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## Commercially Available Halogen free Alternatives to Halogen-Containing Flame Retardant Systems in Polymers Status January 2010

### 1 Overview of flame retardants by polymer

This table gives an overview of commercially available non halogenated flame retardants. Often, combinations of the given substances are used. The individual formulation is up to the polymer compounder and often regarded as company know how. The abbreviations are listed at the end of the document. Please send any comments or information on new FRs and applications to jtroitzsch@troitzsch.com.

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
<b>Thermoplastics</b>				
PE	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO TBNPP / ATO CP / ATO	Intum P-based P-red / halfreeFR
	Building Films DE	UL94V2		P-red
		DIN4102B2	TBNPP / ATO DBDE / ATO	NorHals
	Wire & Cable	IEC 60332-3		ATH
PE / EVA	Wire & Cable	IEC 60332-3		ATH / Nano
PP	E&E	UL94V0	Deca / ATO	Intum P-based
			DBDE / ATO	
			EBTPI / ATO	MOH
			TDPE / ATO	

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
		UL94V2	BEO / ATO CP / ATO HBCD / ATO TBNPP	
	Building Pipes DE	DIN4102B1	TDPE	
	Building Films DE	DIN4102B2	BEO / ATO	
	Building FR	NFP92507 M2	TBNPP / ATO	Intum Pbased
	Wire & Cable	IEC 60332-3		ATH or MOH
HIPS	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO BEO / ATO TBBPA / ATO CP / ATO	
		UL94V2	HBCD	RDP TPP BDP PolyDP
EPS	Building foam DE	DIN4102B1	HBCD	
ABS	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO BEO / ATO TBBPA / ATO	
PA	E&E	UL94V0	Dech / ATO PBBPA / ATO BrPS / ATO BEO / ATO	P-red MC MPP MePh MOH
PET	E&E	UL94V0	Deca / ATO DBDE / ATO BEO / ATO EBTPI / ATO TBBPA-CO / ATO	P-red MePh
	Fibres	BS5852Crib5		Dopo PHPhos Oxa

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
PBT	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO BEO / ATO TBBPA-CO / ATO	MePh
PC	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI TBBPA-CO / ATO TBBPA reactive	SulSalts TPP RDP BDP
PC / ABS	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO TBBPA-CO / ATO BEO / ATO	RDP BDP TPP
PPE / HIPS	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO TBBPA-CO / ATO	RDP BDP TPP
<b>Thermosets</b>				
EP	E&E	UL94V0	Deca / ATO DBDE / ATO EBTPI / ATO	ATH ATH / APP P-red PhPol
		FR4	TBBPA reactive	PhPol Dopo MePh PhPho Dopo
	Transport Air			
PIRrig	Building DE Building FR Building DE	DIN4102B1 NF P 92501 M1 DIN4102B2	BrPol / TCPP P-red / TCPP	P-red APP
PURrig	Building DE	DIN4102B2 and SBI Class C	BrPol / TCPP	APP PhPol TEP

Polymer	Application / Product	Fire Safety Requirement	Halogen-Containing FR System	Halogen free FR System
				DMPP P-red
	Building USA	ASTM E84	BrPol / TCPP	
PURflex	Transport Auto	MVSS 302	TCPP BrPol	PhPol CDP TCP APP APP / Intum
	Transport Air	KerosBurner	TCPP / Mel / EG	
	Building UphFur UK	BS5852Crib5	TCPP / Mel TCPP / Mel	APP / Mel / EG
	USA	CalTB117		PhPol CDP TCP
UP	E&E	UL94V0	Deca / ATO DBPE / ATO EBTPI / ATO TBBPA reactive CP / ATO HET-acid TCEP TCPP	ATH ATH / P-red ATH / APP DMPP DMPP+WMP
	Transport Sea	Flame Spread		ATH
	Transport Rail DE	DIN 5510		APP

## 2 Abbreviations

### Applications

UphFur	Upholstered furniture
E&E	Electrical & electronic equipment
Transport	Transportation
- Air	Aircraft
- Auto	Automotive
- Rail	Railways
- Sea	Ships

## Polymers

### 2.1 Thermoplastics

ABS	Acrylonitrile/butadiene/styrene terpolymer
EPS	Expandable polystyrene
HIPS	High impact polystyrene
PA	Polyamide
PBT	Polybutylene terephthalate
PC	Polycarbonate
PC/ABS	Polycarbonate/ABS blend
PE	Polyethylene
PET	Polyethylene terephthalate
PP	Polypropylene
PPE/HIPS	Polyphenylene ether/high impact polystyrene blend

