

Evaluation of test results obtained from dioxin analyses made on expanded polystyrene samples containing a polymeric brominated flame retardant

On behalf of the EPS (Expandable Polystyrene) Product Group, operating as Sector under the umbrella of PlasticsEurope, an experimental study has been made to investigate the contribution of flame retarded expanded polystyrene (EPS) containing a polymeric brominated flame retardant (CAS number 1195978-93-8) to the formation of polybrominated dibenzo-p-dioxins and furans (PBDD/PBDF) under conditions simulating the development of a fire. The rationale of the tests with the polymeric flame retardant was to find out whether it contributes to higher levels of dioxins compared to other products involved in fires, e.g. wood. This expert statement summarizes the conclusions which can be drawn from the results of these tests.

"Dioxins" refers to a group of toxic chemical compounds that share certain chemical structures and biological characteristics. They basically consist of the polychlorinated dibenzo-p-dioxins and furans (PCDD/PCDF), which have been extensively studied in the last fifty years, and of their counterparts, the PBDD/PBDF. Both groups consist of 75 dibenzodioxins and 135 dibenzofurans each, amounting to a total of 210 congeners per group. The most toxic ones are the 17 congeners with halogen atoms in 2,3,7,8-position. From these 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) is the most toxic of all. Toxic equivalence factors (TEFs) exist for seven congeners of dioxins, and ten for furans. The reference congener is 2,3,7,8-TCDD, which per definition has a TEF of one^{i,ii}. TEFs have not yet been assigned to the PBDD/PBDF as their toxicities are still not well-known, but appear to be somewhat lower than those of their chlorinated counterparts. In the absence of TEFs, the PCDD/PCDF values have been taken over for PBDD/PBDFⁱⁱⁱ.

The fire scenario used was the German DIN tube to DIN 53436^{iv}, which allows to simulate an initiating fire from room temperature up to 500°C, where flashover starts and leads to a fully developed fire. The fire effluents formed during the DIN 53436 tests were sampled as gas and particle phases at the fire laboratory of BASF SE in Ludwigshafen, Germany. Both phases were sent and analyzed at the dioxin testing laboratory Ökometric GmbH in Bayreuth, Germany. The samples were tested to PBDD/PBDF using high-resolution gas chromatography/high-resolution mass spectrometry (HRGC/HRMS). The analytical results are summarized in the Ökometric reports for the various samples (blank sample [test apparatus alone], EPS without flame retardant, EPS with polymeric brominated flame retardant) and are available as pdf files.

The analytical results for the flame retarded EPS grade show that the sum of PBDD and PBDF is mainly determined by the amounts of mono and dibrominated PBDD and PBDF. Both are toxicologically not relevant. The results summarized in table 1 consider the eight toxicologically relevant 2,3,7,8-TBDD/TBDF congeners mentioned in the German Chemicals Banning Ordinance^v.

Table 1. 2,3,7,8-substituted PBDD/PBDF found in the combustion gases of samples tested to DIN 53436

2,3,7,8-substituted PBDD/PBDF	Detection limits (µg/kg)	Test apparatus alone (µg/kg)	EPS without FR* (µg/kg)	EPS + polymeric brominated FR (µg/kg)
2,3,7,8-TBDD	0.02	<0.02	0.03	0.10
1,2,3,7,8-PeBDD	0.02	<0.02	0.02	0.04
1,2,3,4,7,8-HxBDD	0.05	<0.05	<0.05	<0.05
1,2,3,6,7,8-HxBDD	0.05	<0.05	<0.05	<0.05
1,2,3,7,8,9-HxBDD	0.05	<0.05	<0.05	<0.05
2,3,7,8-TBDF	0.02	<0.02	0.19	0.39
1,2,3,7,8-PeBDF	0.07	<0.07	0.14	0.13
2,3,4,7,8-PeBDF	0.07	<0.07	0.18	0.17
Sum of 8 congeners			0.56	0.93

* FR = flame retardant

The results for the 2,3,7,8-substituted PBDD/PBDF in the EPS sample with the polymeric brominated flame retardant show 0.93 µg/kg for the sum of the eight congeners. These dioxin values are insignificant compared to the sum of the 2,3,7,8 PCDD/PCDF congeners (24 and 59 µg/kg) found in the chimney soot of wood-fired fire places in homes according to a study on PCDD/PCDF sources^{vi}.

There are no regulations referring to limit values for chlorinated or brominated dibenzo-p-dioxins and furans in case of fire. A general overview on dioxins, the main sources of dioxins in the environment and the key dioxin regulations is given by the German Environmental Agency (Umweltbundesamt)^{vii}. No mention is made of regulations referring to dioxins and fires. A publication of the German Federal States Working Group Dioxins points out that fires may generally lead to the formation of PCDD/PCDF and concludes that if, according to the opinion of the German Federal Authorities, specific measures are taken to clean up buildings after a fire, no investigations and dioxin tests have to be made in a single fire accident^{viii}.

Conclusions

The flame retarded EPS sample containing the polymeric brominated flame retardant analyzed at Ökometric GmbH shows insignificant levels of toxicologically relevant 2,3,7,8-PBDD/PBDF congeners, when compared to the chlorinated counterparts found in soot from wood. This means that in real fire incidents, there are no increased health and environmental risks arising from the formation of PBDD/PBDF initiated by the flame retarded expanded polystyrene foam evaluated in this statement.

This assessment was developed by Dr. Jürgen Troitzsch, Fire and Environmental Protection Service FEPS, Wiesbaden (Germany), December 2013

References

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- ^v <http://www.gesetze-im-internet.de/chemverbotsv/BJNR172010993.html>. Annex 1, Para 4 Dioxins and furans.
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