Dermal exposure: Harmonisation of Terminology

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Introduction

In view of proper interpretation of dermal exposure measurements and dermal exposure modelling, harmonisation of terminology is extremely important. Results obtained by measurement methods with different sampling principles will represent different parameters of exposure. Consequently, exposure modelling may be biased by including results obtained by different sampling techniques. This paper addresses the need to support the process of harmonization of (dermal) exposure terminology.

Dermal exposure and terminology

One of the difficulties in the scientific investigation of the area of chemical exposure (as in other areas of science) has been a lack of consistent use of terms such as exposure, exposure loading, exposure concentration etc. Progress in this respect has been made by the Exposure Assessment Planning Workgroup Terminology Subcommittee of the WHO International Programme on Chemical Safety who is involved in setting out a terminology for chemical exposure. Recently, the terminology has been adopted by the International Society of Exposure Analysis (ISEA) as the official glossary (Zarterian et al, 2005). According to the ISEA-glossary exposure is defined as “the contact between an agent and a target”, i.e. the human as the target and a contact at an exposure surface over an exposure period. Exposure surface may consist of an outer exposure surface, e.g. the skin surface, or a conceptual surface over the nose and open mouth, and an inner exposure surface, e.g. the respiratory tract. As an exposure surface gets smaller, the limit is an exposure point. In addition, a contact volume has been defined. This is the volume containing the mass of agent that contacts the exposure surface.

Improved understanding of the process of dermal exposure has been achieved through a conceptual model of dermal exposure, which systematically describes the transport of contaminant mass from exposure sources to the surface of the skin. (Scheider et al, 1999) The conceptual model describes the dermal exposure process as an event-based mass transport process, resulting in a ‘loading’ of the skin contaminant layer. This compartment is a three dimensional surface film consisting of sebum lipids, some sweat with additional water from transepidermal water loss, and remaining components from cornification and unshed corneocytes, and covers the surface of the skin. Since in principle all substances belonging to this

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compartment can be identified, compartment mass can be determined.
The concentration gradient-driven transport from the skin contaminant layer into the skin*, i.e.* crossing the (exposure surface) interface between skin contaminant layer and the stratum corneum, as an absorption barrier, is defined as uptake.

The most relevant definitions of dermal exposure parameters in the conceptual model have been summarized in Table I. Taking the ISEA-glossary for the dermal exposure route into consideration leads to the following conclusions as recently adopted by the working group on Dermal Exposure Issues of the Technical Committee on Workplace Atmospheres of the European Standardization Body (CEN TC 137 WG 6, 2005).The results of dermal exposure sampling can be presented either as exposure mass, *i.e.* mass of an agent present in the dermal contact volume, or as exposure loading. This would be determined as exposure mass divided by the exposure surface area. For practical reasons it can be expressed as mass of agent in an exposed part of the skin contaminant layer ($g.cm^{-2}$).
Relevant for uptake would be time-integrated (or time-averaged) concentration of the contaminant in the contact volume. Assuming that contact volume and skin contaminant layer are compatible concepts, both definitions for exposure concentration are comparable and appropriate units for exposure concentration would be mass of agent per mass contained in the skin contaminant layer ($g. kg^{-1}$).

Measurement methods for dermal exposure assessment, *i.e.* taking a substance and identify and quantify an agent, can be grouped into three major principles:
interception of agent mass transport by the use of collection media placed at the skin surface or replacing work clothing during the sampling time; *removal* of the agent mass from the skin surface (skin contaminant layer) at any given time; *in situ detection* of the agent or a tracer at the skin surface, e.g. by image acquisition and processing systems, at a given time. It should be recognized that the different sampling and measurement principles estimate different quantities: Interception techniques estimate exposure mass, whereas removal and in situ (direct) techniques estimate exposure loading.

Conclusions

The exposure assessment arena, including the field of occupational hygiene, is challenged to support the process of harmonization of exposure terminology. The proposed dermal exposure terminology can be considered as a relevant contribution to this process.

References

CEN European Committee for Standardization Strategy for the evaluation of dermal exposure. prCEN/TR 137027, Brussels, Belgium, (2005).

Schneider, T., Vermeulen, R., Brouwer, D.H., Cherrie, J.W., Kromhout, H., and C.L Fogh: Conceptual model for assessment of dermal exposure. Occup. Environ. Med. 56:765-773 (1999).

Zartarian, V., Bahadori, T., McKone, T.,: Adoption of an official ISEA glossary. J. Expos. Anal. Environ. Epidemiol. 15: 1-5 (2005).

Table I Summary of exposure terminology focused on parameters of dermal exposure

Parameter	**Conceptual model** [9]	Units	**ISEA glossary**[8]	Units	**Implementation of ISEA glossary in Conceptual model as adopted by CEN TC 137 WG 6**
Exposure	Event-based mass transport processes towards the skin contaminant layer compartment		Contact between agent and target at a given surface area over a given time	none	Contact results from mass transport processes towards the skin contaminant layer compartment
Exposure surface	Area of the skin which is contaminated with a hazardous substance; [for practical reasons this is represented by a two dimensional representation of the skin contaminant layer]	cm^2	A surface on a target where an agent is present, *i.e.* skin surface. As an exposure surface gets smaller the limit is an exposure point.	cm^2	The skin surface area where am agent is present. [For practical reasons this is represented by a two dimensional representation of the skin contaminant layer]
Contact volume	Volume of the contaminant layer; this compartment is formed by sebum lipids , sweat and additional water from trans epidermal water loss, remaining components from cornification and unshed cornecytes, and pollutants	kg	A volume containing the mass of agent that contacts the exposure surface	cm^3	Volume containing the mass of the agent that contacts the exposure surface.of the skin contaminant layer [For practical reasons it is expressed by the mass of all substances belonging to this compartment]
Exposure mass	Mass of hazardous substance on the skin surface	g	The amount of agent present in the contact volume	g	The amount of agent present in the dermal contact volume. [For practical reasons it is expressed as amount of agent present in skin contaminant layer]
Exposure loading	Not defined		The exposure mass divided by the exposure surface area.	$g.cm^{-2}$	The exposure mass divided by the exposure surface area. [For practicial reasons it is

					expressed as mass of an agent in the exposure part of the skin contaminant layer divided by the surface area of that part]
Exposure concentration	Concentration of hazardous substance in the skin contaminant layer	$g.kg^{-1}$	The exposure mass divided by the contact volume or divided by the mass of the contact volume depending on the medium	$g.cm^{-3}$ or $g.kg^{-1}$	The exposure mass divided by the mass contained in the skin contaminant layer