	20-40	NFPA 701	"
New	Organo Nitrogen	Liquid	Non-Corrosive and Non-Frosting for all fabrics	10-45	NFPA 701, Boston IX-1	"
Flame Out DF	Phosphorus compound	Liquid	Cotton	–	Durable type	"
Emkay Chemical Co. 319 Second Street P.O. Box 42 Elizabeth NJ 07208						
Emkapruf ABR	Boron-phosphate	Conc. Liquid	Polyester/ cotton, blends	6-24	Standards not requiring washing or dry cleaning	N/A
• PF-49	Phosphate blend	Conc. Liquid	Cellulosics blends. paper	6-24	Standards not requiring washing or dry cleaning	"
• ASP	Phosphate blend	White Powder	Cellulosics blends non-wovens	6-24	Standards not requiring washing or dry cleaning	"
Freedom Textile Chemicals Co. 8309 Wilkinson Bl'vd Charlotte, NC 28214						
Non-Durable Freetex™ Flame Retardant	Proprietary	Powder	Cellulosic	12-15	CS-191	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
(Freedom, Continued)						
Durable Pyroset TKOW Flame Retardant	Phosphonium salt (sulfate)	Liquid	Cellulosic	10-30	FF 3&5 NFPA-701 CPAI 84 (DOC) FTMS-191-5903. MVSS 302	"
" TPO Flame Retardant	Phosphonium salt precondensate	Liquid	Cellulosic	10-30	NFPA 701, CPAI-84 (DOC) FTMS 191-5903 MVSS 302	"
" TKC Flame Retardant	Phosphonium salt (chloride)	Liquid	Cellulosic	10-30	FF 3&5. NFPA-701 CPAI-84 (DOC) MS-191-5903 MVSS-302	"
" TPC Flame Retardant	Phosphonium salt precondensate (chloride)	Liquid	Cellulosic	10-30	FF 3&5, NFPA-701 CPAI-84 (DOC) FTMS-191-5903, MVS-302	"
FR Systems International 1060 Meyerside Dr. Unit 8 & 9 Mississauga, Ontario L5T 1J4 Canada						
FRTX 5000	Proprietary neoprene Blend	White	Natural fibers	20	CA 133 most stringent full scale seating flammability tests Transforms decorative Upholstery into fire blocking barrier-fabrics	N/A
FRTX 5050	Proprietary neoprene Blend	White	Synthetics	5-15	California, Boston 9 NFPA70i . NYC MVS 302	N/A
Glo-Tex International, Inc. 25 Stan Perkins Road Spartanburg, SC 29307 (864) 579-9897 1-(800) 768-6771						
Glo-Tard BG	Phosphonate	Clear Liquid	1008O Polyester	8-15	NFPA-701. MVSS-302	N/A
Glo-Tard NTB	Phosphonate	Clear Liquid	100% Polyester	8-15	NFPA-701. MVSS-302 DOC FF-3 and FF-5 Cal. Reg. No. 79.02	N/A
Glo-Tard NY-22M(G)	Thiourea	Clear Liquid	100% nylon	15-25	NFPA-701, MVSS-302	N/A
Glo-Tard TM	Blend of buffered inorganic salts	Tan powder	100% cotton 100% rayon 100% wool	12-20	Cal. Reg. No. 79.00 NFPA-701, MVSS-302	N/A
Glo-Tard WP-I	Blend of buffered salts	White powder	100% cotton 100% rayon	12-20	NFPA-701, MVSS-302	N/A
Glo-Tard FRCH	Blend of inorganic salts	White powder	Polyester/blends 100% Polyester	15-20	NFPA-701, MVSS-302 Cal. Reg. No. 79.01	N/A
Glo-Tard TM-70	Blend of inorganic salts	Thin. clear Liquid	Nylon/cotton blends	25-40	NFPA-701, MVSS-302 Cal. Reg. No. 79.00	N/A
Glo-Tard 58L	Self-emulisifiable halogenated	Thin. clear liquid	100% Polyester	12-15	NFPA-701, MVSS-302	N/A
Guardex PFR-DPH	Organic Halogen Phosphorus Compound	Powder	Natural & Synthetic Fibers	5-20	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex PFR-DPHN	Organic Halogen Phosphorus Compound	Powder	Specific to Polypropylene	5-20	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
(Glo-Tex, Continued)						
Guardex PFR-PHN	Complexed Phosphorus Compound	Powder	Natural & Synthetic Fibers	5-20	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex PFR-BCD	Complexed Phosphorus Compound	Powder	Compound Polyester/Nylon	5-20	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex FR-DPH	Organic Halogen Phosphorus Compound	Dispersion	Natural & Synthetic Fibers	10-30	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex FR-DPHN	Organic Halogen Phosphorus Compound	Dispersion	Polypropylene	10-30	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex FR-PHN	Complexed Phosphorus Compound	Dispersion	Natural & Synthetic	10-30	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex FR-BCD	Complexed Phosphorus Compound	Dispersion	Polyester/Nylon	10-30	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex FR-P78	Noncottosive/ Nondurable Inorganic	Solution	Polyester & P/C	10-30	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex FR-MEH	Organic Phosphorus	Solution	Wool & Blends	10-30	NFPA-701, BS 5852	N/A
Guardex FR-MEHN	Organic Phosphorus	Solution	Nylon	10-30	NFPA-701, BS 5852 Cal. 133, 129, etc.	N/A
Guardex FR-GWN	Inorganic salts	Solution	Cottons	10-30	NFPA-701, BS 5852	N/A
Guardex FRC-DPH (S, M, H)	Flame Retardant and Polymer	50% Blend	All Natural Synthetic Fibers	10-25	All Standard Flame Tests	N/A
Guardex FRC-DPHN (S, M, H)	Flame Retardant and Polymer	50% Blend	All Natural Synthetic Fibers	10-25	All Standard Flame Tests	N/A
Guardex FRC-PHN (S, M, H)	Flame Retardant and Polymer	50% Blend	All Natural Synthetic Fibers	10-25	All Standard Flame Tests	N/A
Guardex FRC-BCD (S, M, H)	Flame Retardant and Polymer	50% Blend	All Natural Synthetic Fibers	10-25	All Standard Flame Tests	N/A
Great Lakes Chemical Corporation One Great Lakes Blvd West Lafayette, IN 47903						
CD-75P™	Hexabromo Cyclododecane	Solid	Polyester Polyolefin	N/A	Most Regulations For Coated Textiles	N/A
DE 83R™	Decabromodi-phenyl Oxide	Solid	Polyamide Polyester Polyolefin	–	–	–
HP-36™	Halogenated Phosphate Ethane	Liquid	Polyester	–	–	–
FF-680	Bis (Tribromo-phenoxy) Ethane	Solid	Polyamide Polyester	–	–	–
FR 756™	Disodium Salt Of Tetrabromo-phthalic Anhydride	Solid	Polyamide Wool	–	–	–
NH 1197	Proprietary Non-Halogen Cyclic Phosphate Ester	Solid	Polyamide Polyester. Polyolefin	–	–	–
Manufacturers Chemicals, L.P. 4325 Old Tasso Road Cleveland, TN 37311						
Properties Fire Retard KK	Polyphosphate	Liquid	Cellulosic	5-15	Semi-durable, non-	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
(Manufacturers, Continued)						
	nitrogen compound				corrosive	
Fire Retard 102-52A	Nitrogen compound modified complex	Liquid	Cellulosic in blends	5-20	Semi-durable, excellent latex compatibility,corrosive	N/A
Fire Retard 66	Organic phosphate blend derivative	Liquid	Polyester	5-15	Durable	N/A
Nicca USA, Inc. **5000 Nelson Rd** **Fountain Inn, SC 29644** **(800) 593-4110** **(803) 862-1426** **Fax: (803) 862-1427**						
Fi-None P-3	Phosphorus compound	Liquid	Synthetics, blends	10-30	MVSS-302	N/A
" H-45	Phosphorus/ resin compound	Liquid	Synthetics, blends	10-30	MVSS-302	N/A
All are designed to be compatible with many other textile finishing agents (W/R. A/S. softeners. etc.). Further information available upon request.						
Omega Chemicals. Inc. **P.O. Box 1723** **Spartanburg, SC 29304-1723**						
Omega Flame Retardant 190	Inorganic salt	Clear liquid	Cellulosic blends	20-30	Standards not requiring washing or dry cleaning	N/A
" 261	Inorganic salt	Clear liquid	Cellulosic blends	20-30	Standards not requiring washing or dry cleaning	N/A
" 262	Inorganic salt	Clear liquid	Cellulosic blends	20-30	Standards not requiring washing or dry cleaning	N/A
Polymer Research Corp. of America **2116 Mill Avenue** **Brooklyn, NY 11234**						
Research and Development of Durable FR Formulations	As Needed	Chemical Graft	All Fibers	1 or less	All Fed'l/ State requirements	N/A
Prochem Incorporated **890 Fern Hill Road** **West Chester, PA 19380** **(215) 436-4812**						
Progard FR-3	Phosphate ester	Liquid	Polyester and blends	5-25	N/A	N/A
" FR-6	Phosphate ester	Liquid	Wool. nylon. blend wool/nylon, polyester/wool	5-25	"	"
Soluol Chemicals Co., Inc. **P.O. Box 112** **Green Hill & Market Sts.** **West Warwick, RI 02893**						
Solucote Top FR 731 " Base FR 536	Solvent Based Polyurethane Flame retardant coating	Liquid	Polyester Nylon	Varies	CPAI 84 NFPA 701	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
(Soluol, Continued)						
Solucote Top FR 1047 Base FR 1041	Waterbased Polyurethane flame retardant coating	Liquid	Polyester Nylon	Varies	CPAI 84 NFPA 701	"
Spartan Flame Retardants, Inc. **P.O. Box 395** **Crystal Lake, IL 60014** **1-800-435-5700, In IL-815-459-8500**						
Spartan CM	Inorganic	Granular	Cotton, wool,	12-15	New York City Calendar	N/A



Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
(Spartan, Continued)						
		or solution	silk, rayon.	(textile)	#822-40-SM, MVSS-302, TAPPI	
			Paper, paper-board	15-20 (paper)	T-461, DOC FF2-70 NFPA 701 & 702, California Registration #C-69	
Spartan FI-RETARD 5M (formerly Arkansas Co)	Inorganic	"	Cellulosic and synthetic textile fibers	10-15	California Registration #C-69	N/A
Spartan AR 295 (New)	Inorganic and Organic	"	Emulsion binder compatibility for use with cellulosic and textile fibers	10-20	TAPPI T-461 NBS-PA 4671 NFPA 701 & 702 MVSS-302 AATCC	N/A
Spartan AR 371 (New)	Organic and Inorganic	—	Emulsion binder compatibility for use with cellulosic and synthetic textile fibers	10-20	TAPPI T-461 NBS-PS 4671 NFPA 701 & 702, MVSS-302, AATCC	N/A
" X12 (formerly DuPont)	Inorganic	"	Cotton. wool, silk, rayon, linen paper, paperboard (non-yellowing under heat exposure)	12-15 (textile) 15-20 (paper)	California Registration #C-69 MVSS 302, T-PPI T-i61 DOC FF2-70, NFPA 701 & 702, VA & GSA Approvals, New York City Calendar #539-53-SM	N/A
" 590D	Inorganic and Organic	"	Cellulosics, emulsion binder compatibility	10-15	TAPPI -461, MVSS-302, NFPA 701& 702, NBS-PS 4671	N/A
" FF4-72 (formerly Virginia Chemicals)	Proprietary	Liquid	Mattress cotton, cotton batting cellulosics Furnishings Bulletin 117, US Government	12-16	DOC FF4-72, UFAC DeckingTest, California Home (Army) Spec. V-M-96H, Approved for mattress batting by the Office of the Surgeon General.	N/A
" FR-48 (formerly Virginia Chemicals)	Proprietary	Liquid	Paper, paperboard, ground paper products,cotton batting, shoddy. cellulose linsulation	9-15	N/A	N/A
" FR-53 (formerly Virginia Chemicals)	Proprietary	Liquid	Mattress cotton, cotton batting, cellulosics	10-15	DOC FF4-72	N/A
" 742-D	Organic and Inorganic blend	Powder	Cellulosic and synthetic textile fibers	10-20	AATCC	N/A
Sybron Chemicals, Inc. P.O. Box 125 Wellford, SC 29301						
FlameGard DSH	Blend of inorganic salts	Liquid	Cellulosic nylon, polyester and blends	20-50	CS-181-5903. NFPA 701, California MVSS-302	N/A
FlameGard 908	Organic nitrogen compound	Liquid	Nylon	20-30	California NFPA 701, CPAI 84 CS191-5903,MVSS302. NFPA 701	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
(Sybron, Continued)						
FlameGard AFP	Complex salt blend	Liquid	Polyester/cotton cellulosics to be used with water repellents and fluorocarbon finishes	N/A		"
FlameGard PE Conc	Organic phosphorus	Liquid	Polyester	8-15	California CPAI 84.MVSS302	"
FlameGard POL						
FlameGard SR	Blend of inorganic salts	Liquid	Acetate, polyester synthetics cellulosic blends. acrylics. rayon	20-60 O.W.B.	CS191-5903, NFPA-701 MVSS-302	"
FlameGard STS	Blend of inorganic salts	Liquid	Polyester. polyester/ cotton. cotton	20-50 O.W.B.	California CS 191-5903, NFPA-701. MVSS-302	"
" Pyroban 20M	Organic phosphorous salt	Liquid	Textiles	20-40	Vertical Flame Test	
" Pyroban 109	Ammonium Bromide modified organic Phospnorous salts	Liquid	Textiles	20-40	Vertical Flame Test	"
" Pyroban 110	Ammonium phosphate	Liquid	Textiles & Paper	20-40	Vertical Flame Test	

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Following Standards	Cost (¢/lb)
(Sybron, Continued)						
Resin CNX Spec.	Modified thiomides	Liquid	Nylon	N/A	California CS 191-5903, CPAI-84	
Synthron, Inc. **305 Amherst Rd.** **Morganton, NC 28655** **(704)-437-8611**						
Protenyl PN5723S	Phosphorous/ nitrogen compound	Liquid	Cellulosics	25-35	Durable NFPA 701, BS 5852 MVSS 302 Water repellents and other military fabrics, sleepwear	N/A
Protenyl BN 5724P	Bromine/ nitrogen compound	powder	Cellulosics blends synthetics	10-20	MVSS 302 Non corrosive	N/A
Protenyl BN 5724S	Bromine/ nitrogen compound	Liquid	Cellulosics blends synthetics paper	10-20	MVSS 302 Acrylic lattices Non corrosive	N/A
Protenyl BSB 40206	Antimony/ halogenated derivatives compound	Liquid	Cellulosics blends synthetics	30-40	Durable Water repellent Antistatics	N/A
Protenyl NSP 1916S	Organo mineral compound	Liquid	Cellulosics wood cardboard	7-15	MI Water repellent Tarpaulin-tent fabrics	N/A
Protenyl SB 5500S	Antimony compound	Liquid	Cellulosics blends synthetics paper	2-8	Durable MVSS 302 Automotive industry	N/A
Protenyl 460	Nitrogen compound	Liquid	Cellulosic wood paper	10-15	Water repellent and others	N/A
Protenyl 1822S	Bromine compound	Liquid	Polypropylene	10-15	Noncorrosive Acrylic Lattices	N/A
Tanner Chemicals, Inc. **P.O. Box 1967** **Furman Hall Court** **Greenville SC 29602** **(864) 232-3893**						
Tancotard CC	Organic phosphate	Liquid	Cellulosics and blends with polyester	15-20	Standards employing vertical flame test Cal . No C- 13006	N/A
" 407	Antimony organic halogen compounds	Viscous liquid dispersion	Nylon polyester	15-25	Standards employing vertical & honzontal flame test Cal No. C-130.04	N/A
" 408	Antimony organic halogen compounds	Viscous liquid dispersion	Polyester poly- ester/cotton coated with crushed foam	15-25	Standards employing vertical & honzontal flame test Cal No. C-130.05	N/A
" 410C	Blend of organic and inorganic salts	Liquid	Nylon, polyester and blends with cotton or rayon	15-25	Standards employing vertical flame test Cal No. C-130.03	N/A

Company Product Trade Name	Active Chemical or Chemical Nature	Form	Fibers Treatable	Add on (%)	Designed to Meet the Foilowing Standards	Cost (¢/lb)
(Tanner, Continued)						
Tancotard TA-432	Antimony Free, Phosphorus Halogen	Viscous Liquid	polyester and blends	15-25	Standards employing vertical flame test Cal . No C- 130.03	N/A
" DP LV	Organic phosphate cornpounds	Viscous liquid	Polyester	10-15	Standards employing vertical (horizontal flame test. Durable to laundering)	N/A
" TA-4130	Polymer emulsion compounded with antimony and halogenated organics	Viscous liquid	Nylon, poly-propylene. cotton poly-ester	2-4 (oz/yd)	BSI 5852	
Tancoat	Polymer emulsions compounded with antimony and/or halogenated organics	Viscous liquid	Nylon, polyester and blends with cotton and rayon as well as polypropylene and fiberglass	1-3 oz. per sq. yd	Standards employing vertical and horizontal flame test including SS 701. MVSS 302, BSI 5852, 9.3, and FAA test requirements. ASTM E-84	N/A
Yorkshire Pat-Chem. Inc. P.O. Box 1926 Greenville, SC 29602 (803) 233-3941						
Fyran J3	Ammonium	Liquid	Cellulosic	15-35	California Fire Marshall Standards Not Requiring Washing	N/A

Cotton And Flammability—Overview Of New Developments

By P.J. Wakelyn, Ph.D., William Rearick, John Turner, Ph.D., National Cotton Council, Wash., DC

Abstract

Resistance to burning is one of the most useful properties that can be imparted to cotton fibers and textiles containing cotton. Processes presently used to impart flame resistance (FR) characteristics to cotton yarns and fabrics for the various end uses (e.g., protective clothing, children's sleepwear, carpets, upholstery, bedding, etc.) are discussed, as well as research needs.

Introduction

Cotton, like most textile fibers, is combustible. Whenever cotton is in the presence of oxygen and the temperature is high enough to initiate combustion (360-420°C), untreated cotton will either burn (flaming combustion) or smolder (smolder combustion).[1] The degree of flammability depends on the fabric construction. Fabrics have different flammability requirements depending on the particular end use. Practically all of these requirements are met by cotton fabrics without the use of special flame retardant finishes.

Resistance to burning is one of the most useful properties that can be imparted to cotton fibers and textiles. Some end uses for cotton in textile items for apparel, home furnishings, and industrial, can depend on its ability to be treated with chemical agents (flame retardants) that confer flame resistance (FR). End uses requiring flame retardant finishes include protective clothing (e.g., foundry workers apparel and fire fighters uniforms), children's sleepwear, furnishing/upholstery, bedding, carpets, curtain/drapes, and tentages. In the US, the market for chemically modified flame resistant cotton fabrics is about 16 million square yards per year,[2] which is less than 0.2 percent of total cotton consumption in the US. The variable manufacturing cost of a flame retardant treatment is about $1-2 per yard, depending on fabric weight and other factors.[2] This can be a major limitation. The flammability and flame resistance of cotton have been studied extensively and several comprehensive reviews of the subject are available.[3-9]

Government regulations, insurance company requirements, building codes, and voluntary standards dictate where and when flame-resistant textiles must be used. Also in today's litigious environment, textile producers are becoming increasingly concerned with the liability to which they may be exposed if someone accuses their product of causing an injury or fatality. This article provides a brief overview and update of the present state of cotton and flammability.

Regulations Examined

In the United States, federal textile flammability regulations are promulgated and enforced by the US Consumer Product Safety Commission (CPSC). If there is a federal standard, CPSC has preemption over state and city regulations. Presently, federal standards developed pursuant to the Federal Flammable Fabrics Act, cover general wearing apparel, children's sleepwear, carpets, and mattresses (Table IA, IB).

The state of California has developed mandatory standards for upholstered furniture and independent standard setting organizations (e.g., ASTM, NFPA, ISO)[3] and trade and industrial associations (e.g., UFAC, BIFMA[3]) have developed voluntary standards for upholstered furniture and other products. Table IA, IB lists some of these standards that apply to the various textile end uses. These should be consulted for details of the test method. The 1996 Annual Book of ASTM Standards Vol. 07.02 (p. 474) contains a summary of the various test methods.

