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Safety assessment of the substance zinc oxide, nanoparticles, for use in food contact materials

EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF)

Abstract

This scientific opinion of the EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF Panel) deals with the safety assessment of zinc oxide, nanoparticles, (FCM No 1050) for use as a transparent ultraviolet light absorber in unplasticised polymers at up to 2% by weight. The substance is added as a dispersion of the powder in nanoform. In the final polymer, nanoparticles are still present. The specific migration of the substance (determined as zinc) was tested from low-density polyethylene plaques containing 2% of the additive, into 3% acetic acid, and 10% and 50% ethanol for 10 days at 60°C. Migration levels of zinc into these three simulants was 2.0, 0.05 and 0.06 mg/kg, respectively. In 2003, the Scientific Committee on Food established for zinc a no observed adverse effect level of 50 mg/person per day and an upper limit of 25 mg/person per day was recommended. Taking into account the knowledge about the diffusional properties of nanoparticles in polymers and the solubility characteristics of the zinc oxide nanoparticles, the CEF Panel concluded that the substance does not migrate in nanoform and therefore the safety evaluation should focus on the migration of soluble ionic zinc. The migration data for ionic zinc coming from the substance used in low-density polyethylene as a worst case representative of non-plasticised polymers, comply with the current specific migration limit (SML), but in combination with the dietary exposure from other sources the upper level (UL) of 25 mg/person per day could be exceeded.

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Keywords: zinc oxide nanoparticles, FCM No 1050, food contact materials

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Table of contents

Abstract.....	1
1. Introduction.....	4
1.1. Background and Terms of Reference as provided by the requestor	4
2. Data and Methodologies	4
2.1. Data.....	4
Non-toxicity data.....	4
Toxicity data	4
2.2. Methodologies	4
3. Assessment	5
3.1. Non-toxicological data	5
3.2. Toxicological data	6
4. Conclusions	6
5. Recommendations.....	6
Documentation provided to EFSA	6
References.....	7
Abbreviations	8

1. Introduction

1.1. Background and Terms of Reference as provided by the requestor

Before a substance is authorised to be used in food contact materials and is included in a positive list EFSA's opinion on its safety is required. This procedure has been established in Articles 8 and 9 of the Regulation (EC) No 1935/2004¹ of the European Parliament and of the Council of 27 October 2004 on materials and articles intended to come into contact with food.

According to this procedure, the industry submits applications to the Member States competent Authorities which transmit the applications to EFSA for their evaluation.

In this case, EFSA received an application from the Ministry of Health, Welfare and Sport, the Netherlands, submitted by BYK Chemie GmbH, Germany, requesting the evaluation of zinc oxide, nanoparticles (FCM No 1050).

According to Regulation (EC) No 1935/2004 of the European Parliament and of the Council on materials and articles intended to come into contact with food EFSA is asked to carry out an assessment of the risks related to the intended use of the substance and to deliver a scientific opinion.

2. Data and Methodologies

2.1. Data

The applicant has submitted a dossier in support of their application for the authorisation of zinc oxide, nanoparticles, to be used in food contact materials (FCM).

Data submitted and used for the evaluation are:

Non-toxicological data and information

- Chemical identity
- Physical and chemical properties
- Intended use
- Existing authorisation
- Data on purity, impurities and thermal stability
- Information on the production technology
- Data on physical properties of the substance incorporated into the polymer
- Data on migration and residual content of the substance

Toxicological data

- None

2.2. Methodologies

The assessment was conducted in line with the principles laid down in Regulation (EC) No 1935/2004 on materials and articles intended to come into contact with food. This Regulation underlines that applicants may consult the Guidelines of the Scientific Committee on Food (SCF) for the presentation of an application for safety assessment of a substance to be used in FCM prior to its authorisation (EC, 2001), including the corresponding data requirements. The dossier that the applicant submitted for evaluation was in line with the SCF guidelines (EC, 2001).

¹ Regulation (EC) No 1935/2004 of the European parliament and of the council of 27 October 2004 on materials and articles intended to come into contact with food and repealing Directives 80/590/EEC and 89/109/EEC. OJ L 338, 13.11.2004, p. 4–17.

The methodology is based on the characterisation of the substance(s) object of the request for safety assessment prior to authorisation, its impurities and reaction and degradation products, the evaluation of the exposure to those substances through migration, and the definition of minimum sets of toxicity data required for safety assessment.

To establish the safety from ingestion of migrating substances, the toxicological data indicating the potential hazard and the likely human exposure data need to be combined. Exposure is estimated from studies on migration into food or food simulants and considering that a person may consume daily up to 1 kg of food in contact with the relevant FCM.

As a general rule, the greater the exposure through migration, the more toxicological data is required for the safety assessment of a substance. Currently, there are three tiers with different thresholds triggering the need for more toxicological information as follows:

- a) In case of high migration (i.e. 5–60 mg/kg food), an extensive data set is needed.
- b) In case of migration between 0.05 and 5 mg/kg food, a reduced data set may suffice.
- c) In case of low migration (i.e. < 0.05 mg/kg food), only a limited data set is needed.

More detailed information on the required data is available in the SCF guidelines (EC, 2001).

The assessment was conducted in line with the principles described in the European Food Safety Authority (EFSA) Guidance on transparency in the scientific aspects of risk assessment (EFSA Scientific Committee, 2009) and considering the relevant existing Guidances from the EFSA Scientific Committee.

