TEMPLATE

for third party submission of information on alternatives for

Applications for Authorisation

HBCD use in EPS for Building Applications

NON-CONFIDENTIAL

CORRECTED VERSION 06-07-2014

Legal name of submitter(s): *ICL-IP Europe BV*

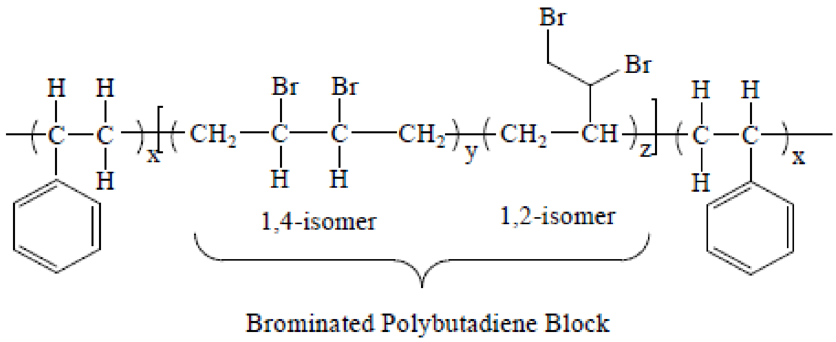
Fosfaatweg 48 1013 BM Amsterdam

TABLE OF CONTENTS

1. ALTERNATIVE ID AND PROPERTIES

ICL-IP alternative to Hexabromocyclododecane (HBCD Cas No. 3194-55-6) for use in EPS and XPS insulation foams is **FR-122P.**
FR-122P chemical designation is benzene, ethenyl-, polymer with 1,3-butadiene, brominated (FR-122P) (CAS # 1195978-93-8). The chemical structure is shown in figure 1 below.

Figure 1: Chemical Structure of FR-122P



The polymeric flame retardant (pFR) has been developed by Dow Chemicals Company as a polymeric, high molecular weight flame retardant alternative to HBCD. Exclusive rights for the production, sales and marketing of the pFR have been granted by Dow to three flame retardant manufacturers worldwide: ICL-IP, Chemtura and Albemarle. The new product is marketed by ICL-IP as FR-122P.

Figure 2 illustrates FR-122P properties.

Figure 2: Properties of FR-122P

Properties of *FR-122P*	
Physical appearance	white to off-white powder white to off-white compacted
Bromine content, w %	65
Solubility (water), g/L	Insoluble
Loss on drying, %	0.50 max
Molecular Weight, Daltons	100,000
Specific gravity, g/cm^3	1.6
TGA, %weight loss@T^{0}C	2%@243 5%@257 10%@264

FR-122P has been proven to be effective in EPS and XPS applications due to:

- Chemical compatibility with styrenic polymers, see chemical structure in figure 1.
- Flame retardancy efficiency, aliphatic Bromine being readily available at the adequate burning temperature for styrenic polymers.

2. TECHNICAL FEASIBILITY

For many years, Hexabromocyclododecane (HBCD CAS No. 3194-55-6) was used as a flame retardant in polystyrene foams, both in the expanded (EPS) and extruded version (XPS). Only very small quantities of HBCD are needed to meet the flame retardancy standards. In EPS production, HBCD is added to a 50/50 suspension of monomeric Styrene and water, together with other additives (catalysts, nucleation agents, etc.), with a final concentration of 0.5%-1.0%.. HBCD dissolves in the styrene which is polymerized into the small Polystyrene beads. During polymerization a blowing agent is added. The beads are later foamed into blocks or shaped articles by application of steam in an autoclave.

The XPS process makes use of a two-step extrusion process. It starts from polystyrene which is blended with the flame retardant in a first step and the addition of a blowing agent in a second step. Leaving the second extruder, the product expands into sheets which are cut in shape. In view to the flame retardant, XPS requires slightly higher levels of addition, 1.5 -2.5%. Also, the flame retardant is introduced into the polystyrene as masterbatch (a concentrate containing about 50 % of flame retardant). For XPS production, the flame retardant is mainly sold to producers of masterbatches who have developed formulations based on their own know-how.

In 2012 ICL-IP signed the license agreement with DOW Global Technologies Inc. on production and marketing of a polymeric brominated flame retardant (pFR) for use in polystyrene foams, replacing HBCD. The new product, CAS No 1195978-93-8, is marketed by ICL-IP as FR-122P and shown to be effective in both EPS and XPS.

