Research Article

Study on the migration of bisphenol-A from baby bottles by stir bar sorptive extraction-thermal desorption-capillary GC-MS

Migration of bisphenol-A (BPA), the principal monomer of polycarbonate (PC) baby bottles, was investigated using an aqueous migration simulant. BPA was determined in 200 mL water samples using stir bar sorptive extraction (SBSE) after in situ derivatization with acetic acid anhydride followed by thermal desorption (TD)-capillary GC-MS. Calibration for BPA was shown to be linear in a concentration range from 1 ng/L to 10 µg/L with a correlation coefficient \( r^2 = 0.99 \). The LOD for BPA (as acetate) was 0.12 ng/L and LOQ 0.40 ng/L (ppt). PC bottles were heated in a water bath and in a microwave oven at four different temperatures (37, 53, 65, and 85°C). The higher the temperature, the more the BPA was released, and after a few heating cycles, the released concentrations became constant. At normal use, i.e. at 37°C, concentrations are ca. 10 ng/L. No significant difference was noted between water bath and microwave heating illustrating that migration of BPA is mainly temperature dependent.

Keywords: Bisphenol-A / Polycarbonate baby bottles / Stir bar sorptive extraction / Thermal desorption / Capillary GC-MS

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1 Introduction

Bisphenol-A (BPA) is the principal monomer in the production of polycarbonate (PC) that has found widespread use in the manufacturing of baby bottles. PC has high transparency, good wear resistance, and can be sterilized in boiling water [1]. However, since most polymerization processes do not have a 100% yield, the finished plastic material might contain trace residue levels of the monomer [2]. Moreover, though PCs are tough and durable plastics having good physical stability at high temperatures, it is possible that at higher temperatures and especially at alkaline pH, hydrolysis of PCs can occur, releasing traces of BPA monomer on its surface. Consequently, BPA can migrate in food or beverages [2–4].

BPA has well-characterized estrogenic and endocrine disrupting activities that are mediated via multiple molecular mechanisms [5, 6]. Recent investigations on the environmental distribution and presence of BPA in humans and wildlife have generated scientific, regulatory, and public interest in assessing the potential health risks associated with BPA exposure. BPA is detected in water samples (river, water, tap) at nanogram per liter (ppt) levels [7–11], and BPA has also been found in trace amounts in human urine and blood [7, 12–16].

In 1990, the European Commission (EC) established a specific migration limit (SML) for BPA of 3 mg/kg of food or food simulant in Directive 90/128/EEC [17–20]. SML is the maximum allowed concentration of a migrated compound in food [21]. In 2002, BPA was re-evaluated by the Scientific Committee on Food, resulting in the establishment of a provisional tolerable daily intake for BPA at 0.01 mg/kg body weight per day [1, 22]. Hence, the drafted first amendment of the consolidated EC Directive related to plastic materials intended to come into contact with food-stuffs (2004/19/EC) has lowered the SML for BPA to 0.6 mg/kg of food or food simulant [1, 23].

To assess environmental and human exposure to BPA, a reliable, sensitive, and selective analytical method is required. Many analytical methods for the determination of phenolic xenoestrogens in water samples have been reported including LC with UV detection [24], electrochemical detection [10], fluorescence detection [13–14, 18, 24–26], chemiluminescence detection [27], and MS [28]. GC-MS is also used for the determination of phenolic compounds in aqueous samples. Derivatization is preferred since it leads to
better extraction, better peak shape, and higher sensitivity [7–9, 11, 12, 15–17, 28–30].

Traditional techniques for the extraction and concentration of BPA from aqueous samples are liquid–liquid extraction [14, 17, 18] and SPE [1, 10, 12, 13, 15, 18, 21, 26–28]. In recent years, solid-phase microextraction [8, 19, 31] and stir bar sorptive extraction (SBSE) [7, 9, 11, 16, 32] have also been employed for the enrichment of BPA from water samples.

The aim of this study was to develop a method to detect trace amounts of BPA released from PC baby bottles. BPA was determined in 200 mL samples of water by SBSE with in situ derivatization followed by thermal desorption (TD)-GC-MS. In situ derivatization was performed with acetic acid anhydride (AA) as the acetylation reagent. The determination of BPA in trace amounts using SBSE-TD-GC-MS and in situ derivatization was already described by Kawaguchi et al. [7, 9] and Nakamura and Daishima [11]. Only small sample volumes were used in these studies. In this study, the migration of BPA from PC baby bottles during simulated everyday use was evaluated and SBSE was performed on 200 mL of water, i.e. using the whole sample volume to avoid errors and artifacts by sub-sampling.

