Flame-Retardants for ABS

General Application Data about Flame-Retardants for Acrylonitrile-Butadiene-Styrene (ABS)

Fire-Safety

ABS plays a very important part in the electronics, automotive and appliances industries. It is used mainly for the production of housings forcomputers and office equipment such as printing/copying machines, scanners and remote controls.
Its flammability involves a real hazard to users and it has been necessary to significantly improve its fire retardancy. This has been achieved mainly by the use of brominated fire retardants, employing antimony trioxide as a synergist.

ICL IP FRs product line

This data sheet provides preliminary information on the preparation of **FR ABS.**

An FR system is always preferrably introduced as a master-batch concentrate in order to improve its dispersion and efficiency. A master-batch normally contains circa 70-80% of FR including antimony oxide and the carrier is selected to achieve optimal compatibility with the polymeric matrix. For ABS, ABS itself, acrylate copolymers, SBR or Kraton type copolymers can be used.

The type of ABS may have a considerable influence on properties such as melt flow, impact and heat distorsion temperatures.
ICL IP offers a broad line of Flame-Retardants (FRs) and tailor-made solutions that provide additional benefits in new market segments and applications.
The following FRs are particularly suitable for FR ABS passing class V-0 according to the UL 94 standard:

- **FR-1524 (Tetrabromobisphenol A – 58% bromine)**, is cost effective for most common applications if the processing temperature does not exceed 220^{0}C. It is not recommended when high impact or high distortion temperature are needed.

- **FR-245 [Tris(tribromophenyl) cyanurate- 67% bromine]**, a joint development between the Japanese Company Dai-Ichi Kogyo Seiyaku (DKS) and ICL IP, provides at an attractive cost an optimal balance of properties:
    - high melt flow during injection molding
    - light stability
    - good impact properties
    - high heat distortion temperature (HDT)

- **F-2000 series (brominated epoxy oligomers and high molecular weight species – 50 to 53% bromine)**, are polymeric FR additives specially designed for application in ABS. They have good flame retardancy and are suitable for compounds with high UV stability. They are non-blooming.

- **F-3000 series (modified brominated epoxy oligomers – 55 to 58% bromine)** are non blooming polymeric FR additives offering an optimal combination of UV stability and impact properties. These melt blendable FRs enhance flow properties during injection molding and are free from metal adhesion.

In addition to the previous list, a second series of FRs are also offered by ICL IP but only for applications where less severe fire retardancy is acceptable such as class V-2 (UL- 94):

- **FR-720 [bis (2,3-dibromopropyl ether) of TBBA – 67% bromine],** includes 33.5% of the more FR efficient aliphatic bromine, is melt-blendable with an optimal thermal stability and is cost efficient.

- **FR-370 [tris(tribromoneopentyl) phosphate – 70% bromine + 3% phosphorus],** is offered for applications including exposed sections which require **light stability , brightness, good initial colors and impact resistance.**

All these FRs have undergone extensive toxicological and environmental testing and have been proven to pose no risk to health and the environment.
Detailed application data sheets of these FRs in ABS are available from http://www.iclfr.com website.

Thermal stability

Thermogravimetric analysis of the above mentioned flame-retardants (Table 1) reflects their good thermal stability, enabling high to fairly high processing temperatures.

Table 1: Thermogravimetric analysis (TGA-10^{0}C/min in air)

	Temperature, ^{0}C					
FR Type	**FR-1524**	**FR-245**	**F-2000 series**	**F-3020**	**FR-720**	**FR-370**
Weight loss, %						
2	**263**	**360**	**318-339**	**348**	**292**	**285**
5	**283**	**385**	**339-350**	**360**	**306**	**309**
10	**298**	**400**	**349-358**	**366**	**313**	**319**

Processing conditions

Typical processing conditions for compounding and mold ABS flame retarded with these FRs are as follows:

Compounding

Compounding in a co-rotating twin-screw extruder (L/D= 32:1)
Temperature profile, ^{0}C: amb.-130-160-200-210-210-210-220-220
(For FR-1524 only, ^{0}C: amb.-130-150-160-180-200-210-200-200)
Screw speed, rpm: 300
Throughput, kg/h 14

Injection molding

Temperature profile, ^{0}C: 180-200-230-230-230
(For FR-1524 only, ^{0}C: 180-200-210-210-210)
Mold temperature, ^{0}C: 40
Pressures, Bar:
- Injection 500
- Holding 250
- Back 20