Worldwide, there are a large number of flammability regulations and these vary from country to country. In the US, regulations as well as building codes covering products such as upholstered furniture, and other internal furnishings can vary from state to state and even city to city. It should be noted that flammability of materials is defined by test methods and the logic behind the test methods is not always obvious. These test methods include open flame tests with different ignition sources, ignition times and vertical or 45° angle placement of the fabric, as well as cigarette and pill ignition tests.

The details of these various tests can determine what fibers or fabrics are

Note—Philip J. Wakelyn, Ph.D., is affiliated with the National Cotton Council, Wash., DC; William Rearick and John Turner, Ph.D., with Cotton, Inc., Raleigh, NC.

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87(2) 13-21 (1998)

vc sa. Boric acid, for example, has been widely used on certain cotton substrates because it is a good cost effective water soluble glowproofing agent but has little ability to prevent afterflaming of fabric. The ammonium salts of phosphoric acid are among the best examples of the relatively few inorganic compounds which a: - able to produce effective resistance tc ooth afterflaming and afterglow.

The temporary or non-durable flame retardant finishes have been used on products that will not be laundered such as draperies and upholstery. Many of the more common water soluble type retardants will hydrolyze or decompose at temperatures in the range 135-149°C. This must be considered in mill processing or ironing/pressing if these materials are applied in commercial laundering. Mixtures of borax and boric acid will lose hydrated water at 127-134°C, and consequently lose effectiveness.[6]

Durable Treatments

Most of the emphasis is currently on flame retardant treatments which are durable to multiple launderings. The regulations specify the details. There have been many techniques for imparting durable flame resistance properties to cellulosic substrates described in the literature.[4,7,8,12] However, there are relatively few that are practiced today, either due to commercial availability of the chemicals, safety concerns, process control issues or other reasons. Durable flame retardants are more complex, more expensive and more difficult to apply than non-durable treatments.[7] The main flame retardant finishes used on cotton are phosphorus-based:[13] the mechanism of phosphorus-based flame retardant finishes on cotton is complex and has been described.[14,15] This article will be limited to systems which are widely available.

"Precondensate" /NH3 Process: The flame-retardant agent which conveys flame resistance exists as a polymer in the fibrils of cotton fibers and is not combined chemically with OH groups in the cotton fiber. This process imparts durable flame resistance to 100% cotton fabrics when applied under proper application procedures. It produces fabrics with a good hand and strength retention. Proper application of precondensates to cotton fabrics requires:

- *Adequate fabric preparation*
- *Proper padding/uniform application*
- *Proper phosphorus add-on relative to fabric properties*
- *Appropriate moisture control prior to ammoniation*
- *Control of the ammoniation step to ensure adequate polymer formation*
- *Effective oxidation and washing of the treated fabric*

A generalized precondensate[4] formulation, applicable to a range of fabric weights and constructions, is a follows

	% By Weight
Precondensate	*20.0 to 50.0*

[4] Precondensate is the designation for a tetrakis(hydroxymethyl)phosphonium salt pre-reacted with urea or another nitrogenous material. The reaction products are complex oligomers; exact compositions are proprietary information of chemical suppliers. The precondensate treatment using ammonia gas to polymerize the procondensate in the fi- er is the largest commercial use of flame re ardants in the US.[13]

[5] The amount of anhydrous sodium acetate is 4% of the amount of precondensate used. Some precondensates are available with the sodium acetate already combined.

ends). Disposal of exhausts into the atmosphere may not be permissible; scrubbing to remove excessive amounts of chemicals may be required .[16]

Reactive Phosphorus Based Flame Retardants: These are compounds (e.g., N-methylol dimethyl phosphonopropionamide (MDPPA)) that react with cellulose, the main constituent of cotton fiber. These compounds can be used for cotton alone and for cotton blends with low synthetic fiber content. The finish promotes char formation. The finish is usually applied to the fabric after the coloring stage. The durability of the finish makes treated fabric acceptable for curtains, upholstery, bed linen and protective clothing. The reactive phosphorus based flame retardants typically are applied by a pad/dry/cure method, in the presence of phosphoric acid catalyst. The finish is sometimes applied with a methyolated melamine resin to increase bonding/fixation of the agent to cellulose, which enhances the flame retardancy.[7] Afterwashing is generally required often with an alkali such as soda ash followed by further rinsing and drying. This helps to reduce fabric strength loss.[7] A reactive phosphorous based process has the advantage of not requiring specialized equipment such as an ammonia cure unit and has less affect on dyes. However, this process can cause more strength loss than the precondensate and there can be a durability problem in some wash treatments if the instructions of the chemical supplier are not followed.[17]

Other

Fiber Blends: A more recent approach to flame-resistant cotton-containing fabrics involves the use of core-spun yarns.[18,19] These are specialized yarns that are made from two components. One component is a central core usually made from a man-made synthetic like polyester or nylon or a non-flammable core like fiberglass. The other component is a cotton cover that is wound around the central core to form the yarn. The core yarn is woven or knitted into an appropriate textile, then treated with a finish to make the cotton cover flame resistant. When the core yarns are spun so as to restrict their synthetic content to 40% or less, the flame-retardant treatment of the cotton component alone will frequently make the array flame resistant. The need for a separate flame-retardant treatment of the polyester or nylon component is no longer required. If fiberglass is the core yarn no flame retardant treatment may be necessary.

Fleece, sherpa and other raised surface garments that contain 5-50% polyester or acrylic generally will pass the general wearing apparel standard (16 CFR 1610) without FR finishes, depending on their construction and weight. Fleece garments of 100% cotton with no FR finish are also marketed. However, the formation of yarns and fabrics is very important for untreated 100% cotton fleece fabrics to pass 16 CFR 1610.

It has been reported[20] that naturally colored brown cotton has increased flame resistant properties over conventional white cotton. This is most likely due to an increased nitrogen content. The nitrogen level may also be beneficially increased by blending with nylon, wool, or applying selective nitrogen containing chemicals.

As discussed, in this section are the most commercially available flame retardant compounds for cotton contain phosphorus and nitrogen. The phosphorus moieties act in the condensed phase as char formers. Nitrogen-containing compounds alone have little flame retardant effect, except when present with phosphorus, where they have a synergistic effect creating enhanced char formation. Recently it has been reported that if intumescent systems, 1. ammonium polyphosphate, melamine, pentaerythritol, and 2. melamine phosphate and dipentaerythritol, are dispersed about flame resistant cotton fibers, their effectiveness is increased.[21] More char is formed and the char is more resistant to oxidation. These systems may be effective for back coating fabrics or for cotton composite barriers.

Product Categories

FR Apparel/Protective Clothing

Cotton is reported as maintaining a 50% market share of the total US industrial flame resistant apparel market.[2] The main competition for cotton is aramid and more exotic fibers. For industrial workwear FR cotton provides equal or better protection at roughly one-third the price of Nomex.[®][2, 22] Flame resistant apparel for protective clothing includes uniforms for the petroleum and petrochemical industries, metal workers, and utility workers, protective apparel (flight uniforms) for space shut-

Due to environmental concerns, the high phosphate detergents that were used in the 1970's are no longer allowed for use in the United States. Investigations currently underway at the CPSC indicate that the old high phosphate detergents appear not to remove the FR-properties of cotton garments and may even help to maintain the FR-properties. Today's consumer uses low or non-phosphate detergents and low water temperatures (below 105°F) which may cause some FR-garments to fail the vertical flame test (required by the children's sleepwear flammability standards) after laundering. However, the use of non-phosphate detergents do not necessarily harm FR durability as long as softened water is used. When non-phosphate detergents are used in hard water, deposits (e.g., calcium stearate and carbonate) can build up on the fabric, which harms FR-performance, particularly with regard to afterflame and afterglow.[7,28] Liquid non-phosphate detergents readily dissolve in water whereas solid non-phosphate detergents in cold hard water can more readily leave deposits, which can harm FR-performance.

Fleece/sherpa (garments with raised fiber surface)

Fleece goods are an area where untreated 100% cotton has generally been excluded because of the requirement of passing 16 CFR 1610 (a 45° angle test). The increase in demand for 100% cotton apparel has spurred interest in 100% cotton fleece goods. There has recently been a very limited number of commercial 100% cotton fleece fabrics in the market which pass 16 CFR 1610. Judging from the FTIR and NIR analysis, these fabrics do not contain flame retardants. It may be that heavier, denser fabrics with denser naps are what is required for fleece to pass this test without flame retardants. Another option, which has been considered for making 100% cotton fleece practical, is surface spraying on the side which is to be napped, either before or after napping, using a reactive phosphorus based flame retardant. It should be technically feasible and will probably only require a very low level of flame retardant, but may require the afterwash and second drying step.

Upholstery

Currently in the US there are no mandatory federal regulations for upholstery fabrics going into residential end uses. However, there are voluntary standards (UFAC) and the state of California has regulations. The CPSC has a rulemaking underway to determine if a standard is necessary to address the risk of small open flame for furniture. CPSC has developed a small open flame test that is being evaluated. It appears that this would be the equivalent of a vertical flame test for upholstery fabrics. If this ultimately became law, it would require flame retardant treatments for most upholstery fabrics.

Residential furniture in California has to meet the requirements of CA TB 117 (open-flame test for resilient filling materials and fabric). This is a component test where the fabric has to meet a test similar to the 45° angle general wearing apparel test and the batting/filling has to meet a 45° angle open flame test if synthetic and a vertical flame test if natural (e.g., cotton) batting. Most cotton upholstery fabrics over 2 oz/yd² do not have to be treated to pass TB 117. Cotton

Table IB:

Upholstered Furniture

- CA TB 116 Requirement, Test Procedures and Apparatus for Testing the Flame Retardance of Upholstered Furniture (cigarette test; mock-up or full chair)
- CA TB 117 Requirements, Test Procedures and Apparatus for Testing the Flame Retardancy of Resilient Filling Materials Used in Upholstered Furniture (open flame test, 45° / and vertical; component test)
- CA TB 133 Flammability Test Procedure for Seating Furniture for Use in High Risk and Public Occupancies
- UFAC (voluntary standards) - 83 UFAC Test Methods - six individual tests: Fabric Classification Test Method; Interior Fabric Test Method; Barrier Test Method; Filling/Padding Component Test Method; Weltcore Test Method; Decking Material Test Method
- NFPA 260A Standard Method of Test and Classification System for Cigarette Ignition Resistance of Components of Upholstered Furniture (Similar to UFAC-83)
- NFPA 260B Standard Method of Test for Determining Resistance of Mock-up Upholstered Furniture Material Assemblies to Ignition by Smoldering Cigarettes

Blankets

- ASTM D4151 Standard test flammability of blankets

Curtains and Drapes (films or other textiles)

- NFPA 701 Standard Methods of Fire Tests for Flame-Resistant Textiles and Films
- ISO 6940: 1984 Textile Fabrics - Burning Behavior - Determination of Ease of Ignition of Vertically Oriented Specimens.
- ISO 6941: 1984 Textile Fabrics - Burning Behavior - Determination of Flame Spread Properties of Vertically Oriented Specimens.