### 2.2 Thermosets

EP	Epoxy resins
PIRrig	Rigid polyisocyanurate foam
PURflex	Flexible polyurethane foam
PURrig	Rigid polyurethane foam
UP	Unsaturated polyester resins

## Flame retardants

### Brominated flame retardants

BEO	Brominated epoxies
BrPS	Brominated polystyrene
BrPol	Brominated polyols
DBDE	Decabromodiphenyl ethane
Deca	Decabromodiphenyl ether
EBTPI	Ethylene bis(tetrabromophthalimide)
HBCD	Hexabromocyclododecane
PBB-PA	Poly(pentabromobenzyl acrylate)
TBBPA	Tetrabromobisphenol-A
TBBPA-CO	TBBPA carbonate oligomer
TBNPP	Tris(bromoneopentyl) phosphate
TDPE	TBBPA (2,3-dibromopropyl ether)

### Chlorinated flame retardants

CP	Chloroparaffin
Dech	Alicyclic chlorinated compound (Dechlorane plus)
HET-acid	Hexachloroendomethylenetetrahydrophthalic acid
TCEP	tris(chloroethyl) phosphate
TCPP	tris(chloropropyl) phosphate

### Organo phosphorous flame retardants

BDP	Bisphenol A bis(diphenyl phosphate)
CDP	Cresyldiphenyl phosphate
DMPP	Dimethylpropane phosphonate
Dopo	Dihydrooxaphosphaphenanthrene oxide
MePh	Metal phosphinate
Oxa	Oxaphospholane
PhPol	Phosphorous polyol
PhPhos	Phenyl phospholane
PolyDP	Polymeric diphenyl phosphate
RDP	Resorcinol bis(diphenyl phosphate)
TCP	Tricresyl phosphate
TEP	Triethyl phosphate
TPP	Triphenyl phosphate
WMP	Intumescent system based on ethylenediamino phosphate

### **Nitrogen-containing flame retardants**

MC	Melamine cyanurate
Mel	Melamine
MPP	Melamine polyphosphate
NorHals	N-alkoxy hindered amine

### **Inorganic flame retardants**

APP	Ammonium polyphosphate
APP/intum	Intumescent system based on APP
ATH	Aluminium hydroxide
ATO	Antimony trioxide
EG	Expandable graphite
Intum P-based	Intumescent flame retardant system based on APP, MC, etc...
MOH	Magnesium hydroxide
Nano	Nanocomposite based on montmorillonite clays
P-red	Red phosphorous

### **Other**

SulSalts	Sulfonate salts
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### 3 Overviews and environmental assessments of alternatives to specific halogen-containing flame retardants

There are some third party overviews / assessments of flame retardants from various consultants and environmental agencies. These reports sometimes come to different conclusions on the same products and are often seen as controversial by the FR producers. One controversial point is that the flame retardants deca-BDE, TBBPA and HBCD have undergone comprehensive risk assessments, while the substitution products often have not. However, this will change in the near future with the implementation of REACH, as extensive data will have to be provided for all flame retardants.

Examples are:

- German UBA (2001): Substituting Environmentally Relevant Flame Retardants: Assessment Fundamentals Volume I: Results and summary overview - <http://www.umweltbundesamt.de/uba-info-medien/dateien/1988.htm>
- Danish EPA: Environmental Project no. 1141 (2007): Deca-BDE and Alternatives in Electrical and Electronic Equipment <http://www2.mst.dk/Udgiv/publications/2007/978-87-7052-349-3/pdf/978-87-7052-350-9.pdf>
- Morose, Gregory (2006): An Overview of Alternatives to Tetrabromobisphenol A (TBBPA) and Hexabromocyclododecane (HBCD), Prepared for the Jennifer Altman Foundation, <http://sustainableproduction.org/downloads/AlternativestoTBBPAandHBCD.pdf>
- Illinois Environmental Protection Agency (2007): "Report on Alternatives to the Flame Retardant DecaBDE: Evaluation of Toxicity, Availability, Affordability, and Fire Safety Issues", <http://www.epa.state.il.us/reports/decabde-study/index.html>
- European Chemicals Bureau (2007): Review on production processes of decabromodiphenyl ether (Deca-BDE) used in polymeric applications in electrical and electronic equipment, and assessment of the availability of potential alternatives to Deca-BDE. [http://ecb.jrc.it/documents/Existing-Chemicals/Review\\_on\\_production\\_process\\_of\\_decaBDE.pdf](http://ecb.jrc.it/documents/Existing-Chemicals/Review_on_production_process_of_decaBDE.pdf)