RISK ASSESSMENT OF 2,3,7,8-TCDD IN PAPER CONSUMER PRODUCTS[1]

Michael A. Babich, Andrew G. Ulsamer, and Murray S. Cohn

Directorate for Health Sciences
U.S. Consumer Product Safety Commission
Washington, DC 20207, USA

ABSTRACT

CPSC staff have assessed the cancer risks from exposure to 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) in consumer products manufactured from bleached wood pulp, including disposable infant diapers, communications paper, paper towels, facial tissue, toilet tissue, and dinner napkins. Estimated individual risks range from $1x10^{-11}$ for facial tissue to $2x10^{-9}$ for paper towels (household cleaning) with a risk of $5x10^{-9}$ for all products combined. Use of these products is expected to result in less than 0.1 excess cancers per year in the U.S. population.

INTRODUCTION

Chlorinated dioxins and dibenzofurans have been detected in bleached kraft pulp and in paper products, including disposable diapers. These compounds, in particular 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD), are potent chemical carcinogens and toxicants in animals. Exposure to TCDD in consumer paper products may occur by means of dermal absorption. Because TCDD is toxic and there is potential for consumer exposure, the U.S. Consumer Product Safety Commission (CPSC) conducted a quantitative assessment of human exposure and risk (Babich, 1989). In addition, this assessment is part of the multimedia risk assessment for dioxin in paper conducted by the U.S. Environmental Protection Agency (EPA). Paper products under CPSC jurisdiction include disposable infant diapers, paper towels, facial tissue, toilet tissue, dinner napkins, and communications paper (e.g. bond paper, books, and newsprint).

---

[1] Opinions expressed in this article are those of the authors. They do not necessarily represent the official position of the Consumer Product Safety Commission. Because this paper was written by the authors in their capacity as employees of the Commission, it is in the public domain. It may be freely copied or reproduced in accordance with provisions of 17 USC 105.

METHODOLOGY

Methods have been described in detail elsewhere (Babich, 1989). Briefly, exposure was assumed to occur in 2 steps: (1) migration of TCDD to the skin, followed by (2) dermal absorption. Step 1 may be mediated by liquid (e.g. diapers) or unmediated (e.g. communication paper), each requiring different methods.

Products involving liquid mediated exposure were diapers, paper towels, facial tissue, and toilet tissue. The concentration of TCDD in the liquid phase was estimated from pulp:liquid partition coefficients (NCASI, 1987 & 1989). Diaper usage was assumed to average 6 per day for 3 years. Separate exposure parameters were used for daytime, naptime, and overnight diapers.

Products involving unmediated migration are communications paper and napkins. In the absence of empirical data relating to the unmediated migration of TCDD from paper to skin, the rate of migration of the flame retardant tris-(2,3,-dibromopropyl)phosphate (TRIS) from dry cloth to rabbit skin (0.05%/h) was used as a surrogate (Ulsamer et al., 1978). Once transferred, TCDD was assumed to be available for dermal absorption for 24 h. Scenarios for communications paper included home use (adults) and school children; occupational exposure is not under CPSC jurisdiction.

For both unmediated and liquid-mediated exposure, a dermal absorption rate of 1.2%/h was assumed. This was based in part on in vitro data with human skin (Weber et al., 1989). However, unlike Weber et al., it was assumed that TCDD in both the dermis and epidermis would be absorbed systematically. For diapers, the 1.2%/h rate was multiplied by correction factors to account for the effects of anatomical site (2.0) (NCASI, 1987), diaper dermatitis (1.5), and infant skin (1.5) on dermal absorption.

The CPSC potency estimate for TCDD is based on the incidence of hepatocellular adenoma or carcinoma in male $B6C3F_1$ mice (NTP gavage study). Low dose extrapolation was with the multistage model and interspecies scaling was by the surface area correction. Using the male mice data, the maximum likelihood estimate (MLE) of risk was a linear function of dose at low doses. Thus, the MLE of the potency estimate was used; for humans this is 6.7×10^{-5} $(pg/kg\text{-}d)^{-1}$.