In December 2010, first samples of FR-122P from lab trial runs were sent to all ICL-IP customers. The product was found to be suitable and effective. Although in some cases it was reported as a drop-in solution to HBCD, in others, the level of addition and formulation had to be adapted. Together with internal production and product development, the number and size of samples to customers increased constantly. Pilot production trials were carried out after September 2011 and a production line was adapted technically to the process. With further optimization of the process, the quality of the FR-122P was also improved. By mid-2012, the production level reached 20 tons/month. In parallel, customers were able to adapt their processes to the new flame retardant additive, namely FR properties and λ values were now found by customers to be in the desired range. Large scale pilot samples were offered to all customers. All major producers of EPS received FR-122P in 500 kg to 4 tons quantities, allowing them full scale production runs. The current status as of June 2014 indicates that over 80% of ICL-IP customers have found FR-122P to be a suitable alternative for their application, and the remaining 20% are in an advanced approval process. The market share in volume of the customers who have approved FR-122P is more than 90% of the market in the EU and Japan.

In March 2013, the German EPS foam industry organisation IVH published results of a round robin series of tests on various flame retarded EPS products (Südddeutsches Kunstoffzentrum (SKZ) Würzburg, 13.Februar 2014Fachtagung „EPS Partikelschaum" Ulrich Meier, IVH, Heidelberg, „Erfahrungen mit der Umstellung auf ein neues Flammschutzmittel").

Amongst others, HBCD and the new pFR containing materials were also tested in parallel. The FR results were found to be identical within the statistical error margins. Although the physical and mechanical properties were slightly below standards, it was confirmed that further optimization of the production processes would result in properties equal to the standard materials.

Based on the positive feedback from the market, ICL-IP has decided to advance its plans to initiate commercial production. In mid-2013, ICL-IP plant in the Netherlands, with a nameplate production of over 2000 MT/A , went on-stream and is capable to supply the market with the current required quantities. Customers, including HBCD authorization consortium members, have started to take full commercial quantities. ICL-IP is now in the start-up process for its 10.000 MT/A in Israel which will be fully operational in Q4 2014.

3. ECONOMIC FEASIBILITY

The polymeric flame retardant FR-122P (pFR) is an economy-wise feasible alternative to HBCD.
It has to be noted that ICL-IP does not have access to all economic criteria developed by HBCD users. Therefore, the following is based on our best evaluation and knowledge of the current pFR alternative status

- <u>Research and development investments:</u>
  For the pFR: done and completed by Dow Chemicals Company as well as by the pFR producers.
  For EPS and XPS production and implementation: done and completed by the vast majority of customers (see section 2 above).
- <u>Investments:</u>
  For the pFR: done and completed by the pFR producers.
  For EPS and XPS production and implementation: done and completed by the vast majority of ICL-IP customers (see section 2 above).
- <u>Other costs of transfer to the alternative:</u>

For pFR production: done and completed by the pFR producers.
For EPS and XPS production and implementation: done and completed by the vast majority of ICL-IP customers (see section 2).

- Costs and time spent by downstream users in re-specifying alternative products:
pFR based EPS and XPS final article foams exhibit the same properties as HBCD foams. Therefore no costs are associated to HBCD substitution with the pFR.
- Potential market distortions:
The pFR will be supplied by all three producers, namely ICL-IP, Chemtura and Albemarle.

Additional information pertinent to the economic feasibility:

- pFR and EPS estimated cost: according to ICL-IP cost data, FR-122P is expected to be more expensive compared to HBCD. This is due to higher costs of raw materials and production process. However, the overall extra cost of the final EPS article is estimated to be higher by 2% to 3% compared to the present cost of HBCD based final EPS article. This calculation is based on a 0.7% - 1% concentration of FR-122P in the EPS final article.
- As mentioned, investments related to R&D, production and supply of pFRhave already been completed. Although costs associated with non-utilization of production and supply facilities for this pFR are not fully estimated, ICL-IP estimation is that those are high.
- According to “Analysis of Alternatives” submitted by the EPS producers’ consortium: “It is known that the pFR costs more than HBCD, but it is assumed that this will be economically feasible……”(1).

4. HAZARDS AND RISKS OF THE ALTERNATIVE

The alternative chemical designation is: Benzene, ethenyl-, polymer with 1,3-butadiene, brominated (FR-122P) (CAS # 1195978-93-8)

FR-122P is a high molecular weight Polymeric Flame Retardant additive (CAS # 1195978-93-8) for use in Extruded Polystyrene Foam (XPS) and Expanded Polystyrene Foam (EPS) insulation applications, as a replacement for FR-1206 Hexabromocyclododecane (HBCD).

Compared to HBCD, FR-122P exhibits a more sustainable health, safety and environmental profile. High molecular weight polymeric additives by nature have inherently better environmental and health risk profiles and often provide a more sustainable solution than smaller molecules.

Series of mammalian and environmental studies performed under internationally accepted guidelines and principles of Good Laboratory Practice have been conducted on FR-122P.