Water was used as the simulant for the migration testing according to the Directive in force, 85/572/EEC [33–35]. Although concerns were raised regarding the use of water as milk stimulant [36], it should be noted that a typical preparation of baby milk consists of pouring water in the baby bottle and to heating the bottle. After that the addition of milk powder follows [34, http://www.kindengezin.be/Ouders/Baby/Voeding/Flesvoeding/flessenmelk.jsp]. In this way, water as simulant can be considered valid for testing BPA migration from PC bottles as primary migration of BPA occurs in hot water.

In previous studies, migration of BPA under time and temperature test conditions [4, 37], during sterilization [18, 27, 34], and after dishwashing, boiling, and brushing [1, 27, 34] was examined. Migration can be the result of diffusion and/or hydrolysis and both mechanisms are temperature dependent. Residual levels of BPA in PC in the milligram per kilogram range (7–141 µg/g) were reported [4, 18, 38, 39]. De Souter claimed that hydrolysis is the predominant mechanism for BPA release from PC [40]. Under forced test conditions, PC undergoes hydrolysis yielding additional BPA, which also migrates to food simulants [4]. Howdeshell et al. [41] found that the amount of BPA is steadily released into room temperature water. Maragou et al. [34], however, assumed that there is a certain amount of residual BPA available on the surface of the PC bottles, which is released during sterilization and during incubation with hot water, but that it is unlikely that additional BPA is yielded throughout repeated treatment.

Also other publications described that the process is controlled by the diffusion of the compounds through the polymeric matrix, until they reach the interface with the simulant or with the food. As a thermodynamic process, the diffusion increases with the temperature; therefore, when the temperature increases, the migration will increase and, consequently, the risk of food contamination increases [39, 42].

In this study, the influence of temperature on the migration of BPA was tested, and a migration profile in function of use (100 heating cycles) was determined. The PC bottles were subjected to heating in a microwave oven at four different temperatures (37, 53, 65, and 85°C). Two brands of PC bottles were compared under commonly used conditions. The influence of microwave heating was also compared with heating in a baby bottle heater (water bath).

2. Materials and methods

2.1 Materials and reagents

BPA or 2,2-bis(4-hydroxyphenyl)propane 99+%, K2CO3 99+%, and acetone (Chromasolv) were purchased from Sigma-Aldrich Chemie (Steinheim, Germany). BPA diacetate 99 and AA for trace analysis were purchased from Acros (Geel, Belgium). BPA (propane-D6) 98% (d6-BPA) was obtained from Cambridge Isotope Laboratories (Andover, MA, USA). Bottled water (Romy, Jandun, France) was used as the simulant. Stock standard solutions of BPA, BPA diacetate, and d6-BPA were prepared by diluting each compound to a concentration of 1.0 mg/mL in acetone.

2.2 Identification of baby bottles materials with FT-IR

Two commercial brands of PC baby bottles were tested. Specimens of each brand were analyzed using a Perkin-Elmer Spectrum 1000 FT-IR infrared spectrometer (Perkin-Elmer, Beaconsfield, UK). A small piece of each sample was placed in the cell of the spectrometer and scanned within the transmittance range of 4000–370 cm–1. The spectra were compared with a known spectrum of PC [38], and it was confirmed that both materials correspond to the same PC type.

2.3 Sample preparation by SBSE with in situ derivatization

2.3.1 Method validation

Water (200 mL, cold or warm) was poured in a graduated Duran laboratory bottle of 250 mL (d = 70 mm, h = 143 mm, DIN 45 GL) (Schott, Mainz, Germany) and was spiked with BPA and d6-BPA. For pH adjustment 0.5 g K2CO3 (pH 11) and 0.5 mL as derivatization reagent AA were added. Stir bars coated with PDMS (1 mm film thickness, 20 mm length, 126 µL PDMS volume) from Gerstel (Mülheim a/d Ruhr, Germany) were used for extraction. Extraction was
performed for 60 min while stirring at 500 rpm. After extraction, the stir bar was removed with forceps, rinsed with purified water, dried with lint-free tissue, and placed in a glass TD tube. The TD tube was then placed in the thermal desorption system (TDS) unit and thermally desorbed.