Cycle time, sec 15

FR efficiency

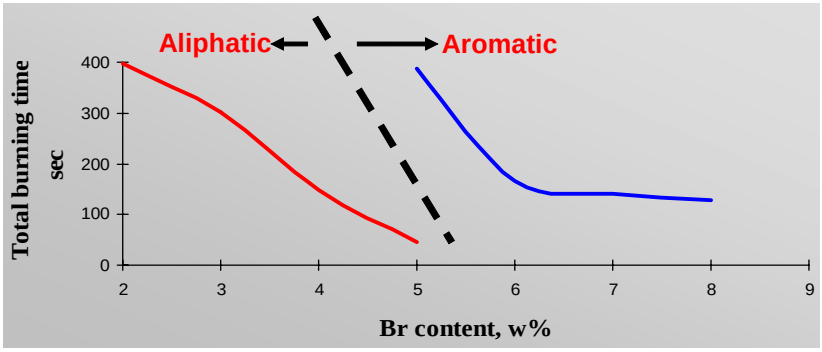
Table 2 gives indicative guidance to define formulations able to pass class V-0 and V-2 according to UL94.

Table 2: Guidance for FR ABS class V-0 and V-2

Class	Thickness mm	Bromine content, %	Antimony trioxide content, %
V-0	3.2	Aromatic Br: 8-10	2.5-4.5
	1.6	Aromatic Br: 9-12	3-6
V-2	3.2	Aliphatic Br: 4-5	2-3
	1.6	Aromatic Br: 6-7	3-4

It must be noted that only fully aromatic bromine containing FRs are suitable to produce UL-94 class V-0 compounds.
For FR-ABS class V-2, aliphatic bromine FRs are significantly more efficient than aromatic bromine types. Figure 1 shows the shorter total burning times achievable with aliphatic bromine FRs.

Fig. 1: Aliphatic versus aromatic bromine (UL 94 1.6 mm)



Usually, FR ABS class V-2, is also expected to pass the "Glow wire Test" at 960^0C according to the standard IEC 695-2.

For high flow grade of ABS, use of FR systems based on SaFRon 5500 Antidrip series is recommended. The enhanced efficiency of SaFRon 5500 series allows significant reduction of the quantity of FR (brominated FR + antimony trioxide). For more details, please contact ICL IP Tecnet Representative.

Overview of properties

Tables 3 and 4 provide guidelines for selecting an optimal FR for ABS applications passing class V-0 or V-2 respectively.

Table 3: Properties of V-0 ABS

Properties	FR-1524	FR-245	F-2000 series	F-3000 series
Thermal stability		√	√√√	√√√
Melt flow	√√√	√	√√	√√
FR efficiency	√√√	√	√√√	√
Impact		√√√		√
UV/light stability		√√	√√√	√
Heat distortion temperature (HDT)		√√√	√√	√
Non-blooming		√√	√√√	√√√
Cost efficiency	√√√	√	√	√

Table 4: Properties of V2 ABS

Properties	FR-720	FR-370	FR-245	F-2000 series	F-3000 series
Thermal stab.	√	√√	√√	√√√	√√
Melt flow	√√√	√√	√	√√	√√
FR efficiency	√√√	√√			
Impact	√√	√√√	√	√	√
UV/light stab.	√	√√√	√√	√√√	√√
HDT			√√	√	√
Non-blooming	√	√	√√	√√√	√√√
Cost efficiency	√√√		√√	√	√

- **Melt-Flow**

FR-1524, FR-720, FR-370, F-2016, F-3020 and FR-245 enhance flow during injection molding as they melt during the process. The comparative values of MFI of flame-retarded ABS shown in Figures 2 and 3 show why, compared with filler type FRs such as brominated diphenyl ethane, these FRs permit shorter cycle times and thinner walls of processed articles.

Figure 2: Melt flow properties in FR ABS V-0 (220°C - 10kg)