The list of results is summarized below:

1. FR-122P has been shown to be non-toxic to test animals when administered orally. It was found to be not irritant to skin and eyes and not a skin sensitizer.

2. FR-122P is not mutagenic by the Ames test and not clastogenic in the Chromosome Aberration test.

3. FR-122P is persistent and not toxic to Daphnia.

4. FR-122P as a high molecular weight polymeric molecule is not expected to bioaccumulate.

5. FR-122P is neither a PBT substance nor a CMR.

   Further, Benzene, ethenyl-, polymer with 1,3-butadiene, brominated was scored "Low" in all parameters tested except persistency in the EPA DfE assessment report "Flame Retardant Alternatives For Hexabromocyclododecane" (appendix 1).

The above data, including details in appendix 2, clearly demonstrate that FR-122P is a suitable alternative to HBCD in respect to its toxicological and environmental profile.

The full product profile of FR-122P can be found in appendix 2.

5. AVAILABILITY

Availability of the pFR alternative has to be assessed by combining expected global demand and planned supply. Global demand over the years is based on the following, confirmed data for past years and forecasted figures for the 2015-2019 coming years, according to conversion ratio of HBCD to pFR and substitution of HBCD by pFR in all geographic relevant areas.

5.1 HBCD global demand in 2011 summed up to 31,000 MT/A, based on ICL-IP internal marketing figures. By 2013, this demand decreased by 12% worldwide due to the economic recession (at an average rate of 10% for 2012 and 10% for 2013) and was steady in 2014. In 2015, demand for HBCD will be influenced by the following:

- Full switch in the EU from HBCD to pFR, as per end of March 2015.
- Japan is to switch to FR-130, a non-polymeric HBCD substitute as well as to the pFR alternative Switching from HBCD will be initiated in October 2014.
- In 2015, Korea will keep HBCD use at a 75% level compared to 2014.
- A forecasted 3% CAAGR in HBCD demand in 2015; no growth for non-EU countries.

Figure 3 illustrates these evolutions:

Figure 3: HBCD global demand (MT/A), 2011-2015

	2011	**2012**	**2013**	**2014**	**2015**
HBCD demand EU	12,300	11,560	10,800	10,800	2,800
HBCD demand non EU	18,700	17,600	16,500	15,900	13,950
TOTAL	**31,000**	**29,160**	**27,300**	**26,700**	**16,750**
	2011	2012	2013	2014	2015
HBCD demand America	2,500	2,350	2,200	2,200	2,200
HBCD demand CHINA	12,100	11,400	10,700	10,700	10,700
HBCD demand Japan	2,500	2,350	2,200	1,600	0
HBCD demand Korea	1,600	1,500	1,400	1,400	1,050
Total non EU	18,700	17,600	16,500	15,900	13,950

5.2 pFR global demand: According to market data gathered by ICL-IP and expected implementation dates for the HBCD ban in the relevant countries, demand over the years 2015-2019 is subject to the following assumptions:

- EU will fully switch from HBCD to pFR alternative by end of March 2015. Although some XPS producers might switch to non-pFR alternative, we assume in this analysis all HBCD substitution is to come from the pFR.
- Substitution rate of HBCD by the pFR is 1:1.2 (based on confirmations from ICL-IP customers which tested and approved the pFR alternative in both EPS and XPS applications).
- In America, 50% of the HBCD will be gradually replaced by pFR from 2015 to 2018 and fully replaced in 2019.
- Japan will fully switch from HBCD to FR-130, a non-pFR alternative, in October 2014 as well as to the pFR alternative. In 2015, Japan is expected to have substituted 50% of the non-pFR with the pFR
- It is assumed that Korea will switch to 25% pFR consumption in 2015 and to 50% from 2016 to 2019.
- EU demand for flame retardants for EPS and XPS is expected to grow as follows: In 2015 by 3%; in 2016 by 5%; in 2017 by 6%; in 2018 and 2019, both years by 7%.
- It is assumed China will replace HBCD in 2020 and start the transition by 2019.

Figure 4 reflects this forecast:

Figure 4: Global forecasted pFR demand (MT/A), 2015-2019

Global pFR demand	2015	2016	2017	2018	2019
PFR demand EU	10,000	14,020	14,860	15,900	17,010
PFR demand non EU	1,480	2,560	3,220	3,220	10,440
Total	**11,480**	**16,580**	**18,080**	**19,120**	**27,450**

Non EU PFR demand	**2015**	**2016**	**2017**	**2018**	**2019**
America	0	660	1,320	1,320	2,640
Japan	1,060	1,060	1,060	1,060	1,060
China	0	0	0	0	5,900
Korea	420	840	840	840	840
Total	**1,480**	**2,560**	**3,220**	**3,220**	**10,440**

