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EMISSIONS OF TETRABROMOBISPHENOL A FROM COMPUTER MONITORS

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Introduction

A significant part of IT equipment consists of plastic materials. The inherent flammability of these plastic materials constitutes a fire hazard to users and in many cases it is necessary to add flame-retardants to the plastic. The most widely used brominated flame retardant (BFR) in IT equipment is Tetrabromobisphenol-A (TBBPA). With a global use of about 120 000 tons per year[1], TBBPA is also the most produced BFR.

TBBPA is mainly used in two different applications. As an additive flame retardant TBBPA is used in Acrylonitrile Butadiene Styrene (ABS) plastic. This material is commonly used for producing housings of IT equipment such as video display units, laser printers or copy machines.
In its reactive application, TBBPA is mainly used to flame retard epoxy resin. Epoxy resin, together with glass fibres, is the base material for the production of printed wiring boards. Since these printed wiring boards are in direct contact with electric currents, they obviously need to be protected against ignition. More than 90% of printed wiring boards use TBBPA for this purpose. In this use TBBPA is covalently bound to the polymer backbone.

Test chamber experiments can be used to study emissions of low volatile substances. They can provide information about the general emission behaviour. However they are known to show specific difficulties. Adsorption on the chamber walls may lead to relevant sink effects. The main transport mechanism for low volatile substances is the transport of adsorbed substance on particles (suspended solids). The simulation of transport in test chambers is thus very difficult as usually filtered air is used and the defined air load with dust is hard to realize. On the other hand, test chamber investigations can be performed under strictly standardized conditions compared to real indoor air investigation. In order to take into account the transport mechanism by suspended solids, the test chamber investigations presented within the scope of this paper were completed by real life indoor air office measurements which will be published at a later stage.

Material and Methods

Description of monitors.

Three monitors were aquired from an electronic retailer. Two monitors contained additive TBBPA in the cabinet, an additional monitor that did not contain TBBPA in the cabinet was used as a reference monitor. The monitors used are described in table 1.

Table 1: Description of monitors investigated

Type of monitor	**TBBPA content in cabinet [%]**
Acer Color Monitor (two products analysed seperately) 15“(38cm) CRT size (measured diagonally), Made in Malaysia	12,6
Samsung Sync Master 710s (Reference monitor) 43cm (17“CRT,40cm viewable image size), Made in the U.K.	-

Test chamber parameters

The test chambers were made of high grade steel with connecting tubes for the air inlet/outlet and were equipped with various inlets for different sensoric systems (e.g. for the control of humidity and temperature). An adjustable ventilator was used for air mixing.

For the investigation, two test chambers with a volume of 0.51 m³ each were used (dimensions: 0.8 m x 0.8 m x 0.8 m). The input air was purified by a filtration system of oil separators, carbon filters and silica gel. In a further step, the air was led through a moistening system to control the humidity. An additional filter and a PU-foam system were used for cleaning before the air reached the chamber.

The chambers were kept at a temperature of 22°C (+/- 1°C). Air temperature in the middle of the chamber (above the monitor) was typically in the range of 25°-27°C. The air exchange rate was 2 per hour.

Sampling procedure

A combination of PU foam and glass fibre was used for sampling of TBBPA from air. This sampling system is widely used for the sampling of compounds with low volatility[2]. Before the sampling, the cartridge was spiked with the internal standard TBBPA (^{13}C-labeled).

Before the beginning of every individual experiment, the chamber was cleaned by means of solvents. After the cleaning, the monitor was placed in the chamber, switched on and connected with a computer. All energy saving settings were inactivated in order to enable a permanent operation of the monitor during the whole test period.

The individual sampling was usually carried out over a period of 20 to 24 hours, leading to typical sampling volumes of approx. 20 m³ (volume flow of 1 m³/h). Within the scope of quality assurance, two air samples were taken consecutively (e.g. after 9 res.10 days).

