Release of melamine and formaldehyde from dishes and kitchen utensils

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Melamine resins are polymers and consist of the starting substances (monomers) melamine and formaldehyde. The materials are hard and unbreakable, and for these material properties they are used for the production of dishes and kitchen utensils.

Consumer products made of melamine resins such as plates, cups, bowls or cutlery can release melamine and formaldehyde if they are exposed to high temperatures above 70 ° C. Migration limits have been set for the migration of melamine and formaldehyde into foods.

Testing by the Federal Institute for Risk Assessment (BfR) as well as test results of the competent *Länder* (regional) authorities for the official control of foodstuffs reveals that the regulatory migration limits for the migration of melamine and formaldehyde to food are exceeded at higher temperatures. This occurs especially at 100 °C, the boiling point of water.

If kitchen utensils made of melamine resin are used for frying and cooking or the heating of foods in a microwave oven, amounts of melamine and formaldehyde which present a health risk can transfer into food. This is especially the case for acidic foods including many fruit and vegetable preparations. Furthermore, the health risk through inhalation of formaldehyde from kitchen utensils is possible, as the substance also distributes into the air. BfR thus maintains that consumers should avoid the use dishes and kitchen utensils made of melamine resins when frying or cooking or when heating foods in a microwave oven.

If the products are used at temperatures up to 70 °C, they are not likely to be dangerous to human health. Such temperatures are reached, for example, when hot beverages or foods are filled into cups, bowls or onto plates. Products made of melamine are also safe for use as salad servers or cutlery.

1. Subject of the assessment

Melamine and formaldehyde are used in the production of polymers, so-called melamine resins, which are used to manufacture kitchen dishes such as plates, cups or bowls as well as kitchen utensils such as cooking spoons or spatulas. These two monomer starting substances are released especially when they come into contact with foods at high temperatures and then transfer into the food.

2. Results

If kitchen utensils made of melamine resins remain in boiling foods for a longer period of time, concentrations of the monomers melamine and formaldehyde that are likely to be dangerous to human health can transfer into the food. In addition, possible respiratory exposure to formaldehyde also presents a health risk.

Therefore, according to BfR, consumer products made of melamine resins are not suitable for use when cooking or in microwave ovens. However, the use of melamine resins at room temperature and temperatures up to 70 °C – conditions such as those when hot beverages or foods are filled into cups, bowls or onto plates – can be considered safe for human health.

Labelling with regard to restrictions for the use of kitchen utensils (cooking spoons) will, according to BfR, not be helpful, as such information does not correspond to the customary use of such utensils in food preparation.

3. Rationale

According to EU Regulations, melamine and formaldehyde are authorised as monomers and additives in the production of plastics for food contact [1]. The use of melamine is currently subject to a specific migration limit (SML) of 30 mg/kg food. This SML was established based on the tolerable daily intake (TDI) of 0.5 mg/kg body weight [2] which was determined by the EU Scientific Committee on Food (SCF) in 1986. This SML was derived under the standard assumption that a person with a body weight of 60 kg consumes 1 kg of a correspondingly contaminated food per day. The additional assumption that 1 kg food comes into contact with 6 dm² plastic surface yields an SML in regard to surface area of 5 mg/dm². In the result of its re-assessment of melamine in 2010, the European Food Safety Agency (EFSA) lowered the TDI to 0.2 mg/kg body weight [3] and recommended to reconsider the specific migration limit taking into account all sources of exposure to melamine. Formaldehyde has an SML of 15 mg/kg food corresponding to 2.5 mg/dm² [1].

EFSA's re-assessment of melamine included an estimation of the contribution that melamine migration makes to the total exposure through food contact materials. The release of melamine from food contact articles made of melamine-formaldehyde resins (melamine, melamine resins, melaware) was deemed as a considerable source of exposure. Research literature did not provide sufficient data for this aspect. Thus, additional testing was done in a research programme under participation of several laboratories in the United Kingdom, the Netherlands and Germany (including BfR) and these values were also taken into account in EFSA's Scientific Opinion. The study results were published [4]. Under test conditions akin to hot filling, migration values of up to 4.6 mg/kg were found, while cooking conditions yielded values of up to 14.4 mg/kg.