Protective Clothing

- ASTM D 4108 Test Method for Thermal Protective Performance of Materials for Clothing by Open-Flame Method
- NFPA 1971 Protective Clothing for Structural Fire Fighting
- ASTM F 1506 Textile Materials for Wearing Apparel for Use by Electrical Workers Exposed to Momentary Electric Arc and Related Thermal Hazards
- ISO 6942:1993 Clothing for Protection Against Heat and Fire - Evaluation of Thermal Behavior of Materials and Material Assemblies When Exposed to a Source of Radiant Heat.

Cellulose Insulation

- (CPSC) 16 CFR 1209 Interim Safety Standard for Cellulose Insulation (cigarette test for smoldering combustion and test for small open-flame sources such as matches or candles; corrosiveness to copper, aluminum or steel if exposed to water)
- (CPSC) 16 CFR 1404 Cellulose Insulation (potential fire hazard labeling)

can be obtained. It is expected that there will be continued improvement in application systems.[7]

In closing it should be remembered that most all textile products burn and that it is necessary to be careful around ignition sources. Public education is important for preventing textile related fires.

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WOLF CORPORATION
Mattresses, Box Springs & Fiber Products
P.O. Box 11306, 3434 Adams Ctr. Rd.
Fort Wayne, Indiana 46857
219.749.9393
FAX 219.749.5829

CPSA 6 (b)(1) Cleared
No Mfrs/Prvt Lbl Identified
Products Identified
Excepted by
Firms Notified,
Comments Processed.

May 28, 1998

Ron Medford
U.S. Consumer Product Safety Commission
Washington, D.C. 20207

Dear Mr. Medford:

We were recently apprised that during the CPSC hearing on Flame Retardant Chemicals for Upholstered Furniture, boric acid was classified as a toxic chemical. As a member of the International Sleep Products Association, a producer of commercially flame retardant cotton batting using boric acid as a retardant and as a member of the Futon Association International we were dismayed by this claim.

We submit the enclosed study for the record regarding the Public Hearing on Upholstered Furniture and Flame Retardant Chemicals held April 21, 1998.

We sincerely hope this helps set the record straight.

Sincerely,

Tony Wolf
President
Wolf Corporation

AEW/laz

INTERTOX

A Review of General Acute Toxicity Studies of Boron#10 in Cotton-Based Batting Product

Prepared For

Incide Technologies, Inc.
50 North 41st Ave.
Phoenix, AZ 85009

May, 1998

Richard C. Pleus, Ph.D.

Intertox, Inc.
2601 Elliott Avenue
Suite 4315
Seattle, WA 98121

206.443.2115 phone
206.443.2117 facsimile

EXECUTIVE SUMMARY

Intertox, Inc. has extensive experience reviewing the general use and toxicity of boron-based products, and in particular Boron#10™, which is sodium polyborate. A general review of boron-based compounds indicates that these compounds occur naturally in low concentrations in air, water, and soil and are of generally low toxicity. This report documents the general acute toxicity of Boron#10™ added to cotton fiber and used as batting in sleeping mattresses and futons. Boron#10™ cotton fiber batting is used as a flame retardant. We review here six acute animal toxicity studies in which a boron-containing additive (BCA), or the active ingredient, Boron#10™, was tested.[1,2] The chief difference between BCA, as tested, and the mattress or futon product is that cotton fiber in the batting replaces the generic cellulose fiber in insulation. Boron#10™ is added to cotton batting, in a 10 to 14% loading dose. The cotton-based batting is placed inside the mattress or futon and, therefore, only presents a potential exposure to humans in the unlikely event that the mattress or futon is opened or destroyed. The acute toxicity studies reviewed include those examining adverse health effects associated with contact with the product on the skin and eyes and through inhalation and ingestion. These studies appear to have been performed according to acceptable experimental protocols.

Four of the six studies reviewed indicate no observed adverse health effects from exposure of the test animals to the BCA, hence to Boron#10™ added to cotton batting. A fifth study indicated temporary and minimal eye irritation when 10 milligrams of the product was placed under test animals' eyelid, a reaction no more severe than would be expected from an equal amount of untreated cotton fibers, or similarly innocuous particles, placed in the eye. The sixth study, an oral toxicity study, successfully established the benchmark toxicity measure, LD_{50}, for the product, but only by treating animals with pure Boron#10™. The LD_{50} for sodium polyborate was extrapolated to be 3,339 mg/kg. When Boron#10™ is added to cotton batting, the LD_{50} is extrapolated to be 23,850 mg/kg.[3] Boron#10™ alone is similar in toxicity to boric acid or table salt. When Boron#10™ is added to cotton batting, it becomes even less toxic because its concentration is lower and total ingestion of Boron#10™ in cotton batting is limited due to the bulkiness of the product. Further, test animal ingestion of the BCA in the range of this amount was

[1] The materials tested in these animal studies are Zone Defense® and InCide® PC Insulation. Zone Defense® is 100% sodium polyborate, which is also called Boron#10™. InCide® PC Insulation, which we refer to in this document as a boron-containing additive, is shredded newspaper treated with Boron#10™.
[2] The chemical load factor for Boron#10™ in the cotton batting used in the mattresses is 10% to 14% sodium polyborate (Boron#10™) by weight.

regarded by those conducting the study as impractical because of the bulkiness and low density of the product. Based on these reviews, even assuming the unlikely worst-case circumstances of exposure to a damaged or opened mattress or futon so that a consumer is exposed directly to cotton fiber or batting treated with Boron#10™, we do not expect the product to have adverse health impacts beyond those that are mild and temporary.

[3] Since Boron#10™-treated cotton batting contains at most 14% of the active ingredient (sodium polyborate), a comparison between the toxicity of the active ingredient and the material as a whole can be made by dividing the LD_{50} for the sodium polyborate by the fraction of sodium polyborate in the batting (0.14). Hence 3,339 mg/kg ÷ 0.14 = 23,850 mg/kg. Note that we assume that the other ingredients in the batting (i.e., cellulose fibers) are not of toxicological significance if ingested.

TABLE OF CONTENTS

INTRODUCTION

Boron#10™ is a flame retardant added to cotton batting and used in making sleeping mattresses and futons. The chemical load of the compound in the cotton batting is approximately 10% to 14%. The cotton batting treated with Boron#10™ is placed inside the mattress or futon where it does not come into consumer contact.

Many boron compounds exist naturally throughout our environment, and boron is an element commonly ingested on a daily basis in small amounts by humans. Such compounds, commonly found in soil, fruits and vegetables, and water, generally have low toxicity and pose little threat to human health unless great quantities are ingested or absorbed through damaged skin. In the following sections, several toxicity studies of a boron-containing additive (BCA) are reviewed and evaluated.[4]

REVIEW OF ANIMAL TOXICITY STUDIES

Animal toxicity studies are performed to indicate whether a given compound is likely to be toxic to humans. For each study, test animals are exposed to high dosages of the test product and both behavioral and physical responses are studied. The species chosen for each type of study is chosen because of its demonstrated sensitivity to a given type of exposure (e.g., New Zealand White albino rabbits are generally very sensitive to substances applied to the skin) and because of knowledge that the animal's biological means of processing such exposures is most likely similar to that of humans.

Given the difficulty and expense of conducting studies of long-term exposures, short-term, or "acute," toxicity studies are the most commonly performed. The principles described above apply to such studies; dosages are often extreme in order to produce obvious, observable effects. One of the most commonly measured observed effects of such an extreme exposure is death of the test animal. Survival rates in these extreme exposures are used to estimate a toxicity measure known as the "lethal-dose-50," or LD_{50}, defined as the dose of a compound that would be lethal for 50% of a group of test animals. Because

[4] The principal difference between the two products is that the cotton mattress batting formulated with Boron#10™ contains 10 to 14% of the exact boron-based compound by weight; 9 to 11% less than Zone Defense®, the product tested in the animal studies. This means that it would take more of the Boron#10™-treated cotton batting to show the same minimal results discussed in the original studies, however they provide an adequate basis for general acute toxicity evaluation.

individual test animals have differing capacities to survive exposure to a given compound, some being highly sensitive to exposure and some being relatively insensitive, this measure of lethality for half the test group has become a standard measure of acute toxicity. Additionally, acute toxic response to BCA was studied through skin and eye exposures and through ingestion and inhalation because a compound can have toxicity through some routes of exposure and not others.

To simplify application of toxicity values to humans, LD_{50}s are measured in mass of compound per mass of body weight, e.g., milligrams BCA per kilogram body weight of the subject. LD_{50} values have been determined for many chemicals. Therefore, given the results of the studies reviewed here, toxicity comparisons can be made between BCA and many other products and compounds using this value.

Each of the six acute animal studies reviewed here was conducted in 1986 by American Biogenics Corporation in Decatur, Illinois, and appears to have been performed in conformity with the Food and Drug Administration (FDA) and Environmental Protection Agency (EPA) Good Laboratory Practice regulations. These regulations require, among other practices, the humane treatment of animals during testing. Each study was examined for its experimental protocol, in part because the studies are 10-years old. Each study report provides substantial information about the procedures and protocols used, which are deemed to be adequate.

The following subsections provide descriptions of the studies and summarize the studies' findings and our opinion regarding the potential for Boron#10™, as contained in the mattress or futon batting, to cause adverse health effects in humans.

ORAL TOXICITY STUDY

The purposes of an acute oral toxicity test are to 1) estimate acute toxicity, 2) identify organs that are affected by compound exposure and the toxic effects, 3) determine the reversibility of the toxic effects, and 4) provide a dose range for further studies, if necessary.[5] In this test, as in most tests of this type, the test animals were rats.

[5] Klaassen, 1996.