Laboratory procedure

After the air sampling, approx. 5 ml 1 N H_3PO_4 (for buffering) were added to the PU-foam which was soxhlet-extracted by means of ethyl acetate/ toluene (9/1, v/v) over a period of 8 hours. The extracts were reduced in volume to 50 µl. Afterwards, a syringe standard, Tetrachlorobisphenol A (TCBPA native), was added and a derivatization with diazomethane was carried out.

The measurements were carried out by means of HRGC/LRMS (high resolution gas chromatography/ low resolution mass spectrometry), using a DB 5 column (length: 50 m, inner diameter: 0,2 mm, film thickness: 0,33 µm) for gas chromatographic separation. The quantification was done by means of isotope dilution, based on ^{13}C-labeled TBBPA. For each compound analyzed, two masses were monitored.

Results and Discussion

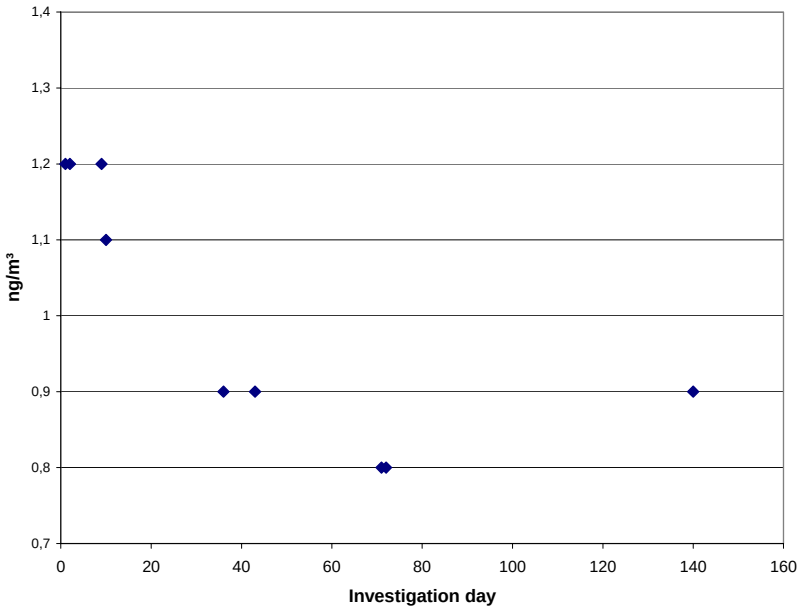
Table 2 and figure 1 present the concentrations of TBBPA measured in the test chamber outlet air over a period of 140 days. The general emission level of TBBPA was found to be 1 ng/m³. A slight decrease of TBBPA over the test period (140 days) was discernible. Chamber tests of the second monitor led to comparable air data.

Table 2: Test chamber investigation of Acer monitor 1, test chamber 1

Day	TBBPA [ng/m³]	TBBPA, mean [ng/m³]
Blank sample*	< 0,05	-
1	1,2	1,2
2	1,2	
9	1,2	1,2
10	1,1	
36	0,9	0,9
43	0,9	
71	0,8	0,8
72	0,8	
139	1,4	1,1
140	0,9	

** Empty test chamber before experiment*

Figure 1: TBBPA-test chamber investigation of Acer monitor 1, corrected for outliers



TBBPA data of two corresponding measurements (e.g. after 9 resp. 10 days) was usually very similar. The concentrations measured at days 139 / 140 (0,9 resp. 1,4 ng/m³) showed a higher difference compared to the other data sets. To our point of view, the data point of day 139 should be considered as an outlier.

In the test chamber air of chamber 2 (reference monitor without TBBPA in housing) no TBBPA was detected during 219 days (detection limit: 0,05 ng/m³). Our findings thus indicate that no TBBPA was emitted by other electronic component present in the monitor that potentially contained TBBPA (such as printed circuit boards).

Our study found comparatively low levels of emissions of TBBPA. Measured levels ranged between 0.8 and 1.4 ng/m^3 and were declining with time. This decline might be due to the fact that only the TBBPA molecules present at the surface of the plastic material are able to volatilize, whereas the potential diffusion of TBBPA from inside the plastic matrix to the surface is probably extremely slow. The decline of emissions of a real office experiment (data not shown here) was even more pronounced.

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