The following conclusions were drawn:

- It must be noted that melamine is not only transferred to foods through migration. Melamine resins are chemically degraded especially at high temperatures and probably accelerated by acids, thereby melamine is released.
- The influence of acidity of the food simulant is not as great as expected. Transfers resulting from 3 % acetic acid are only one of about two factors above values that were detected when water was used. The use of 3 % acetic acid as simulant adequately represents transfer in acidic beverages.
- The conditions of temperature and time have strongly impacted the results. Especially when kitchen utensils such as kitchen spoons were tested under boiling conditions, degradation processes on the surface resulted in high rates of melamine release. The degradation of the polymer surface is visually observable.
- In microwave heating, high peak temperatures (hot spots) have been shown to result in high melamine transfers despite short contact times.

Additional test results were discussed within the BfR Committee for Consumer Products according to which the regulatory migration limits for melamine and formaldehyde are clearly exceeded during tests of kitchen utensils made of melamine and formaldehyde resins [5, 6]. Tests carried out by control laboratories also revealed that at an oven temperature of 100 °C, the test medium itself only reaches temperatures of 85 to 90 °C. This effect is due to heat deprivation as a result of evaporation of water. Because temperature is of major influence on

the release of melamine, it must be assumed that tests at 100 °C in the laboratory oven do not reflect the transfer that occurs during cooking processes.

Therefore the National Reference Laboratory carried out further tests on substances intended to come into contact with food in regard to melamine transfer into real foods during cooking. In comparison, the transfer into 3 % acetic acid was also tested. Two different cooking spoons made of melamine resin were tested. In accordance with requirements for testing food contact articles that are used repeatedly, three successive migration tests were carried out. The simulant, i.e. the food, was heated to the boiling point on a hot plate and stirred constantly with the respective cooking spoon for two hours at this temperature. For the choice of foods, tomato soup, plum sauce and sauerkraut was taken into account due to the predictably long heating process. The chemical analysis was carried out as described in the publication cited above [4].

The applicable specific migration limit for melamine was exceeded in all cases. The third migration test yielded a value of 33 mg/dm² in 3 % acetic acid as well in Sauerkraut. The results of comparable tests verify that a 3 % acetic acid solution is a suitable simulant for cooking. While these are initial results, further testing to substantiate these findings are under way.

In addition to melamine, formaldehyde is the second monomer used in the production of melamine resins. In order to determine the transfer of formaldehyde in migration solutions, the acetylacetone method described in pre-standard DIN CEN/TS 13130-23 [7] was optimised at BfR. With this photometric method, detection in real foods is not possible, for which reason tests were limited to the testing of formaldehyde transfer in boiling 3 % acetic acid. The migration solutions were produced in the same manner as described for melamine.

Testing of formaldehyde transfer yielded values of 22 mg/ dm² for both cooking spoons, which is thus a considerable exceedance of the specific migration limit for this substance as well.

Formaldehyde is a highly volatile substance, which is released into the ambient air. In order to examine the release behaviour, formaldehyde was added to a 3 % acetic acid solution and kept at boiling point for two hours while stirring. Though formaldehyde is very soluble, the volatility led to a 60 % decrease of the original value after two hours of cooking. This means that 60 % of the formaldehyde is released into the ambient air and could be taken up via inhalation.

In order to estimate potential inhalative exposure, the following assumptions were made in an exemplary simplified manner:

- 20 mg formaldehyde migration in 1 kg food
- 50 % transfer, i.e. 10 mg formaldehyde, into the ambient air during cooking
- Room dimensions (kitchen) of 3.0 x 4.0 x 2.5 m (w x d x h), i.e. a volume of 30 m^3.

This results in a calculated concentration of 0.33 mg/m^3 formaldehyde in the ambient air, i.e. 0.28 ppm.