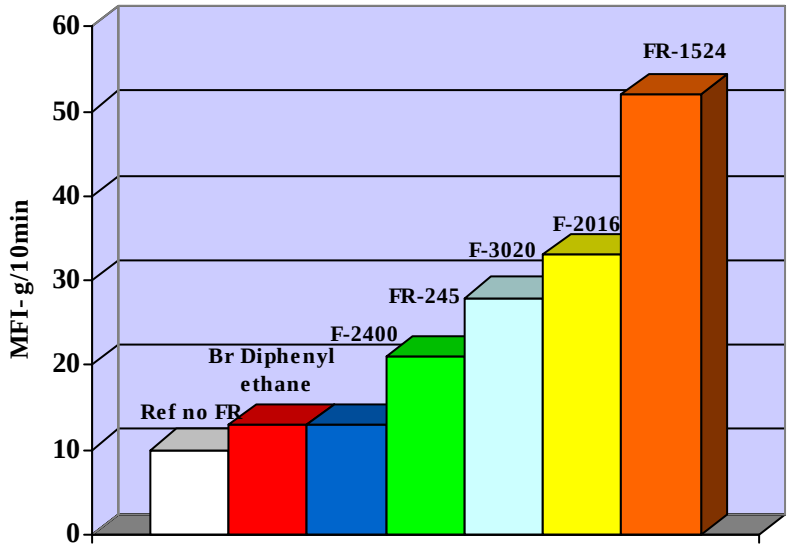
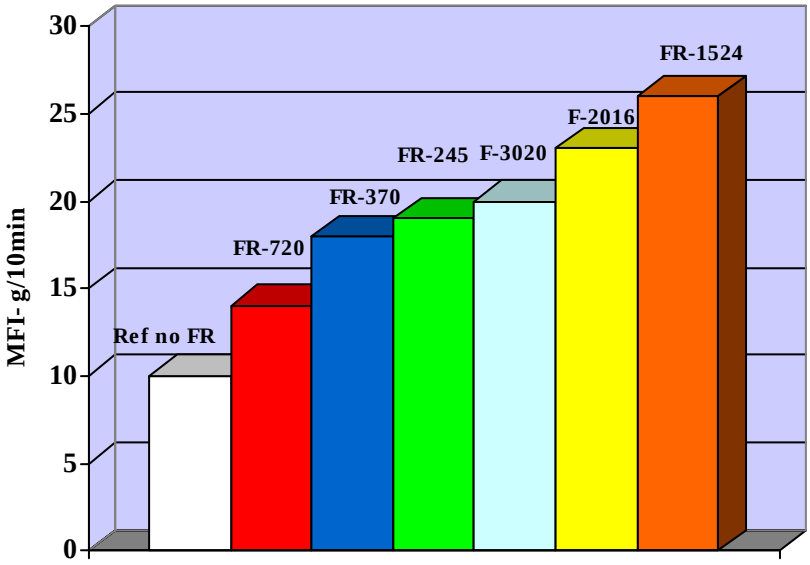


Figure 3: Melt flow properties in FR ABS V-2 (220°C - 10kg)



Impact properties

As shown in Figures 4, 5 and 6, better impact properties are achieved with the following FRs:

- For V-0: FR-245 is the front-runner followed by FR-1524 and F-3020
- For V-2: FR-720, FR-370, FR-1524 and FR-245 and F-3020