BCA could not be tested directly for acute oral toxicity because the bulkiness and low density of the product made it impractical to feed the test animals enough product to induce toxic effects. Instead, through consultation with the EPA, this test was conducted on the active constituent of BCA, sodium polyborate,[6] thus avoiding the bulky paper-fiber material (deemed non-toxic) found in the insulation.

Using groups of five rats, including both males and females, American Biogenics Corporation tested the following one-time dosages of the sodium polyborate: 2,818, 3,548, 3,758, 3,981, 4,467, and 5,000 milligrams per kilogram (mg/kg) of animal weight. Based on the study calculations, these doses of sodium polyborate would be toxicologically-equivalent to the following doses of BCA: 12,809, 16,127, 17,082, 18,096, 20,305, and 22,727 mg/kg of animal weight. Given the study results and the calculation noted above, the oral LD_{50} of BCA was calculated to be 15,177 mg/kg. Thus, the extrapolated lethal oral dose for an average (70 kg) adult human would be roughly 1.1 kg, or 2.3 lbs. Because cotton batting treated with Boron#10™ has a lower concentration of boron compounds, we expect the LD_{50} to be greater (the batting treated with Boron#10™ would be less toxic with an extrapolated LD_{50} of 23,850 mg/kg).[7]

Postmortem examination of rats treated with fatal doses of sodium polyborate revealed abnormalities including discoloration of various tissues and moderate deformation of kidney and liver tissues. No such symptoms or conditions were noted in rats surviving the test exposure to the product. Additionally, based on the mortalities within the test groups, the range of product amounts administered to the test animals proved to be appropriate for developing an LD_{50}. This indicates no need for additional testing outside of the range of tested exposures.

DERMAL TOXICITY STUDY

The purposes of an acute dermal toxicity test are to 1) determine if exposure to a large dose of a compound can result in absorption through the skin in quantities great enough to result in an acute toxic effect, 2) determine the reversibility of the toxic effects, and 3) provide a dose range for further studies, if

[6] Letter from Ms. Sandra Smith, September 9, 1986.

[7] Since cotton batting treated with Boron#10™ contains at most 14% of the active ingredient (sodium polyborate), a comparison between the toxicity of the active ingredient and the material as a whole can be made by dividing the doses of sodium polyborate by the fraction of sodium polyborate in the batting (0.14). For example, in the case of the LD_{50}: 3,339 mg/kg (for males and female rats combined) ÷ 0.14 = 23,850 mg/kg. Note that we assume that the other ingredients in the product (i.e., cellulose) are not of toxicological significance if ingested.

necessary. For those compounds that cross the skin in sufficient quantities and cause death, a dermal LD_{50} can be calculated.

In this test, as in most tests of this type, test animals were New Zealand White albino rabbits and their exposure to the test product was for 24 hours. BCA toxicity was tested on five male and five female rabbits. Fur from approximately ten percent of the surface of the rabbit was shaven and 2000 milligrams of the test product per kilogram of body weight was applied to the shaven area. Following the exposure period, the site was wiped, and the rabbits were monitored for adverse health effects. No adverse health indications were associated with these exposures. Because there were no adverse health effects or deaths, the authors used the largest dose category for this type of study and concluded "the acute dermal LD_{50} was considered to be greater than 2 grams per kilogram of body weight."[8] Thus, the extrapolated lethal dermal dose for an average adult human would be some level greater than 1/3 lb. Because the batting treated with Boron#10™ has a lower concentration of boron compounds, we expect the LD_{50} to be greater (the product treated with Boron#10™ would be less toxic than the BCA tested).

PRIMARY DERMAL TOXICITY STUDY

The purposes of a primary dermal toxicity test are to 1) determine if exposure to a large dose of a compound can irritate skin, 2) determine the reversibility of the irritation, and 3) provide a dose range for further studies, if necessary. In this test, as in most tests of this type, test animals were New Zealand White albino rabbits and their exposure to the test product was for 4 hours. Fur was shaven from an area of six rabbits' backs and 500 milligrams, the maximum practical amount, of Boron#10™ was applied to each of the shaven areas. In this experiment, rabbits were treated with 100% Boron#10™, not BCA. Substances that can irritate skin cause the following signs: none, reddening, swelling, and, in some cases, the development of lesions. A scale, called the Primary Irritation Scale, ranging from 0 (no effects) to 8 (most severe), is used to measure dermal irritation. In repeated observations during 72 hours after application, BCA caused only minimal irritation of treated skin in three of the six animals tested. Therefore, it was given a ranking of 0.3 on the Primary Irritation Scale and deemed minimally irritating. Because the batting treated with Boron#10™ has a lower concentration of boron compounds, a similar or lower ranking would be expected.

[8] Smith et al., July 28, 1986, Acute Dermal Toxicity...

PRIMARY EYE IRRITATION STUDY

Primary eye irritation studies are conducted to 1) observe the effect that large doses of a compound have on the eyes and body of a rabbit, 2) determine the reversibility of the toxic effects, and 3) provide a dose range for further studies, if necessary. In this test, as in most tests of this type, test animals were New Zealand White albino rabbits. One eye of each of six rabbits was treated with 10 milligrams of BCA and test animals were observed repeatedly during the following 72 hours for adverse effects.

Health effects can range from no effect or reversible adverse effects (e.g., redness of eye structures, swollen iris) to irreversible damage to the eye (e.g., clouding of the cornea, corrosive action to the tissues). The Primary Eye Irritation Scale is a rating system used to measure the degree of severity of a chemical exposure. The grading system is based on the effects of a test compound on three eye structures: 1) the cornea (the transparent structure that covers the iris and pupil), 2) the iris (which surrounds the pupil), and 3) the conjunctivae (the white of the eye). The scale ranges from 0 (no effect for any of the three structures) to 110 (severe effect in all three structures).

One hour after exposing the test animals' eyes to BCA, effects such as redness and discharge were noted. After 24 hours, these symptoms had substantially reduced and by 48 hours had completely reversed. Based on the study, BCA "was considered to be mildly irritating" to the eyes.[9] Because the batting treated with Boron#10™ has a lower concentration of boron compounds, it would also be expected to be no more, and likely less, irritating to the eyes.

DERMAL SENSITIZATION STUDY

The purpose of a dermal sensitization study is to determine the potential of a compound to sensitize skin. Sensitization is also called hypersensitivity or allergy. Sensitization is a complex biochemical phenomenon in which the body requires a previous exposure to elicit a reaction. In this test, as in most tests of this type, the test animal was the guinea pig and multiple treatments of the test product were applied to the shaven skin of guinea pigs over a period of 2 to 4 weeks. The test material was applied again 2 to 3 weeks after the last treatment and the skin was scored for swelling and redness. This last treatment is a low non-irritating dose. The skin is graded on a scale of 0 (no effects) to 4 (severe effects). No test animal was observed to have adverse health response to the initial or the final treatments,

therefore, BCA "was not considered to be a contact dermal sensitizer."[10] Because the batting treated with Boron#10™ contains the same active ingredient as the tested compound but at a lower concentration, it is also unlikely to be a contact dermal sensitizer.

FOUR-HOUR INHALATION TOXICITY STUDY

The purpose of a 4-hour inhalation study is to determine if breathing air with a high concentration of BCA can adversely affect the body or the respiratory system of an animal. In this test, as in most tests of this type, the test animal was the rat. One group of ten rats was continuously exposed for 4 hours to a time-weighted average concentration of 5.8 milligrams per liter (mg/l) dust aerosol of sodium polyborate dispersed in the atmosphere of a special exposure chamber. This was the highest airborne concentration the experimenters could create with the test product and equipment and is more than 350 times the workplace maximum recommended concentration for "inert or nuisance particulates."[11] Such a standard for non-toxic airborne materials is set in part because particles themselves can cause adverse effects (e.g., irritation and coughing).

Health effects of such an exposure can range from no adverse effects to death of the animal. If death occurs, an LC_{50} (lethal concentration in air for 50 percent of a test group) can be calculated. In this study, no animals died and no lesser adverse health effects were noted either during a 14-day observation period or during postmortem examinations. The experimenters concluded that an LC_{50} for sodium polyborate would be greater than an air concentration of 5.8 mg/l.[12] The equivalent concentrations of batting treated with Boron#10™ would be 41.4 mg/l.[13] Based on the signs of exposed animals in this study and all of the experiments as a whole, we would not expect adverse health effects at these high air concentrations of the product.

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[9] Smith et al., July 11, 1986, Primary Eye Irritation...
[10] Smith et al., August 18, 1986, Dermal Sensitization Study...
[11] ACGIH, TLV-TWA for particulates, not otherwise classifiable, 1994-1995.
[12] Newton et al., July 28, 1986, Four Hour Inhalation...
[13] Again, assuming batting treated with Boron#10™ contains at most 14% sodium polyborate, the lower bound on the LC_{50} for the compounds can be found by dividing the lower bound on the LC_{50} for sodium polyborate by 0.14.

SUMMARY

The six animal studies reviewed herein provide fundamental information needed for assessing the inherent acute toxicity of cotton batting treated with Boron#10™. The studies appear to have been performed using appropriate experimental protocols. These studies suggest that the product, which contains the same boron ingredient as the tested product but at a lower concentration:

- would have an extrapolated oral LD_{50} of 23,850 mg/kg;
- would have a dermal LD_{50} of more than 2000 mg/kg;
- would not be a dermal irritant;
- would be minimally irritating to the eyes;
- would not be a contact dermal sensitizer; and
- would have an LC_{50} of greater than 41.4 mg/l.

Four of the studies indicated no treatment-related adverse health effects whatsoever in the test animals. The acute oral toxicity study in rats (using only the active ingredient, sodium polyborate) indicated a steep dose-response curve for large doses between 2,818 and 3,981 mg/kg, indicating a closely defined range of toxicity for the population. This range of toxicity in rats indicates that the typical adult human lethal dose of cotton batting treated with Boron#10™ would be greater than 3 lbs. Assuming that the cotton batting were exposed due to a damaged mattress or futon, and was ingested by an average (15 kg) child, the lethal dose would be about 12 oz. Both of these amounts are quite large and would not be expected to occur from an incidental ingestion. Similarly, most domestic pets such as cats and dogs, would need to ingest impracticably large volumes of the treated cotton batting to reach the average lethal dose for their body weights. The primary eye irritation study indicated short-term, minimal irritation as a result of introduction of the product into the test animals' eyes. This irritation is not surprising in light of the fact that the material is a solid and the particle masses themselves would cause some irritation, regardless of their chemical composition. However, recovery was complete within 48 hours of exposure, indicating that even minor adverse ocular effects were transitory.