In the context of the harmonised classification and labelling of substances and mixtures within the EU, the classification of formaldehyde as inhalation carcinogen is under debate, and a corresponding classification proposal was prepared by France. In a toxicological assessment of formaldehyde in 2006, BfR derived a tolerable air concentration as so-called

"safe level" from animal testing data on cell proliferation as well as human data on sensory irritation of the upper respiratory tract of 0.1 ppm (parts per million), which is 0.124 mg/m³ [8]. This "safe level" is exceeded under the assumed conditions, thus creating a potential consumer health hazard through inhalation exposure to formaldehyde even taking into account the relatively short exposure time.

Manufacturers have in part reacted to the test results by labelling consumer products made of melamine resin with limitations accordingly (e.g. "Do not keep in hot food", "To be left in food for max. 15 min and 170 °C", "max. 150 °C, max. 20 seconds", "max. 10 minutes/100°C"). However, labelling that provides such limitations of the use of kitchen utensils intended for cooking purposes (cooking spoons) is not helpful, according to BfR, as such information restricts the customary use of such utensils in food preparation strongly. Furthermore, such labels are often not firmly affixed to the consumer good, and as a consequence the consumer can often disregard such limitations in everyday use.

4. Risk management options

If kitchen utensils remain in boiling foods for a longer period of time, concentrations of the monomers melamine and formaldehyde that present a health risk can be released into food and the ambient air. The inhalative exposure to formaldehyde also constitutes a potential health risk.

According to BfR, for these reasons consumer goods made of melamine resins should not be used for cooking or in microwave ovens. However, the use of melamine resins at room temperatures and at temperatures of up to 70 °C – conditions such as those when hot beverages or foods are filled into cups, bowls or onto plates – can be considered safe for human health.

References

1. Directive 2002/72/EC relating to plastic materials and articles intended to come into contact with foodstuffs (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CONSLEG:2002L0072:20080327:EN:PDF)

2. Scientific Committee for Food (SCF) 1986. Report of the Scientific Committee for Food on certain monomers of other starting substances to be used in the manufacture of plastic materials and articles intended to come into contact with foodstuffs. Seventeenth series. Opinion expressed on 14 December (1984). (http://ec.europa.eu/food/fs/sc/scf/reports/scf_reports_17.pdf/)

3. Scientific Opinion on Melamine in Food and Feed*; EFSA Journal* 2010; **8**(4):1573

4. Bradley, E.L. et al.: Comparison of the migration of melamine from melamine–formaldehyde plastics ('melaware') into various food simulants and foods themselves, Food Additives & Contaminants: Part A., 27 (2010), 1755-1764

5. Sitzung der BfR-Kommission für Bedarfsgegenstände, Protokoll vom 17. November 2009, Tagesordnungspunkt 22c (Melaminfreisetzung aus Küchenutensilien)(http://www.bfr.bund.de/cm/207/4_sitzung_der_bfr_kommission_fuer_bedarfsgegenstaende.pdf)

6. Sitzung der BfR-Kommission für Bedarfsgegenstände, Protokoll vom 22. April 2010, Tagesordnungspunkt 8 (Melaminfreisetzung aus Küchenutensilien) (http://www.bfr.bund.de/cm/207/5_sitzung_der_bfr_kommission_fuer_bedarfsgegenstaende.pdf)

7. Vornorm DIN CEN/TS 13130-23, Werkstoffe und Gegenstände in Kontakt mit Lebensmitteln - Substanzen in Kunststoffen, die Beschränkungen unterliegen - Teil 23: Bestimmung von Formaldehyd und Hexamethylentetramin in Prüflebensmitteln; Deutsche Fassung CEN/TS 13130-23:2005 (2005-05)

8. Toxikologische Bewertung von Formaldehyd, Stellungnahme des BfR Nr. 023/2006 vom 30. März 2006 (http://www.bfr.bund.de/cm/252/toxikologische_bewertung_von_formaldehyd.pdf)