Figure 4: Izod notched in FR ABS V-0

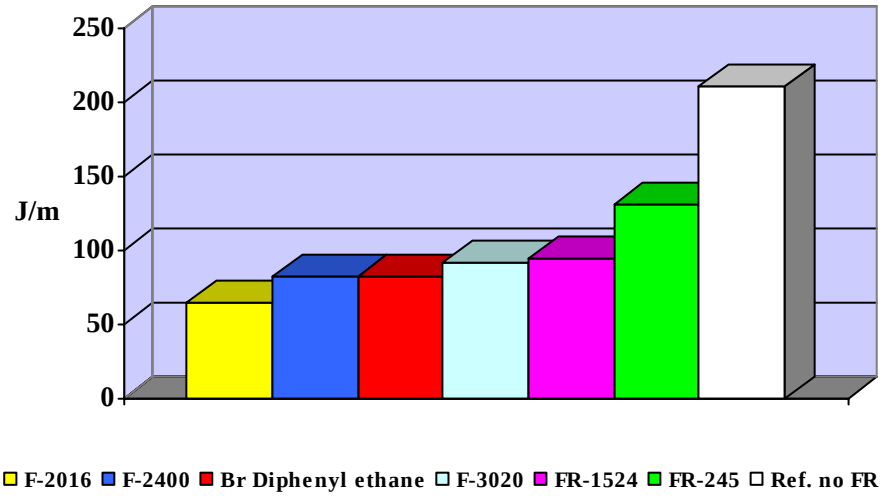


Figure 5: Gardner impact in FR ABS V-0

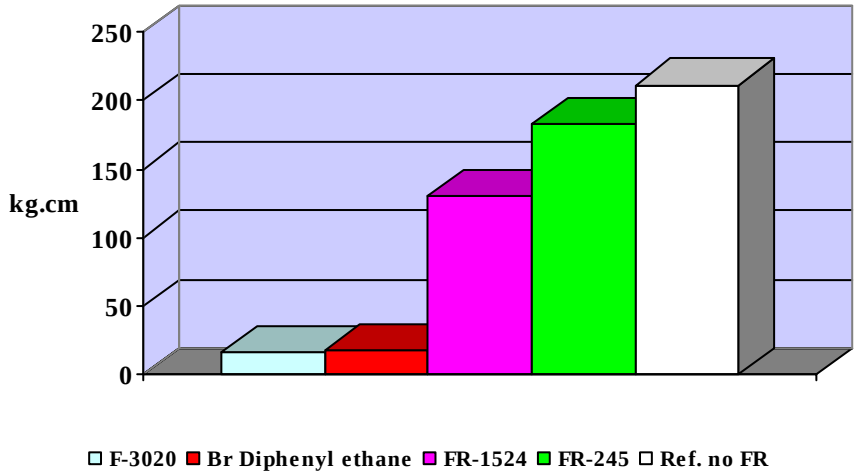
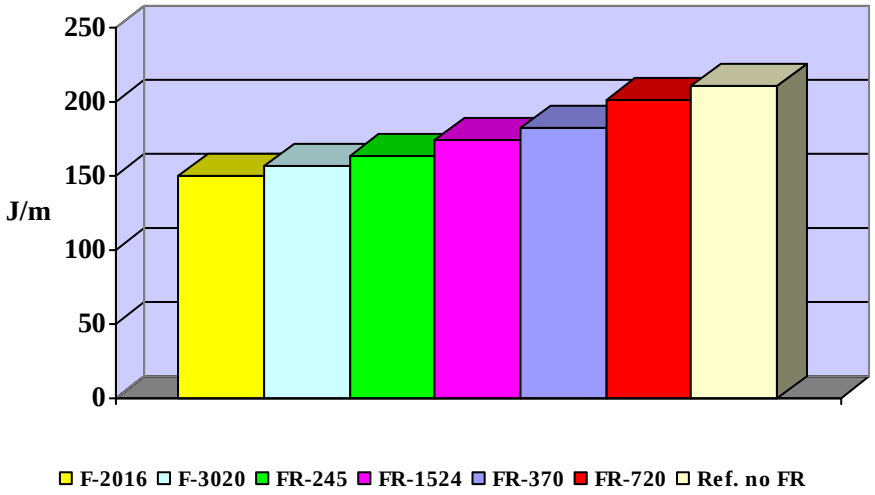


Figure 6: Izod notched in FR ABS V-2



UV/Light Stability

The use of benzotriazole UV absorbers is preferred over the HALS ones to limit the detrimental effect associated with brominated flame retardants. It is recommended to combine 0.25 to 0.5% benzotriazole UV absorber with 1 to 2% of titanium dioxide.
As shown in Figure 7 and 8, following FRs are recommended for UV stable applications:

- For V-0: F-2000 series, the best, followed by FR-245 and F-3000 series
- For V-2: F-2000 series is the front-runner followed by FR-370, FR-720, as well as FR-245 and F-3000 series.

Figure 7: UV stability Xenotest - 300h in FR ABS V-0
(ASTM D4459-93)