2.3.2 Migration tests of BPA

Water (200 mL) was poured into a PC baby bottle and spiked with d6-BPA (100 ng). The PC bottle was heated in a microwave oven or in a baby bottle heater at selected temperatures. The water was allowed to have 30 min contact time with the bottle. This was repeated 100 times for every bottle at each temperature. The influence of different temperatures by heating in the microwave oven was also evaluated, using a new PC bottle for each temperature. After 30 min contact time the water was poured in a Duran laboratory bottle of 250 mL. Then, 0.5 g K2CO3 and 0.5 mL AA were added. The extraction procedure was the same as described in Section 2.3.1.

Blank measurements were performed in the same way, but instead of using PC-bottles, glass bottles were taken.

2.4 Instrumentation

GC-MS was carried out on an Agilent 6890/5973 system (Agilent Technologies, Little Falls, DE, USA) equipped with a Gerstel TDS-2 thermodesorption system. A CIS-4 PTV injector (Gerstel) was used for cryofocusing the analytes before transfer onto the analytical column. Liquid nitrogen was used to cool the CIS-4 down to −150°C during TD. SBSE desorption was performed at 35°C for 1 min, then programmed at 60°C/min to 300°C and held for 10 min under a flow of 100 mL/min helium. The injector temperature was held at −150°C for 0.1 min, then programmed at 10°C/s to 300°C, and held for 5 min. Injection was performed in the splitless mode (2 min). A HP-5MS capillary column (30 m × 0.25 mm id and a film thickness of 0.25 μm) was used. The oven temperature was programmed from 40°C (held for 1 min) to 300°C (held for 3 min) at 10°C min⁻¹. Helium was used as carrier gas at a constant column flow rate of 1.2 mL/min. The mass spectrometer was operated in the SIM mode with electron ionization (70 eV). For SIM, within the 20–30 min elution window four ions were monitored (m/z 213 and 228 for the acyl derivative of BPA and 216 and 234 for the acyl derivative of d6-BPA). The italicized values are the m/z of the ions used for quantification.

3 Results and discussion

3.1 Recovery of BPA and BPA-diaceate

In SBSE, the recovery (extraction efficiency) depends on the phase ratio (VPDMS versus Vsample) and on the partition coefficient of the solute between PDMS and water. The value of the latter is very close to the water–octanol partitioning coefficient [43]. Table 1 shows the log KOW values and the theoretical recoveries of BPA and BPA-acetate in function of sample volume and PDMS quantity (VPDMS). The first observation is that the recoveries for the diacetate derivative are much higher than that for the free phenolic form. Other reasons to select the derivative are the much better chromatographic performance and robustness of the method. For small sample volumes (e.g. 10 mL), extraction of BPA diacetate is >98%. Increasing the sample volume to 200 mL drops the recovery to 78% due to the less favorable phase ratio. For this reason, a long stir bar with thick coating was used. The use of a high PDMS volume (126 μL) results in a high (theoretical) recovery of 95% for BPA diacetate.

The experimental recovery was measured by spiking 100 ng BPA and d6-BPA into 200 mL water, followed by in situ derivatization (0.5 mL AA+0.5 g K2CO3). The solution was stirred with the thick PDMS bar for 1 h (sample A) and for 5 h (sample A') both at 500 rpm. The peak areas were compared with the peak area obtained by spiking the same absolute BPA diacetate amount on a small plug of glass wool placed inside an empty desorption tube (sample B). The recovery after 1 h sampling (A/B) was 25.5% ± 3.5% (n = 6). The recovery after 5 h sampling (A'/B) was 64.4% ± 7.0% (n = 6). This is much lower than theoretically predicted. This difference can be due to the fact that equilibrium has not been reached, to incomplete derivatization or to wall adsorption effects.

The completeness of the in situ derivatization reaction was verified by spiking 100 ng of BPA diacetate, corre-

<table>
<thead>
<tr>
<th>Compound</th>
<th>Log KOW</th>
<th>Theoretical recovery (%) 10 mL, 24 μL</th>
<th>Theoretical recovery (%) 200 mL, 24 μL</th>
<th>Theoretical recovery (%) 10 mL, 126 μL</th>
<th>Theoretical recovery (%) 200 mL, 126 μL</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPA</td>
<td>3.90*</td>
<td>88.4</td>
<td>27.5</td>
<td>97.6</td>
<td>66.6</td>
</tr>
<tr>
<td>BPA diacetate</td>
<td>4.48*</td>
<td>98.6</td>
<td>78.4</td>
<td>99.7</td>
<td>95.0</td>
</tr>
</tbody>
</table>

* Log KOW values for BPA and BPA diacetate as predicted by “IA log P predictor” and [14, 21].
sponding with the same quantity of BPA in sample A, into 200 mL water and SBSE was performed for 1 h at 500 rpm (sample C). The peak area ratio A/C was 98% ± 3.2%. From this test it could be concluded that derivatization is complete as similar recoveries are obtained for BPA and BPA diacetate. The absolute recovery of 64.4 is thus the result of wall effects and incomplete equilibrium.

