SAFR®: Integrating exposure with hazard in a new assessment approach for responsible fire safety solutions.

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Introduction

The increased use of plastics, foams and synthetic fibre-based fillings has transformed our spaces into practical and comfortable living, but it has also brought an increased risk of fire as many of these materials are combustible. Flame retardants (FRs) enable inherently flammable materials to meet rigorous fire safety standards. From everyday electronics to airplane plastics and cinema seating, flame retarded materials are an essential part of safe modern living. Nevertheless, fire safety should not compromise safety for human health and the environment.

ICL-IP set itself a challenge: could an easy to follow system be introduced for flame retardants to reward best in class based on performance, inherent properties and the level of potential human and environmental exposure in use? The Systematic Assessment for Flame Retardants (SAFR®) is a framework that provides an evaluation of specific flame retardants in their applications, thus enabling users to choose the most sustainable product for the intended use. By using the latest available scientific data, SAFR® ensures the use of the appropriate flame retardant for the application in question and when needed, the replacement with an effective and more sustainable solution.

Materials and methods

Building on accepted hazard criteria, SAFR® measures the extent to which hazards translate into potential risks due to possible exposure to humans and/or the environment during a product's service life. SAFR® has an exposure-based approach that utilizes quantifiable accelerated blooming, leaching or volatilization data from the base material matrix (e.g. plastics used for TVs casing) to thoroughly evaluate the use of the chemical in the chosen application.

SAFR®'s assessment of the given flame retardant leads to the identification of:

(i) uses that are either recommended, acceptable or not recommended, or
(ii) unacceptable hazards in which case alternatives can be identified.

The exposure assessment has a two-tiered approach, considering both:

1. The frequency of contact during the intended use (eg. TV, computer, car seats, insulation boards)
2. The potential emissions of the FR used due to either migration to surface (booming), leaching or volatilization.

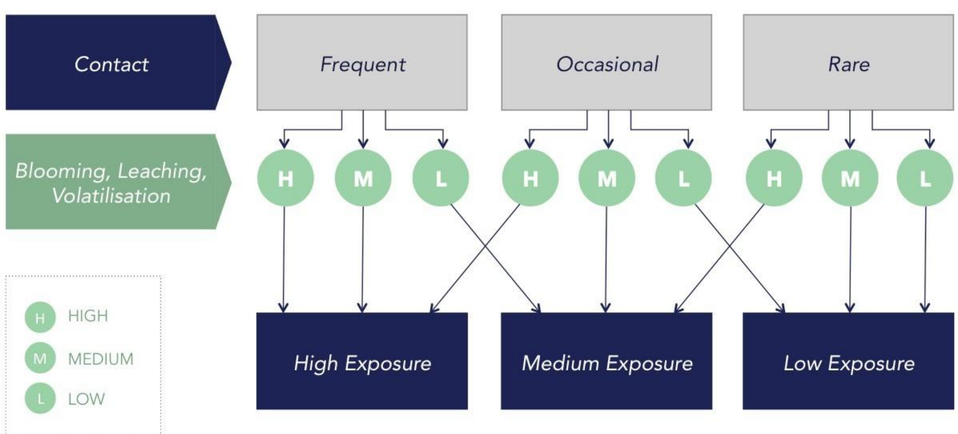
The general scheme for this methodology is presented in figure 1. The hazard assessment reflects four levels of hazards, where the highest (unacceptable) leads to phasing out of the product. Three other levels (high, medium, low) are further defined and addressed in the context of the potential exposure. The exposure component has three levels of potential exposure. The combination between the level of hazard and the level of exposure in a certain intended use will result in one of three categories for the specific uses: recommended, acceptable or not recommended. In the case of “not recommended”, a more sustainable solution can be recommended.

Figure 1: SAFR® assessment

HAZARD / EXPOSURE	LOW	MEDIUM	HIGH	UNACCEPTABLE
LOW POTENTIAL	RECOMMENDED	RECOMMENDED	ACCEPTABLE	TO BE PHASED OUT
MEDIUM POTENTIAL	RECOMMENDED	ACCEPTABLE	NOT RECOMMENDED	
HIGH POTENTIAL	ACCEPTABLE	NOT RECOMMENDED	NOT RECOMMENDED	

The exposure assessment is done in two steps. In the first step, the contact level to humans or to the environment during the intended use is evaluated. Then, the potential migration from the end product via the most relevant pathway (blooming, leaching, or volatilization) is measured and factored into a final exposure assessment as illustrated in Figure 2.