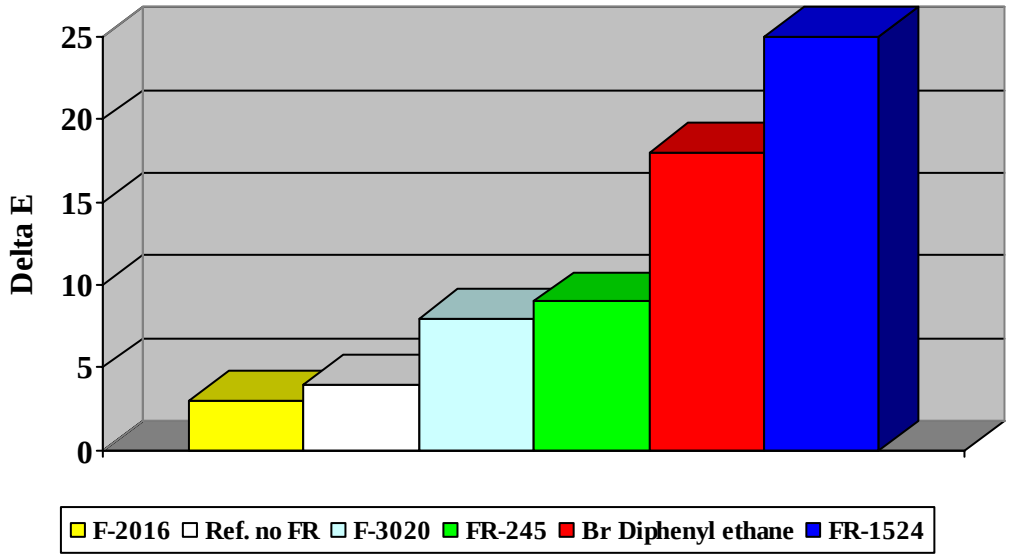
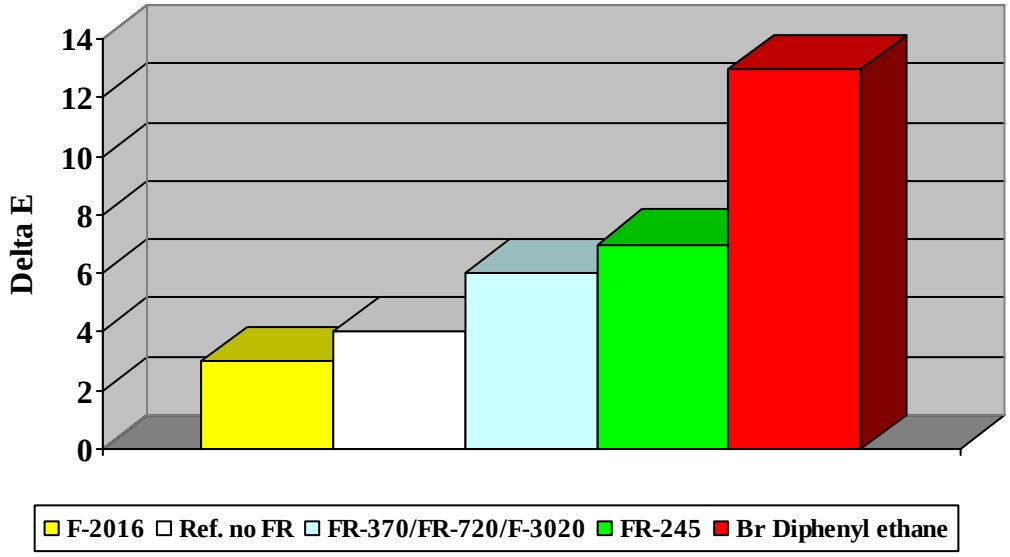


Figure 8: UV stability Xenotest - 300h in FR ABS V-2
(ASTM D4459-93)



Health – Safety - Environmental aspects

ICL IP FRs product line has undergone extensive toxicological and environmental testing[1], and has been proven to pose no risk to health and the environment.

For instance, results of analyses performed by Institut Fresenius Chemische und Biologische Laboratorien GmbH on ICL IP FRs product line itself and under conditions simulating a modern municipal solid waste incinerator for presence of polybrominated dibenzo-para-dioxins/dibenzofurans (PBDD/PBDF), have shown it to be in full compliance with the requirements of the global most strict criteria of the German Dioxin Ordinance and EPA TSCA 40 §766.27 Final Rule requirements[1].
As part of an ongoing Product Stewardship Program and Customer oriented policy, ICL IP is committed to implement further toxicological and environmental tests, should this be needed.

Recyclability

Several studies completed in Japan, Germany and the US have demonstrated that ABS and HIPS containing brominated flame retardant are fully recyclable, with the flame retardant able to withstand multiple cycles. The studies analysed both the possible degradation of the flame retardant, and also compliance with the tightest dioxin emissions standards during the recycling process.

ABS containing brominated flame retardants such as FR-1524, F-2000 and FR-245 have proved to be the material most suited to mechanical recycling due to their stability.
ABS flame retarded by these brominated FRs passed all test criteria and maintained their original properties while halogen free comparable system using PC ABS alloys are a complete failure. They are also able to retain important properties such as colour and fire rating, while meeting the stringent environmental requirements of the German Dioxin Ordinance.

[1] Further information available upon request

Applications

Recommended applications of fire retarded ABS are (Figure 9) :

- housing of electronic and electronic devices such as personal computer, laptop, printer, scanner, copying machine, remote control and mobile phone. Production is usually made by injection molding

- parts of appliances such as refrigerator, garden equipment, automotives and planes. Production is made by thermoforming of extruded sheets.

Figure 9: Applications of FR- ABS

ICL Industrial PRODUCTS

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