CONCLUSION

Cotton batting treated with Boron#10™, with an extrapolated benchmark LD_{50} in excess of several grams per kilogram of body weight, can be classified as "relatively harmless."[14] Table salt, with an oral LD_{50} of about 4000 mg/kg,[15] is several times more acutely toxic.[16] Compared to other related household products and materials, the treated cotton batting is generally less toxic. For example, the LD_{50} for aspirin is 1500 mg/kg in male rats,[17] requiring substantially less to be ingested to produce a toxic effect than would be the case for the batting material. The results of the reviewed studies indicate that the effects of acute exposures to this product are minor and temporary unless large doses are taken orally. Furthermore, ingestion of large doses, by weight, of this product is impractical due to the low density of the product. Lastly, consumer exposure to this product is greatly diminished because cotton batting treated with 10 to 14% Boron#10™ is placed into the mattress or futon. Only by destroying or opening the mattress or futon can an individual have possible exposure.

Assuming that an individual came into contact with Boron#10™-treated cotton batting, minor and temporary health impacts of exposure to the product noted in the studies are consistent with exposure to non-toxic particulate matter, which can cause irritation when introduced under the eyelid and into the respiratory system. Beyond these effects, we expect no adverse health impacts to result from acute exposure under foreseeable product application.

[14] Klaassen, 1996.
[15] Klaassen, 1996.
[16] Klaassen, 1996.
[17] The Merck Index, 1996.

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AKZO NOBEL

SHERA
Safety, Health, Environmental,
and Regulatory Affairs

June 2, 1998

Mr. Dale Ray
Mr. Michael Babich
Flame Retardant Chemicals
Office of the Secretary
United States Consumer Products Safety Commission
4330 East West Highway
Room 502
Bethesda, MD 20814

Re: Tri(1,3 dichloropropyl-2) phosphate

Dear Sirs:

At the recent CPSC hearing concerning the use of flame retardant chemicals in upholstered furniture, the committee requested further information related to the results of the two year bioassay that was performed on tri (1,3 dichloropropyl-2) phosphate. Following is a detailed discussion of that study which was conducted for Stauffer Chemicals, currently Akzo Nobel Chemicals Inc., by Bio/dynamics.

A Chronic Toxicity/Carcinogenicity Study was conducted for Stauffer by Bio/dynamics, tri(1,3 dichloropropyl-2) phosphate was administered in the diet, at three dose levels, to male and female rats for two years. A control group received identical rodent diet with no test material. Parameters evaluated during the study include, body weight gain, food consumption, gross necropsy observations, hematology, clinical chemistry, urinalysis, survival, organ weight and tissue examination. Findings from the treated rats were compared to the data obtained from the non-treated control animals.

Ten animals from each group were sacrificed after 12 months. The remaining animals (50 per sex per dose group) were sacrificed at the end of the 24th month.

During the second year of the study, the mean body weights for the high dose animals were significantly lower than for the control animals, and the mean absolute liver, kidney and thyroid weights were significantly higher in the high dose group, confirming that the high dose administered represented the Maximum Tolerated Dose.

Microscopic examination of the tissues from the treated and control rats revealed statistically significant increases in the incidence of liver tumors in the high dose male and females, renal cortical tumors in the mid and high dose males and females, interstitial cell testicular tumors in mid and high dose males, and adrenal cortical adenomas in the high dose females.

AKZO Nobel Chemicals Inc.
5 Livingstone Avenue
Dobbs Ferry,
New York 10522-3407
Tel. (914) 674 5000
Fax (914) 693 0836

Tumor incidences for kidney, liver, testes and adrenal gland are summarized in the following table.

Organ and Tumor Type	Sex	0	5	20	80 mg/kg
KIDNEY					
Renal Cortical Tumor	M	1/60	3/60	9/60*	32/59*
	F	0/60	1/60	8/56*	29/60*
TESTES					
Interstitial Cell Tumor	M	7/58	8/60	23/60*	36/56*
LIVER					
Adenoma	M	2/60	7/60	1/60	16/60*
	F	1/60	1/60	4/55	9/60*
Carcinoma	M	1/60	2/60	3/60	7/60
	F	0/60	2/60	2/55	4/60
ADRENAL					
Cortical Adenoma	M	5/59	3/14	5/16	4/57
	F	13/59	5/27	2/33	20/59*

* = Statistically significant at $p<0.05$

The biological significance of each tumor type needs discussion. Interstitial cell tumors of the testes are commonly found in older male rats, as seen in the control group. The significant increase in these tumors in the mid and high dose animals appears to be an exacerbation of a spontaneously occurring tumor. These tumors do not metastasize, but remain local, and apparently do not affect an animal's life span. The liver changes were primarily increased numbers of benign tumors of the type commonly found in Sprague-Dawley CD rats. The incidence of this tumor type has been shown to increase after treatment with a variety of different chemicals. Therefore, this is not an uncommon tumor type worthy of significant concern.

The occurrence of renal cortical tumors are of concern because this tumor rarely develops spontaneously in Sprague-Dawley rats. Therefore, the presence of renal cortical tumors is biologically significant. In response to a request from Stauffer to clarify whether the "renal cortical tumors" were benign or malignant neoplasm's, Bio/dynamics responded that they were unable to do so. Since Bio/dynamics described an "absence of metastasis", a lack of invasion of the surrounding tissues, and a lack of distinctive histochemical or ultrastructural features which would allow the classification of renal carcinoma, it was concluded that the renal tumors had the growth and structural characteristics of benign renal adenomas.

Tri(1,3 dichloropropyl-2) phosphate causes benign tumor growth in rats exposed daily for two years, to dietary levels of 20 and 80 mg/kg. The no-observable-effect-level (NOEL) in this study is 5 mg/kg.

I hope that this information is useful to the committee. If you have any questions, please don't hesitate to contact me.

Sincerely,

Richard T. Henrich
Principal Toxicologist
Tel. 914-674-5531
FAX 914-693-0836

cc: Mr. Russell C. Kidder
Fire Retardant Chemicals Association
851 New Holland Ave
Box 3535
Lancaster, PA 17604

Cal 65 ok 6/4/98

AKZO NOBEL

SHERA
Safety, Health, Environmental, and Regulatory Affairs

June 2, 1998

Mr. Dale Ray
Mr. Michael Babich
Flame Retardant Chemicals
Office of the Secretary
United States Consumer Products Safety Commission
4330 East West Highway
Room 502
Bethesda, MD 20814

Re: CPSC Hearing on Flame Retardant Chemicals in Upholstered Furniture

Dear Sirs:

Akzo Nobel Chemicals Inc. (ANCI) is submitting (attached documents) to the CPSC, summaries of all the toxicology data that we have in our files on the flame retardant chemicals ANCI would potentially supply for use in upholstery fabrics. ANCI hopes that this information will be helpful to the CPSC relative to your discussions concerning the safety of flame retardant chemicals for use in upholstered furniture.

Sincerely,

Richard T. Henrich
Principal Toxicologist
Tel. 914-674-5531
Fax 914-693-0836

cc: Mr. Russell C. Kidder
Fire Retardant Chemicals Association
851 New Holland Ave
Box 3535
Lancaster, PA 17604

Flamretardchem.rth.

Akzo Nobel Chemicals Inc.
5 Livingstone Avenue
Dobbs Ferry,
New York 10522-3407
Tel. (914) 674 5000
Fax (914) 693 0836

ORGANOPHOSPHATE FLAME RETARDANTS

The following attachments contain summaries of all of the toxicology data that Akzo Nobel Chemicals Inc. (ANCI) has on organophosphate flame retardants that ANCI supplies for use in upholstery fabrics. These products can have a variety of trade names, depending on the company that supplies them, so we have listed them by chemical name for consistency.

In general, these chemicals can be used to flame retard fabrics as a backcoating. In this use, these chemicals are applied, encapsulated in a polymer, to the back of the fabric. Potential consumer exposure scenarios include ingestion, inhalation or dermal exposure from sitting, lying or chewing on the furniture. The likelihood of exposure to these chemicals under these potential scenarios is negligible. This is because the chemicals are encapsulated in a polymer on the back of the fabric which effectively limits their potential migration and/or release. Wetting the fabric with water, beverages/liquid foods or urine is unlikely to effect the chemicals availability. These chemicals have a very low aqueous solubility which will not be effected by a change in pH or heat due to the chemicals structure. These chemicals are also very unlikely to be extracted by cleaning solvents used by the consumer on furniture due to its low solubility.

Toxicology Summary

Tri (beta chloroethyl) phosphate

The oral LD50 values for this product in rats was 430-1410 mg/kg. The dermal LD50 in rabbits was greater than 4640 mg/kg. Irritation studies with rabbits showed this product to be a mild eye irritant but not a skin irritant. In 16-week oral studies, the NOELs in rats and mice were 22 and 88 mg/kg, respectively. Mortality, neuronal necrosis of the hippocampus, cholinesterase inhibition and organ weight changes (liver, kidney) occurred in rats at doses of 175 mg/kg and above; organ weight changes (liver, kidney) were seen in mice at doses of 175 mg/kg and above and kidney toxicity (cytomegaly, karyomegaly) occurred at 700 mg/kg. The histopathological damage of the hippocampus was also seen in rats following a single oral dose of 275 mg/kg. It was not neurotoxic to hens following 5 daily doses of 420 mg/kg. This product was not teratogenic to rats when administered at a dose of 200 mg/kg on days 7-15 of gestation. It was not carcinogenic to mice following dermal administration of a 5 or 50% concentration twice a week for 79 weeks. In 2-year oral carcinogenicity studies, this product caused an increase in benign kidney tumors in rats at doses of 44 and 88 mg/kg but not in mice at doses up to 350 mg/kg. Although this product was not mutagenic in the Ames test or genotoxic in an in vivo chromosome aberration assay, it did cause an increase in sister chromatid exchange in vitro and results several transformation assays and micronucleus tests were equivocal. This product was not readily biodegradable.