5.3 Global supply of pFR:

ICL-IP Netherland plant is already producing in commercial quantities since Q4/2013 at a capacity of over 2000mt/a. A scaling up of this plant is the additional 10,000 MT/A in Israel. This project is finalizing construction and starting the commissioning stage. Initiation of production is expected by 30/9/2014.This schedule will be fully met thanks to ICL-IP's technical capability to extent production in Israel based on the acquired experience in the Netherlands (see appendix 3 for further details). ICL-IP plans to bring production to a level of 20,000MT/A already in 2017, as expansion in the NL site can be achieved according to current existing planning, permits and partly existing equipment at a relatively short period of time. As per 2014, Chemtura production capacity is already of 10,000MT/A.

Figure 5 illustrates pFR global supply over the years 2015-2019. Global pFR supply for the years 2015-2019 is in accordance with the "Analysis of Alternatives- HBCDD use in EPS for building applications", submitted by the HBCD Authorization consortium.

Figure 5: Global forecasted pFR supply (MT/A), 2015-2019

PFR GLOBAL SUPPLY	2015	2016	2017	2018	2019
	23,350	**29,850**	**31,350**	**31,350**	**31,350**

5.3 Global demand and supply: Figure 6 shows clearly that no shortage is expected in the years 2015-2019. The pFR commercial activity is expected to be initiated in March 2015, as a preparation of the HBCD sunset date in Europe.

Figure 6: Global forecasted demand and supply (MT/A) for pFR, 2015-2019

PFR Supply versus Demand	2015	2016	2017	2018	2019
Total demand	11,480	16,580	18,080	19,120	27,450
Total Supply Availability	23,350	29,850	31,350	31,350	31350
Difference	**11,870**	**13,270**	**13,270**	**12,230**	**3,900**

It should be noted that ICL-IP is in advanced stages of supply agreements negotiations with several EPS and XPS producers. Based on the FR-122P availability described above, ICL-IP is willing to engage in similar discussions towards such agreements with additional EPS and XPS producers.

6. Conclusion on suitability and availability of the Alternative

In accordance with all data presented above, it can be reasonably concluded that the pFR (ICL-IP product code FR-122P) is a true and feasible alternative to HBCD in EPS and XPS applications.

PFR technical substitution of HBCD has been already proven to be feasible by a vast majority of EPS and XPS manufacturers.

Economic feasibility has been shown as a non-issue, since both pFR suppliers and users have already made all necessary investments to ensure a smooth switch to the pFR alternative, in full accordance with the HBCD banning timetable in the EU and in the others concerned regions of the globe. These investments can definitely be regarded as "sunk costs".

The hazards and risks analysis of the pFR alternative show a superior toxicological and environmental profile compared to HBCD. In that respect, it should be mentioned that continued use of HBCD in Europe beyond the year 2015 will have an additional drawback: due to HBCD content, recycling of EPS and XPS will be delayed by four years. This will certainly contribute to further environmental issues in the EU.

Availability of pFR as per the pertinent period of 2015 and on is well confirmed.

7. OTHER COMMENTS

REFERENCES

1. Analysis of Alternatives- HBCDD use in EPS for building applications, submitted by the EPS producers consortium, p. 81, §4.4a.
2. Great Lakes Chemical Corporation. Ames/Salmonella plate assay report on bis(2,3-dibromopropyl)ether of tetrabromobisphenol A with attachments. TSCA Section 8E, OTS0503680. U.S. EPA Doc. No. 8888200436.
3. Evaluation of the mutagenic activity of FR-720-purified in the salmonella typhimurium reverse mutation assay and the escherichia coli reverse mutation assay (with independent repeat), 2002, NOTOX B.V., Hambakenwetering 7 5231 DD's-Hertogenbosch, The Netherlands.
4. http://ntp.niehs.nih.gov/?objectid=BD48F894-123F-7908-7B7E35D7CFAA5298 (NTP site)
5. In vitro sister chromatid exchange in chinese hamster ovary cells with GLCC # 785-104C, 1984, Hazelton Biotechnologies Corporation, 9200 Leesburg Turnpike, Vienna, Virginia 22180 USA.
6. Evaluation of the mutagenic activity of FR-720 in an in vitro mammalian cell gene mutation test with L5178Y mouse lymphoma cells, 2002, NOTOX B.V., Hambakenwetering 7 5231 DD's-Hertogenbosch, The Netherlands.

APPENDIXES

Appendix 1: DfE report

http://www.epa.gov/dfe/pubs/projects/hbcd/hbcd-full-report-508.pdf

Appendix 2: FR-122P data sheet

FR-122 Fact Sheet_06-05-2013.pd

Appendix 3: ICL-IP polymeric FR-122P capacity expansion, attached.