3. Assessment

According to the applicant, the substance zinc oxide in nanoform is intended to be used as an ultraviolet light (UV) absorber in all types of unplasticised polymers at up to 2% by weight, intended for contact with all types of foodstuff, for long-term storage at room temperature.

Zinc oxide in bulk form is authorised as an additive for plastic materials and articles in contact with food (Regulation (EU) No 10/2011²), with a specific migration limit (SML) of 25 mg/kg food, expressed as zinc (FCM No 402).

Zinc oxide nanoparticles, uncoated (FCM No 1050) and coated with [3-(methacryloxy)propyl] trimethoxysilane (FCM No 1046) have been evaluated recently by the EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids (CEF Panel) (EFSA CEF Panel, 2015) for use as UV absorbers in polyolefin plastics. The CEF Panel concluded that the zinc oxide does not migrate in nanoform, and therefore, the safety evaluation focused on the migration of soluble ionic zinc. Migration data for ionic zinc coming from that application complied with the current SML for zinc, but in combination with the dietary exposure from other sources the upper limit of 25 mg/person per day could be exceeded.

3.1. Non-toxicological data

Chemical formula: ZnO (molecular weight: 81.4 Da)

Information on the particle size distribution of the substance as such and following its incorporation into polyethylene were provided on a confidential basis. In the final polymer, nanoparticles are present.

The solubility in water is low (1.6 mg/L) but the substance rapidly dissolves in 3% acetic acid and in 0.07 M hydrochloric acid with dissolution into Zn²⁺ ions. This was demonstrated by measuring the light transmission (300–430 nm) of dispersions of zinc oxide nanoparticles (concentration range from 30 to 1200 mg/L) in the solvents. It was found that all zinc oxide dispersions in water showed significantly reduced light transmission, due to the absorption by (undissolved) nano zinc oxide. In 3% acetic acid

² Commission Regulation (EU) No 10/2011 of 14 January 2011 on plastic materials and articles intended to come into contact with food. Text with EEA relevance. OJ L 12, 15.1.2011, p. 1–89.

and 0.07 M HCl, the dispersions of zinc oxide nanoparticles became transparent immediately after preparation, resulting in 100% transmission, indicating that full dissolution had occurred rapidly. Zinc oxide is thermally stable far above the processing conditions of polymers.

Specific migration was tested from low-density polyethylene (LDPE) which in this case is considered to be acceptably representative of other polymers. Plaques (thicknesses 2 mm) of LDPE, containing 2% of the substance were exposed to 3% acetic acid, and 10% and 50% ethanol under contact conditions of 10 days at 60°C. Zinc was measured by inductively coupled plasma mass spectrometry and inductively coupled plasma atomic emission spectrometry. Migration of zinc was 2.0 mg/kg into 3% acetic acid, and 0.05 mg/kg and 0.06 mg/kg into 10% and 50% ethanol, respectively.

Based on current scientific understanding on the lack of a diffusion potential of nanoparticles in polymers (Bott et al., 2014a, b, c), no migration of zinc oxide in nanoform is to be expected. For the 3% acetic acid simulant, based on the solubility results provided, the high level of migration is likely to be driven by solubilisation of zinc by the acidic media with dissolution of zinc oxide to the soluble ionic form (i.e. Zn^{2+}). Considering the information on the solubility and dissolution rate of nanoparticulate ZnO that is provided, it is assumed that for the much lower concentrations found to migrate into the non-acidic food simulants, the migrated zinc will also be in the form of dissolved, ionic zinc.

3.2. Toxicological data

Zinc is an essential element with an average requirement of up to 10.2 mg/day for women and up to 12.7 mg/day for men (EFSA NDA Panel, 2014).

Based on human studies the SCF established a no observed adverse effect level (NOAEL) of 50 mg/person per day for zinc, and this was subsequently confirmed by EFSA in 2006 and 2014 (EC, 2003; EFSA Scientific Committee and NDA Panel, 2006; EFSA NDA Panel, 2014). The NOAEL of 50 mg/person per day is based on the absence of any adverse effects on a wide range of relevant indicators of copper status (as the critical endpoint) in the studies by Davis et al. (2000), Milne et al. (2001) and Bonham et al. (2003a, b). In spite of the small number of subjects included in these relatively short-term studies, an uncertainty factor of 2 was considered sufficient owing to the rigidly controlled metabolic experimental conditions employed (EFSA Scientific Committee and NDA Panel, 2006). An upper limit (UL) of 25 mg/person per day was recommended.

4. Conclusions

The CEF Panel, having considered the above-mentioned data, concluded that the substance zinc oxide, nanoparticles, does not migrate in nanoform when used in unplasticised polymers and therefore safety evaluation should focus on the migration of soluble ionic zinc. Available migration data for zinc comply with the current SML, but in combination with the dietary exposure from other sources the UL of 25 mg/person per day could be exceeded.

5. Recommendations

The Panel recommends that the Commission reconsiders the SML of 25 mg/kg for zinc, taking into account the fact that consumers are exposed to zinc from sources other than food contact materials.

Documentation provided to EFSA

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2. Additional data for dossier: Zinc oxide, nanoparticles. Dated February 2015. Submitted by BYK Chemie GmbH, Germany.

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Abbreviations

CEF Panel	EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids
EC	European Commission
FCM	Food Contact Materials
NOAEL	no observed adverse effect level
SCF	Scientific Committee on Food
SML	specific migration limit
UL	upper level
UV	ultraviolet (light)