3.2 Evaluation of extraction time

An important parameter affecting SBSE is the extraction time. The recovery in function of time was tested on 200 mL water samples spiked with 100 ng of the acyl derivative of BPA. Equilibrium was not reached after 5 h for this high volume. Note that for a 10 mL sample equilibrium was reached after 1 h. For SBSE in practice, full equilibrium is not needed if the time is well defined. One hour was selected and, moreover, the deuterated standard d6-BPA corrects for minor time differences and for eventual wall effects that are also time dependent after the derivatization.

3.3 Optimization of the desorption process

The efficiency and completeness of the TD step is also a critical aspect of the method. As a high quantity of sorptive material is used, desorption is expected to be slow [43, 44]. To determine whether there was complete desorption and no carry-over, second desorptions were carried out on the same stir bar at different temperatures and time. These experiments indicated that desorption at 300 °C for at least 10 min is required to reduce the carry-over to less than 0.1%.

3.4 Method validation

Three different waters were tested as simulants: MilliQ-water, HPLC-water, and bottled drinking water. All samples contained traces of BPA with the bottled drinking water giving the lowest amounts of ca. 8 ± 1.5 ng/L (n = 6). This value was taken as background level (blank concentration) and all data were corrected for this value. It is unclear and very difficult to elucidate whether the blank value is due to the water or to the laboratory environment. The linearity was evaluated at 10 concentration levels ranging from 1 ng/L to 10 μg/L in water. Solutions of BPA in acetone were spiked in ten 200 mL water samples. The internal standard was spiked at a constant concentration of 1250 ng/L. The correlation coefficient was 0.9994. The LOD at S/N 3 was 0.12 ng/L and the LOQ at S/N 10 was 0.40 ng/L/L. The repeatability was checked at the 250 ng/L level. The RSD on six replicates was 8.5%. The response factor of BPA versus d6-BPA was 1.04 (RSD = 9.5%).

The repeatability was also tested using water samples at higher temperatures. For this purpose, the water was heated for 40, 60, and 90 s at 1000 W in a microwave oven. After heating, the temperature of the water reached 53, 65, and 86 °C, respectively (Table 2). The water was then allowed to cool for 30 min. After that time, the temperature was 41, 45, and 58 °C, respectively, and SBSE with in situ derivatization was started. After sampling, the temperatures were still 33, 35, and 37 °C, respectively.

The results were compared with the results without heating and responses were all within the RSD range of 8.5%. SBSE can thus also be applied for heated water samples.

3.5 Analysis of PC bottles

3.5.1 Influence of the temperature on the migration of BPA

A PC bottle, filled with 200 mL water and spiked with d6-BPA, was subjected to 100 heating cycles in a microwave oven at 1000 W during a selected time. The BPA release in function of number of heating cycles was measured. This test was performed at four different heating times (20, 40, 60, and 90 s), resulting in different temperatures (see Table 2: respectively, 37, 53, 65, and 86 °C after heating). For each temperature, a new PC baby bottle from the same manufacturer was used. Each baby bottle was also tested twice under cold conditions, namely, before the first heating cycle and after 100 heating cycles. The results of these experiments are shown in Fig. 1.

From the results, it is clear that with increasing temperature more BPA is released from the bottles. At low temperature (cold extraction before first heating cycle and after last heating cycling) only very small quantities of BPA are released.

At the highest temperature (86 °C, 90 s at 1000 W) the released amount reached a maximum after 25 cycles, followed by a decrease in BPA concentration and finally in a nearly constant release after 60 cycles. The profile of 60 s heating (65 °C) is similar, but the highest release is observed after four cycles. The profile of 40 s heating is slightly different, there is a small increase until a constant release is observed after five heating cycles. In the profile of 20 s heating (37 °C), only a constant very low release is observed.