RESULTS AND DISCUSSION

The results are summarized in Table 1, which gives the estimated lifetime individual excess cancer risks. The greatest risk for any product is for paper towels (household cleaning scenario), $2x10^{-9}$. Paper towels would have to contain 5600 ppt TCDD for the risk to be $1x10^{-6}$. The risk for all products combined ($5x10^{-9}$, average of male and female risks) is equivalent to 0.02 excess cancers per year in the U.S. population.

This exposure assessment was based on average or typical parameters. For example, the average pulp TCDD level in the 104 Mill Study (8.6 ppt) was assumed as the TCDD level in all products, except diapers, where 3 ppt was assumed based on available data. The highest reported TCDD levels would increase the estimated risk by about 10-fold. Since, in addition, the TCDD potency estimate was a maximum likelihood estimate, the risks in Table 1 are best estimates, rather than upper bounds.

2,3,7,8-Tetrachlorodibenzofuran (TCDF), which is estimated to be one-tenth as potent as TCDD using toxicity equivalence factors (TEFs), is also present in paper products. Assuming an average TCDF level of 104 ppt for most products (or 25 ppt for diapers), the estimated cancer risks from both TCDD and TCDF (not shown) are roughly twice the risks for TCDD alone.

For products involving liquid mediated extraction, equilibrium partition coefficients were used to estimate the concentration of TCDD in a liquid medium in contact with the skin. However, equilibrium conditions are not necessarily expected to occur during the course of exposure. Equilibrium apparently is reached within 2 h (NCASI, 1989). For exposures less than 2 h, the extent of migration of TCDD from paper may be less than that predicted by equilibrium partition coefficients, leading to an overestimate of exposure. Any error introduced by this assumption would be greater for products involving brief exposures (up to 5 minutes), such as paper towels, facial tissue, and toilet tissue, than for diapers, where the exposure duration is greater (up to 10 h).

Another possible source of error in the exposure assessment is the use of surrogate liquid phases to determine pulp:liquid partition coefficients. For example, 8% ethanol was used as a surrogate for household cleaning solutions, such as window cleaners, many of which contain isopropanol.

Table 1. Estimated Individual Lifetime Excess Cancer Risk from TCDD In Paper Consumer Products.

Product	Scenario	Risk
Disposable Diapers	Conventional Type	1.5×10^{-10}
	Superabsorbent Type*	0.21×10^{-10}
Paper Towel	Drying Hands	6.3×10^{-10}
	Household Cleaning	21×10^{-10}
Facial Tissue	Typical Use	0.12×10^{-10}
	Make-up Removal	6.4×10^{-10}
Toilet Tissue	Male Use	2.7×10^{-10}
	Female Use	12×10^{-10}
Communications Paper	Home Use, Adults	5.1×10^{-10}
	School Children	6.1×10^{-10}
Dinner Napkins	Typical Use	2.1×10^{-10}
All Products	Male Use	45×10^{-10}
	Female Use	61×10^{-10}

*Contains absorbent gelling material.

REFERENCES

Babich, M.A. (1989) CPSC staff assessment of the risks to human health from exposure to chlorinated dioxins and dibenzofurans in paper products. U.S. Consumer Product Safety Commission, Washington, DC. December, 1989.

National Council of the Paper Industry for Air and Stream Improvement (NCASI) (1987) Assessment of potential health risks from dermal exposure to dioxin in paper products. Technical Bulletin No. 534. November, 1987.

National Council of the Paper Industry for Air and Stream Improvement (NCASI) (1989) Interim report on measurement of pulp/aqueous solution partition coefficients. November, 1989.

Ulsamer, A.G., W.K. Porter, and R.E. Osterburg (1978) The percutaneous absorption of radiolabeled TRIS from flame-retarded fabric. Journal of Environmental Pathology and Toxicology, 1: 543-549.

Weber, L.W.D., A. Zesch, and K. Rozman (1989) Penetration of TCDD into human skin in vitro. Annual Meeting of the Society of Toxicology, Atlanta, GA, February 27 - March 3, 1980. Abstract No. 472.