Tri (beta chloroethyl) phosphate

Test	Results
Oral LD50 (Rat)	430-1410 mg/kg
Acute Oral (rat)	Histopatholgical Damage Of Hippocampus (275 mg/kg)
Skin Irritation (Rabbit)	No Irritation
Eye Irritation (Rabbit)	Slight Irritation
90-Day Oral (Rat)	No Adverse Effects (400-8000 ppm)
16-Week Oral (Rat)	NOEL - 22 mg/kg; 44-350 mg/kg - Increase In Relative Liver And Kidney Weight; 350 mg/kg - Mortality, Neuronal Necrosis Of Hippocampus, Thalamus, Cholinesterase Inhibition; 175 mg/kg - Mortality, Neuronal Necrosis Of Hippocampus, Cholinesterase Inhibition
16-Week Oral (Mouse)	NOEL - 88 mg/kg; 175-700 mg/kg - Increase In Relative Liver Weight, Decrease In Relative Kidney Weight; 700 mg/kg - Kidney Toxicity (Cytomegaly, Karyomegaly)
Neurotoxicity (Chicken)	No Neurotoxicity (420 mg/kg)
Teratogenicity (Rat)	No Fetotoxicity Or Teratogenicity (200 mg/kg)
Carcinogenicity (Rat/2-Year Oral)	44, 88 mg/kg - Increase In Benign Kidney Tumors
Carcinogenicity (Mouse/2-Year Oral)	175, 350 mg/kg - No Significant Increase Tumors
Carcinogenicity (Mouse/79-Week Dermal)	Not Carcinogenic At 5 Or 50% Concentration
Mutagenicity (Ames test)	Not Mutagenic
Mutagenicity (Unscheduled DNA Synthesis)	No Consistent Detectable Level Of UDS. Low Levels Of UDS Seen But No Dose-Response. Considered To Have Weak UDS Activity.
Mutagenicity (Transformation)	Significant Number Of Transformed Foci At All Non-Toxic Dose Levels
Mutagenicity (Transformation)	No Significant Increase in Transformation
Mutagenicity (Transformation)	Increase in Transformation
Genotoxicity (In Vivo Chrom. Ab.)	No Increase In Chrom. Ab. At Any Dose
Genotoxicity (Micronucleus/Mouse)	Micronuceli In Bone Marrow Erythrocytes Not Induced
Genotoxicity (Micronucleus/Mouse)	Micronuceli Not Induced

Genotoxicity (Micronucleus/Hamster)	Increase In Miconuceli
Genotoxicity (Sister Chromatid Exchange)	Increase In SCE
Biodegradation (Modified Sturm)	Not Biodegradable

Toxicology Summary

Tri (1,3-dichloropropyl-2) phosphate

The oral LD50 values for this product in rats and rabbits were 3160 and 6800 mg/kg, respectively. The dermal LD50 in rabbits was greater than 4640 mg/kg. Irritation studies with rabbits showed this product to be either nonirritating or mildly irritating to the skin and eyes. It was not neurotoxic to hens at doses up to 420 mg/kg for 5 days but it did cause a decrease in vitro in plasma and red blood cell cholinesterase. This product did not effect fertility in rabbits at doses up to 200 mg/kg for 12 weeks and was not teratogenic when administered to pregnant rats at doses up to 400 mg/kg/day on days 6-15 of gestation. In a carcinogenicity study in rats, the NOEL was 5 mg/kg. Benign tumor growth was seen at 20 and 80 mg/kg. This product is readily absorbed from the skin and gastrointestinal tract and rapidly metabolized. It is not mutagenic or clastogenic in vitro or in vivo. The 96 hour EC50 in algae is 12-39 mg/L. This product was not readily biodegradable.

Tri (1,3-dichloropropyl-2) phosphate

Test	Results
Oral LD50 (rat)	3160 mg/kg
Oral LD50 (rabbit)	6800 mg/kg
Dermal LD50 (rabbit)	>4640 mg/kg
Dermal LD50 (rabbit)	>15 mL/kg
Inhalation LC50 (rat)	>9.8 mg/L
Skin Irritation (rabbit)	No Irritation (4 hr. exp.)
Skin Irritation (rabbit)	Mild (24 hr. exp.)
Eye Irritation (rabbit)	Mild
Eye Irritation (rabbit)	None
Neurotoxicity (chicken)	No Toxicity (420 mg/kg for 5 days)
Neurotoxicity (chicken)	No Toxicity (240-420 mg/kg for 5 days)
Neurotoxicity (chicken)	No Toxicity (4-100 mg/kg for 90 days)
Neurotoxicity (in vitro)	7% Inhibition Of NTE
Neurotoxicity (in vitro)	27% Decrease In Plasma Cholinesterase; 9.1% Decrease In RBC Cholinesterase (2000 mg/kg dose)
Fertility (rabbit)	No Effects On Fertility Or Sperm Quality And Quantity (2-200 mg/kg for 12 weeks)
Teratogenicity (rat)	Not Teratogenic (25-400 mg/kg day 6-15)
Carcinogenicity (rat)	Benign Tumor Growth In Rats Exposed Daily For Two Years To Dietary Levels Of 20 And 80 mg/kg. The NOEL Was 5 mg/kg.
Metabolism (rat)	Readily Absorbed From Skin And GI Tract; Rapidly Metabolized (>80% excreted within 24 hrs.); bis (1,3-dichloro-2-propyl) phosphate is major metabolite
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Ames)	Mutagenic At Doses That Reduced Cell Survival
Mutagenicity (Forward Mutation)	Not Mutagenic (mouse lymphoma cells)
Mutagenicity (DNA Repair)	DNA Repair Not Induced
Mutagenicity (Sex-Linked Recessive)	Mutations Not Induced in Drosophilia
Mutagenicity (Transformation)	No Significant Increase in Transformation
Mutagenicity (In Vivo/In Vitro Urine Assay)	Not Mutagenic

Genotoxicity (In Vitro SCE)	No SCE
Genotoxicity (In Vitro Chrom. Ab.)	Increase In Chromosome Ab. In The Presence Of Met. Activation
Genotoxicity (In Vivo Chrom. Ab.)	No Increase In Chromosome Aberrations
Aquatic Tox (Algae EC50)	96 Hr. EC50 For Growth 12 mg/L 96 Hr. EC50 For Growth Rate 39 mg/L
Biodegradation (Modified Sturm)	Not Biodegradable
Respiration Inhibition (Activated Sludge)	Not Inhibitory

Toxicology Summary

Tri (B-chloroisopropyl) phosphate

The oral LD50 values for this product in rats was 2000-4200 mg/kg. The dermal LD50 in rabbits was greater than 5000 mg/kg. Irritation studies with rabbits showed this product to be mildly to non-irritating to the skin and not an eye irritant. In a 3-month diet study in rats, mild histopathological changes were seen in the thyroid (800-20000 ppm), liver andd kidney (7500-20000 ppm), and bone marrow (20000 ppm). This product was not neurotoxic to hens at a dose of 10 mL/kg. It is rapidly metabolized following intravenous and oral administration and its major metabolite is O,O-[Bis (1-chloro-2-propyl)]-O-(2-propionic acid phosphate). This product was not mutagenic in vitro and not clastogenic in vivo. The EC50 in algae was 47-73 mg/L.

Tri (B-chloroisopropyl) phosphate

Test	Results
Oral LD50 (rat)	2000-4200 mg/kg (male); 1260-2800 mg/kg (female)
Dermal LD50 (rabbit)	>5000 mg/kg
Skin Irritation (rabbit)	Mildly Irritating (24 hour exposure)
Skin Irritation (rabbit)	Not Irritating (4 hour exposure)
Eye Irritation (rabbit)	Not Irritating
Inhalation LC50 (rat)	>4.6 mg/L (4 hour exposure)
3-Month Oral (rat)	20,000 ppm - Mild Histopathological Changes In Liver, Kidney, Bone Marrow, Thyroid; 7500 ppm - Mild Histo-pathological Changes In Liver, Kidney; 800, 2500 ppm - Mild Histopathological Changes In Thyroid
Metabolism/Pharmacokinetics (rat)	Rapidly Metabolized Following Oral, Intravenous Administration; Major Metabolite - O,O-[Bis (1-chloro-2-propyl)]-O-(2-propionic acid phosphate)
Neurotoxicity (chicken)	No Delayed Neurotoxicity (10 mL/kg)
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Forward Mutation)	Not Mutagenic
Mutagenicity (Transformation)	No Significant Increase In Number Of Transformed Foci
Mutagenicity (Unscheduled DNA Synthesis)	Weakly Induced UDS
Genotoxicity (In Vitro Chrom. Ab.)	No Increase In Chrom. Ab. (mouse lymphoma cells)
Genotoxicity (In Vivo Chrom. Ab.)	No Increase In Chrom. Ab. (rat bone marrow)
Aquatic Toxicity (algae)	EC50 - 47-73 mg/L

Toxicology Summary

Diethyl bis (hydroxyethyl) aminomethyl phosphonate

The oral and dermal LD50 values for this product in rats and rabbits were greater than 5000 and 2000 mg/kg, respectively. Irritation studies with rabbits showed this product to be a mild eye irritant but not a skin irritant. The NOEL in a 13-week oral study in rats was 20 mg/kg/day. This product was not neurotoxic to hens at doses up to 10 g/kg. It was not mutagenic in the Ames test and did not transform BALB 3T3 cells but was mutagenic and clastogenic in mouse lymphoma cells. This product is practically nontoxic to rainbow trout and is not treadily biodegradable.

Diethyl bis (hydroxyethyl) aminomethyl phosphonate

Test	Results
Oral LD50 (rat)	>5000 mg/kg
Oral LD50 (rat)	>4640 mg/kg (modified)
Dermal LD50 (rabbit)	>2000 mg/kg
Dermal LD50 (rabbit)	>4640 mg/kg (modified)
Skin Irritation (rabbit)	Not Irritating (4 hr. exp.)
Eye Irritation (rabbit)	Moderate Irritation
13-Week Oral (rat)	NOEL - 20 mg/kg/day; 100, 200 mg/kg/day - liver changes (weight, microscopic) considered minimal, reversible, adaptive; 200 mg/kg/day - kidney changes (weight) considered adaptive
Neurotoxicity (chicken)	No Toxicity (2 doses of 1 or 10 g/kg)
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Forward Mutation)	Mutagenic (mouse lymphoma cells)
Genotoxicity (In Vitro Chrom. Ab.)	Clastogenic (mouse lymphoma cells)
Mutagenicity (Transformation)	No Significant Increase In Number Of Transformed Foci
Aquatic Tox (Rainbow Trout)	96 Hr. LC50 > 10,000 mg/L
Biodegradation (Modified Sturm)	Not Readily Biodegradable (11% at Day 28)
Respiration Inhibition (Activated Sludge)	Not Inhibitory

Toxicology Summary

Ethanol, 2-chloro-, phosphate (3:1), polymer with oxirane and phosphorus pentoxide

The oral LD50 values for this product in rats was 1664 mg/kg. The dermal LD50 in rabbits was greater than 2000 mg/kg. Irritation studies with rabbits showed this product to be a mild skin and eye irritant. The 4-hour inhalation LC50 was greater than 2.2 mg/L. It was not neurotoxic to hens following 5 consecutive daily doses of 420 mg/kg. This product was not teratogenic to rats. It was not mutagenic in vitro.