At 86 °C (90 s at 1000 W), the average concentration of released BPA was 1.550 ng/L (RSD = 8%). At 60 s heating or

<table>
<thead>
<tr>
<th>Heating in the microwave</th>
<th>Temperature after heating (°C)</th>
<th>Temperature after 30 min (°C)</th>
<th>Temperature after 90 min (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20 s, 1000 W</td>
<td>37</td>
<td>32</td>
<td>29</td>
</tr>
<tr>
<td>40 s, 1000 W</td>
<td>53</td>
<td>41</td>
<td>33</td>
</tr>
<tr>
<td>60 s, 1000 W</td>
<td>65</td>
<td>45</td>
<td>35</td>
</tr>
<tr>
<td>90 s, 1000 W</td>
<td>86</td>
<td>58</td>
<td>37</td>
</tr>
<tr>
<td>60 s, 500 W</td>
<td>37</td>
<td>32</td>
<td>29</td>
</tr>
</tbody>
</table>
65 °C, the migration of BPA was 200 ng/L (RSD = 13%). For 40 (53 °C) and 20 s (37 °C), BPA migrated into the water with concentrations of 90 (RSD = 14%) and 13 ng/L (RSD = 20%), respectively. All results were corrected for a blank concentration of 8 ng/L BPA. From these results, it is clear that temperature is the major factor for BPA migration from PC baby bottles into water.

In this study, an exponential relationship between heating temperature and average released concentration was found. During cold extraction, only traces of BPA are detected in the water simulant. At temperatures of 37 and 53 °C, the maximum of release is obtained after a few cycles. In our opinion, in these cases, the release of residual traces of BPA from PC is responsible for the overall BPA concentration in the simulant. Diffusion is proportional to temperature and the difference between room temperature, 37, and 53 °C can be explained by diffusion.

At the two highest temperatures (65 and 86 °C), first the residual BPA is released (diffusion), followed by a drop in released BPA concentration and finally a constant release is observed. At these higher temperatures, we expect that hydrolysis also contributes to the overall BPA release. Hydrolysis is a chemical reaction and the exponential relationship between released BPA concentration and temperature can probably be explained through hydrolysis kinetics.

3.5.2 Influence of the contact time of the PC bottle with the water food simulant on the migration of BPA

The influence of the contact time of the PC bottle with the water food simulant was also tested. This was performed by heating 200 mL of water in the microwave oven for 60 s at 1000 W (65 °C). Bottles that already reached a constant release of BPA were used. After heating and different contact times, namely, 0, 30, and 60 min, SBSE was performed. In Fig. 2, the results are shown. No difference was observed between 0 and 30 min contact time. Apparently BPA migrates only during the heating time. Using a 60 min contact time, a slightly lower BPA release (∼25%) was measured. This can be explained by a wall effect (backadsorption of BPA to PC). This test also clearly indicates that the use of water can be used to simulate migration into milk, as temperature and contact with water during heating is the most important for BPA release. Moreover, a 30 min contact time of the PC bottle with the water gives a realistic scenario since it corresponds well to the real-life situation (cooling, eating, etc.).

3.5.3 Influence of the microwave energy and the heating time on the migration of BPA

BPA release from a baby bottle heated for 60 s at 1000 W (65 °C) and from another one heated for 20 s at 1000 W (37 °C) was compared with a bottle heated for 60 s at 500 W (37 °C).
The data shown in Table 3 confirm that the migration of BPA is mainly controlled by the temperature. Comparing 20 and 60 s at, respectively, 1000 and 500 W (both resulting in the same temperature), similar migration values are obtained although they have a different heating time and power. Only after the first heating cycle, a significant difference was noted, probably due to the release of BPA from the surface (in this case time is important).

### 3.5.4 Migration of other compounds from the PC bottles

In addition to BPA, other compounds were released from PC bottles (Fig. 3). GC-MS analyses were performed in the scan mode (50–550 amu) for bottles heated for 60 s in the microwave oven at 1000 W. The signals were higher for a new bottle (A) compared with the same bottle after 40 heating cycles (B). This corresponds with the observations made by Brede et al. [1].

One of the detected compounds was identified as diphenyl carbonate, a chemical intermediate in the synthesis of aromatic PCs. The migration is the result of residues left in the bottle since the concentration decreased fast in function of time (heating cycle). This means that diffusion rather than hydrolysis is taking place. However, the toxicity of diphenyl carbonate is very low with LD$_{50}$ values exceeding 2 g/kg in rats. The origin of the other migrants was not investigated further, and their concentration also decreased in function of time.