Figure 2: Exposure assessment



The frequency of contact: The contact assessment, to humans and/or to the environment, is based on the known use of the FR in the final application. For any given application (e.g. external housing of TVs/computers, furniture, insulation boards), the worst of human contact or environmental contact is used to assess the intended use.

The potential emissions: Analytical tests were developed to quantify if and how much an FR may be emitted during a product's useful service life. The test used for a given application depends on the most probable pathway for emission: blooming, leaching or volatilization. Since there are no standards for blooming and leaching, internal methods were developed for their assessment. The level of emission was determined based on defined cutoff criteria.

- **Blooming test**

Plastic samples are prepared according to the known formulation used for specific applications (i.e. considering standard additives to the plastic in addition to the FR). The ageing of the samples is done by incubation at 70°C in a circulating air oven for a period of up to 35 days. Duplicate samples are taken for analysis after 0, 14, and 35 days of ageing. Each sample is swept using a filter paper and then the filters are analysed for bromide (for brominated FRs) or phosphorous (for phosphate FRs) content: the filters are combusted and the combustion products are quantitatively analyzed for bromides or phosphorous, as relevant. The level of blooming is calculated assuming that all the bromide/phosphorous originated from the FR.

- **Leaching test**

Soxhlet extraction is used as a worst case scenario for assessing the leaching potential from textile. About 8 grams of fabric, treated with the specific formulation that includes the FR, is used for the Soxhlet water extraction (300 ml deionized water). The system is run at the boil for 8 hours (about 8 cycles). The fabric is then removed and dried at 105°C for one hour and weighed. After evaporation of the water in the flask, the solid extract obtained is weighed and then quantitatively analyzed for bromides or phosphorous, as relevant.

- **Volatilization test**

For some applications, where relatively volatile FRs are used, the most probable pathway for emission is by volatilization. Standard methods exist for this kind of testing, mainly addressing VOCs' (Volatile Organic Compounds) emissions under different conditions and for specific applications. Currently, the possibility to use the VDA 277 and 278 are under consideration. The tests are based on heating a sample for a few hours at 120°C followed by the analysis of the VOCs released.

Results and discussion

An example of SAFR® assessment for textile applications is presented (figure 3). The results led to the identification of three products in our portfolio whose combination of hazard and exposure resulted in recommended solutions for all intended uses (TexFRons solutions). Taking as an example one specific application, the use of FR in tents, it can be seen that an additional FR (FR-1410) is only acceptable, although its hazard is low. The different conclusion is due to the high potential exposure assessment which is based on its high level of leaching. Another FR used for tents is Fyrol FR-2, which is not recommended based on SAFR® (given its high hazard and high exposure). This analysis demonstrates how the application of SAFR® to textile uses provides downstream users with a variety of recommended choices allowing them to choose the most sustainable solution.

Figure 3: SAFR® results for Textile

Flame Retardant	Hazard	Exposure	Uses		
			RECOMMENDED	ACCEPTABLE	NOT RECOMMENDED
TexFRon® 9001	L	L/M	**B&C:** Covered parts (flexible ducts) **Textile:** Upholstery, drapes, carpets, tents **Transportation**: Covered parts (filters)		
TexFRon® P, P+ PL	L	L/M	**Transportation:** Covered parts (filters) **Textile:** Professional protective clothing		
TexFRon® 4002 PL	L	L/M	**B&C:** Covered parts (flexible ducts) **Textile:** Upholstery, drapes, carpets, tents **Transportation:** Covered parts (filters)		
FR-1410	L	H		**B&C:** Covered parts (flexible ducts) **Textile:** Upholstery, drapes, carpets, tents **Transportation:** Covered- filters	
Fyrol® FR-2 (TDCP)	H	H+			**Textile:** Tents
FR-1210 (Deca)	UNACCEPTABLE	NR	BEING PHASED OUT		

Findings of flame retardant chemicals in the environment and biota call on industry, in partnership with the scientific community, to develop sustainable flame retardant solutions that have reduced human and environmental exposure while possessing low hazard properties and maintaining a high level of fire safety performance. SAFR®, which unlike most chemical assessment tools incorporates exposure potential, is a first step to meet these objectives and is put forward as a possible basis for further scientific research and development.