Ethanol, 2-chloro-, phosphate (3:1), polymer with oxirane and phosphorus pentoxide

Test	Results
Oral LD50 (rat)	1664 mg/kg
Dermal LD50 (rabbit)	>2000 mg/kg
Skin Irritation (rabbit)	Slightly Irritating (4 hr. exp.)
Eye Irritation (rabbit)	Slightly Irritating
Inhalation LC50 (rat)	>2.2 mg/L (4 hr. exp.)
Neurotoxicity (chicken)	No Toxicity (420 mg/kg for 5 days)
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Forward Mutation)	Not Mutagenic (mouse lymphoma cells)
Mutagenicity (Transformation)	No Significant Increase In Number Of Transformed Foci

Toxicology Summary

Butylated Triphenyl Phosphate

The oral and dermal LD50 values for this product in rats and rabbits were greater than 4000 and 2000 mg/kg, respectively. Irritation studies with rabbits showed this product to be a mild skin and eye irritant. The NOEL in a 3-month oral study in rats was 400 ppm. Cholinesterase inhibition in the absence of signs of neurotoxicity was reported at doses greater than 11 g/kg. This product was not teratogenic following administration to pregnant rats at doses up to 1000 mg/kg. This product was not mutagenic or clastogenic in vitro.

Butylated Triphenyl Phosphate

Test	Results
Oral LD50 (rat)	>4000 mg/kg (male, female)
Dermal LD50 (rabbit)	>2000 mg/kg
Skin Irritation (rabbit)	Mildly Irritating (24 hour exposure)
Eye Irritation (rabbit)	Mildly Irritating
3-Month Oral (rat)	NOEL 400 ppm; 1600 ppm - Significant Increase In Liver, Adrenal Weight (no microscopic changes)
Neurotoxicity (chicken)	Significant Decrease In Plasma Cholinesterase; No Signs Of Cholinergic Stimulation; No Change In Neurotoxic Esterase (11.83 g/kg)
Neurotoxicity (chicken)	No Delayed Neurotoxicity (11.7 g/kg)
Teratogenicity (rat)	Not Teratogenic (100, 400, 1000 mg/kg)
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Forward Mutation)	Not Mutagenic (mouse lymphoma cells)
Mutagenicity (Transformation)	No Significant Increase In Number Of Transformed Foci
Genotoxicity (In Vitro Chrom. Ab.)	No Increase In Chrom. Ab. (mouse lymphoma cells)
Genotoxicity (Sister Chromatid Exchange)	No Increase In SCE (mouse lymphoma cells)

Toxicology Summary

Propylated Triphenyl Phosphate

The oral and dermal LD50 values for this product in rats and rabbits were greater than 5000 and 2000 mg/kg, respectively. The 4-hour inhalation LC50 in rats was greater than 5.2 mg/L. Irritation studies with rabbits showed this product to be a mild skin irritant but not an eye irritant. It was not neurotoxic to hens at doses greater than 11 g//kg. This product was not mutagenic in the Ames test but was weakly mutagenic in mouse lymphoma cells and transformed BALB 3T3 cells. It was not clastogenic in mouse lymphoma cells.

Propylated Triphenyl Phosphate

Test	Results
Oral LD50 (rat)	>5000 mg/kg
Dermal LD50 (rabbit)	>2000 mg/kg
Skin Irritation (rabbit)	Mildly Irritating (24 hour exposure)
Eye Irritation (rabbit)	Not Irritating
Inhalation LC50 (rat)	>5.2 mg/L (4 hour exposure)
Neurotoxicity (chicken)	Significant Decrease In NTE; No Signs Of Neurotoxicity (2000 mg/kg)
Neurotoxicity (chicken)	No Delayed Neurotoxicity (11.72 g/kg)
Mutagenicity (Ames)	Not Mutagenic
Mutagenicity (Forward Mutation)	Weakly Mutagenic With Activation; Not Mutagenic Without Activation (mouse lymphoma cells)
Mutagenicity (Transformation)	Significant Increase In Number Of Transformed Foci
Genotoxicity (In Vitro Chrom. Ab.)	No Increase In Chrom. Ab. (mouse lymphoma cells)
Genotoxicity (Sister Chromatid Exchange)	No Increase In SCE (mouse lymphoma cells)

Toxicology Summary

Diammonium/Monoammonium Phosphate

The oral LD50 for this product in rats was 3160-4500 mg/kg. The dermal LD50 in rabbits was greater then 4640 mg/kg. Irritation studies with rabbits showed this product to be a mild skin irritant but not an eye irritant.

Diammonium/Monoammonium Phosphate

Test	Results
Oral LD50 (rat)	3160 mg/kg (female); 4500 mg/kg (male)
Dermal LD50 (rabbit)	>4640 mg/kg
Skin Irritation (rabbit)	Mildly Irritating
Eye Irritation (rabbit)	Not Irritating

Phosphonic acid, methyl- dimethyl ester polymer with oxirane and phosphorus oxide

The oral and dermal LD50 values for this product in rats and rabbits were greater than 5000 and 2000 mg/kg, respectively. The 4-hour inhalation LC50 in rats was greater than 2.1 mg/L. Irritation studies with rabbits showed this product to be a mild skin irritant but not an eye irritant. It was weakly mutagenic and clastogenic in vitro.

Phosphonic acid, methyl- dimethyl ester polymer with oxirane and phosphorus oxide

Test	Results
Oral LD50 (rat)	>5000 mg/kg
Dermal LD50 (rabbit)	>2000 mg/kg
Inhalation LC50 (rat)	>2.1 mg/L (4-hour exposure)
Skin Irritation (rabbit)	Mild (24 hr. exp.)
Eye Irritation (rabbit)	None
Mutagenicity (Forward Mutation)	Weakly Positive (mouse lymphoma cells)
Mutagenicity (Transformation)	Significant Increase In Number Of Transformed Foci
Genotoxicity (In Vitro SCE)	Weakly Positive (mouse lymphoma cells)
Genotoxicity (In Vitro Chrom. Ab.)	Weakly Positive (mouse lymphoma cells)

Toxicology Summary

Tricresyl phosphate

The oral and dermal LD50 values for this product in rats and rabbits were greater than 4640 mg/kg. Irritation studies with rabbits showed that this product was not a skin or eye irritant. In 13 week diet and gavage studies in rats, histopathological changes of the testis (diet-6600, 13000 ppm; gavage-400, 800 mg/kg), ovaries (diet-900-13000 ppm; gavage-50-800 mg/kg), kidneys (diet-6600, 13000 ppm) and adrenal cortex (diet-900-13000 ppm; gavage 50-800 mg/kg) were reported. In a 13 week diet and gavage studies in mice, histopathological changes in the peripheral nerves (diet-2100-4200 ppm; gavage-50-800 mg/kg), adrenal cortex (diet-250-4200 ppm; gavage-50-800 mg/kg), ovaries (diet-2100, 4200 ppm; gavage 50-800 mg/kg) and gall bladder (diet-1000-4200 ppm) were seen. This product was not mutagenic in vitro. In 2-year diet studies, it was not carcinogenic to rats (75-300 ppm) or mice (60-250 ppm). Decreases in fertility, litter size and sperm motility were seen in reproductive studies in rats (100-400 mg/kg) and mice (0.05-2%).

Tricresyl phosphate

Test	Results
Oral LD50 (rat)	>4640 mg/kg
Dermal LD50 (rabbit)	>4640 mg/kg
Skin Irritation (rabbit)	Not Irritating (4 hour exposure)
Eye Irritation (rabbit)	Not Irritating
Neurotoxicity (chicken)	100% Inhibition Of Neurotoxic Esterase; No Signs Of Neurotoxicity (2000 mg/kg x 5)
Neurotoxicity (chicken)	Significant Inhibition Of Neurotoxic Esterase (60 mg/kg x 5 days/week for 6 weeks); No Clinical Signs Or Histopathological Evidence Of Neurotoxicity
13-Week Oral (mouse)	Diet Study - Histopathological Changes: 2100-4200 ppm - Peripheral Nerves (demyelination, axonal degeneration), Adrenal Cortex (cytoplasmic vacuolization) And Ovaries;1000-4200 ppm - Gall Bladder; 250-1000 ppm - Adrenal Cortex Gavage Study - Histopathological Changes: 50-800 mg/kg - Peripheral Nerves (demyelination, axonal degeneration), Adrenal Cortex (cytoplasmic vacuolization), And Ovaries
13-Week Oral (rat)	Diet Study - Histopathological Changes: 6600, 13000 ppm - Testis, Ovaries; Kidneys, Adrenal Cortex (cytoplasmic vacuolization); 900-3300 ppm - Ovaries And Adrenal Cortex Gavage Study - Histopathological Changes: 400, 800 mg/kg - Ovaries, Testis And Adrenal Cortex; 50-200 mg/kg - Ovaries And Adrenal Cortex
Mutagenicity (Ames)	Not Mutagenic
Genotoxicity (In Vitro Chrom. Ab.)	Not Clastogenic (mouse lymphoma cells)
Genotoxicity (In Vitro SCE)	No Increase In Sister Chromatid Exchange
Carcinogenicity (mouse/oral)	Not Carcinogenic (60-250 ppm)
Carcinogenicity (rat/oral)	Not Carcinogenic (75-300 ppm)

Reproductive Toxicity (mouse/2-generation oral)	Decrease In Fertility, Litter Size And Sperm Motility In Both Generations (0.05-2% concentration)
Reproductive Toxicity (rat/oral)	Decrease In Fertility, Litter Size and Sperm Motility (100-400 mg/kg)