### 3.5.5 BPA migration under conditions of normal use

At normal use, a baby bottle is heated to body temperature (37–40°C). For this purpose two different brands of baby bottles were tested by heating for 20 s at 1000 W in the microwave oven (37°C). For comparison, we also studied the migration of BPA when they were heated in a baby bottle heater (water bath). The results are shown in Fig. 4.

For the initial three heating cycles, brand 1 showed a higher release of BPA than brand 2 which means that a higher residual BPA level is present in brand 1. After 20 heating cycles, no significant difference between the two brands was observed. From these results, it is also clear that a bottle heated in a bottle heater or in the microwave oven releases a similar amount of BPA, illustrating that migration of BPA is mainly temperature dependent. This was also observed by Castle et al. [45], who found no quantitative effect on migration as a result of microwave energy. During the initial heating cycles, the release of BPA was even somewhat lower using microwave heating in comparison to water bath heating. This can be explained by the fact that in the water bath the PC bottle is heated directly, while the microwaves heat the water inside the bottle. Overall, BPA migrates only at very low concentration level (6–13 ng/L) when the bottles are used under normal conditions.

Under the above test conditions no attention was paid to the common practice that baby bottles are sterilized before each use, until the baby has the age of 6 months. For this purpose a new PC bottle and a used PC bottle (20 s, 1000 W, after 100 times of heating) of both manufacturers were sterilized before performing a migration test. This was done in boiling water for 10 min. Afterwards the bottles were allowed to leak out the water. When they were dry, they were analyzed again using the normal procedure at 20 s at 1000 W.

As can be seen from Fig. 5 more BPA (20–90 ng/L) is released into the water after sterilization. This could be expected because during sterilization the bottles stayed for 10 min in boiling water, releasing a higher amount of BPA. The water was just removed by holding the bottles upside

### Table 3. Influence of the microwave energy and the heating time on the migration of BPA

<table>
<thead>
<tr>
<th>Heating cycle</th>
<th>Conc. BPA (ng/L) 60 s, 500 W (37°C)</th>
<th>Conc. BPA (ng/L) 20 s, 1000 W (37°C)</th>
<th>Conc. BPA (ng/L) 60 s, 1000 W (65°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>53</td>
<td>24</td>
<td>95</td>
</tr>
<tr>
<td>4</td>
<td>15</td>
<td>20</td>
<td>296</td>
</tr>
<tr>
<td>20</td>
<td>25</td>
<td>18</td>
<td>147</td>
</tr>
<tr>
<td>60</td>
<td>11</td>
<td>12</td>
<td>195</td>
</tr>
<tr>
<td>100</td>
<td>17</td>
<td>11</td>
<td>226</td>
</tr>
</tbody>
</table>
down and drying to the atmosphere (common practice), so that some of the released BPA was adsorbed on the walls of the bottle (re-uptake). During the following use, this residue rapidly migrates into the water, resulting in a 4–7 times higher concentration of BPA. It is therefore mandatory that sterilization water is completely removed before baby milk preparation and best is to rinse a sterilized bottle with pure water before use.

To confirm BPA release due to sterilization, 200 mL of the water used for sterilization of two bottles was analyzed. This “sterilization” water samples contained concentrations of 2–3 µg/L BPA. This result is quite comparable to the results obtained when heating a bottle to 85°C (lower temperature than for sterilization), which gave a release of 1.5 µg/L of BPA. It is therefore mandatory that sterilization water is completely removed before baby milk preparation and best is to rinse a sterilized bottle with pure water before use.

4 Concluding remarks

A sensitive method was developed to detect trace amounts (ng/L level) of BPA in 200 mL water samples. The method is based on SBSE with in situ derivatization followed by TD-GC-MS. The detection limit of BPA in water was 0.12 ng/L (ppt). Calibration for BPA was shown to be linear in a concentration range between 1 ng/L and 10 µg/L with a correlation coefficient of >0.99.

PC baby bottles were subjected to simulated everyday use. The higher the temperature, the more the BPA was released from the bottle. After a few heating cycles the released concentrations became constant. The influence of microwaves was also investigated but the released concentrations of BPA were comparable to those obtained using a water bath heater.

At normal use the released BPA quantities are neglectable (maximum 2 ng per feeding) and far below the tolerable daily intake value.

The authors have declared no conflict of interest.

5 References


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