RISK ASSESSMENT OF DIOXINS IN CIGARETTE SMOKE

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Introduction

There is no doubt that smoking cigarettes is harmful to human health. If the dioxin concentrations in cigarette smoke reach or exceed the carcinogenic levels suggested by the US EPA, and further the toxicity levels reported by the World Health Organization (WHO), the detrimental effects of cigarette smoking are much more serious. In this research, we have analyzed the dioxin concentrations in 5 major brands of cigarettes from Japan and the United States. Dioxin, furan and PCB congener concentrations were determined in the cigarette tobacco leaf, paper, ashes and filters. We then estimated the amount of dioxin TEQ in the smoke of the cigarettes, as well as the risk of human intake by smoking.

Methods and Materials

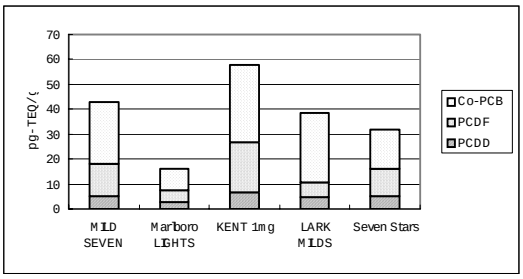
In order to research the risks associated with cigarette smoking, the analysis of dioxins in the smoke is necessary. Based on our detailed review of previous work[1,2], we understand that, technically, it is very difficult to extract a direct sample of smoke generated from smoking, such as main and side-stream smoke. Therefore, conventional automatic smoking equipment (smoke generator) was used. However, it should be noted that sample extraction by this automatic equipment does not necessarily reflect actual human smoking conditions.

Further we have estimated the movement of the dioxin TEQ concentrations between the leaf of the cigarette, paper, ashes and filter before and after smoking as previously researched[1,3,4]. For instance, Miyata[3] pointed out that "Matsueda et al[4] estimated in their research that the dioxins generated by smoking is mostly contained in the main part (leaf and paper) of cigarette, and it vaporized at the time of smoking, shifted to the body by inhaling the mainstream smoke via a filter and also side stream smoke indirectly". Subtracting the quantity of dioxins contained in the ashes and filter after smoking from the quantity of dioxins contained in the main part of the cigarette (leaf and paper) provides a close estimate of the dioxin concentration in the cigarette smoke.

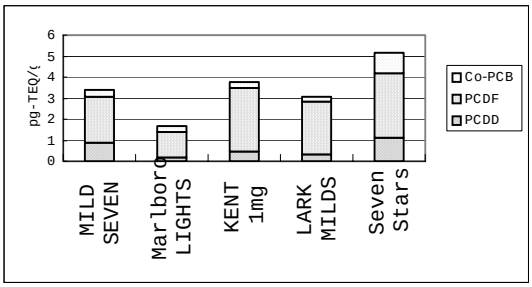
Matsueda et al[1] suggested in their research paper saying that even the mass balance of each parts of the cigarette (main part, butt, filters, ash, mainstream and side stream) were not perfectly balanced, it could be possible to substantiate that the dioxins in the mainstream could be derived from the cigarette leaf and paper (main part). Even though there might be some generation and destruction of dioxin in the process of combustion during smoking, the experimental data shows that dioxin levels of cigarette leaf and paper (main part) were much higher compared to the total dioxin levels of each part obtained by smoke generation experiment.

Therefore, the dioxin concentration in the smoke (d) can be calculated by subtracting the sum of the dioxin concentrations in the filter after smoking (b) and in the residues/ash (c) from the original concentrations determined in the leaf and paper before smoking (a), as follows:

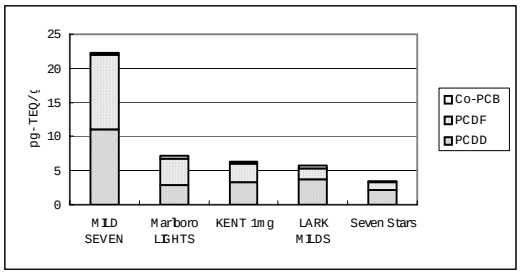
$$(d) = (a) - [(b) + (c)] \qquad \text{Formula 1}$$



(Main Parts: Leaf and paper)



(Ashes)



(Filters after smoking)

Fig.1 Dioxins in 1box of cigarette

As for the quantity of sample used per brand, about 200 cigarettes were used for main parts, i.e., leaf and paper, and about 160-370 cigarettes were smoked to collect the ash and filter samples. All samples of ash and filter were collected from cigarettes smoked by people in the office of Weekly Magazine. To determine dioxin TEQ concentrations in this research, PCDDs, PCDFs and dioxin-like PCBs (Co-PCBs) analyzed. Maxxam Analytics Inc. of Canada carried out the analysis of dioxins. The analytical method was based on EPA Method 8290B. Toluene was used as the solvent for extracting the main part of the cigarette samples, and hydrochloric acid was used to facilitate the extraction of ashes and filters.

Results and Discussion

(1) Analysis results

The analytical results for dioxins, furans and PCB congeners are shown in Figure 1. The results are presented per one box (20 cigarettes).

(2) Verification by the Congener pattern

The congener patterns of dioxins for the 3 different brands are shown in Figure 2. It turns out that there is a close correlation between the congener patterns in the main parts (leaf and paper) of the cigarette and the filters by brand. It appears that the dioxins in the main parts have moved to the filter as estimated in the hypothesis. We also found that the congener patterns of the main parts and the filter were also quite similar, as reported in previous research papers[1,2]. Additionally, the congener pattern in the smoke (mainstream and side stream) is also similar to the main parts and filters[1,2]. This correlation of patterns is also observed for the dioxin-like PCBs. However, the quantity of dioxin-like PCBs captured by the filter was small compared to PCDDs/PCDFs.

(3) Trial calculation of the amount of dioxins

In main and side stream smoke, Figure 3 shows the variation of dioxins levels (pg TEQ/20 cigarettes) before and after smoking. As for both Mild Seven and Marlboro LIGHTS, figure 3 shows

that the filter removes about half of the dioxins in the leaf and paper parts. On the other hand, KENT 1mg, Lark MILDS, and Seven Star showed significantly lower removal of dioxins by the filter. In order to evaluate the health risk of smoking here, the total amount of the dioxins contained in mainstream and side stream smoke was estimated.

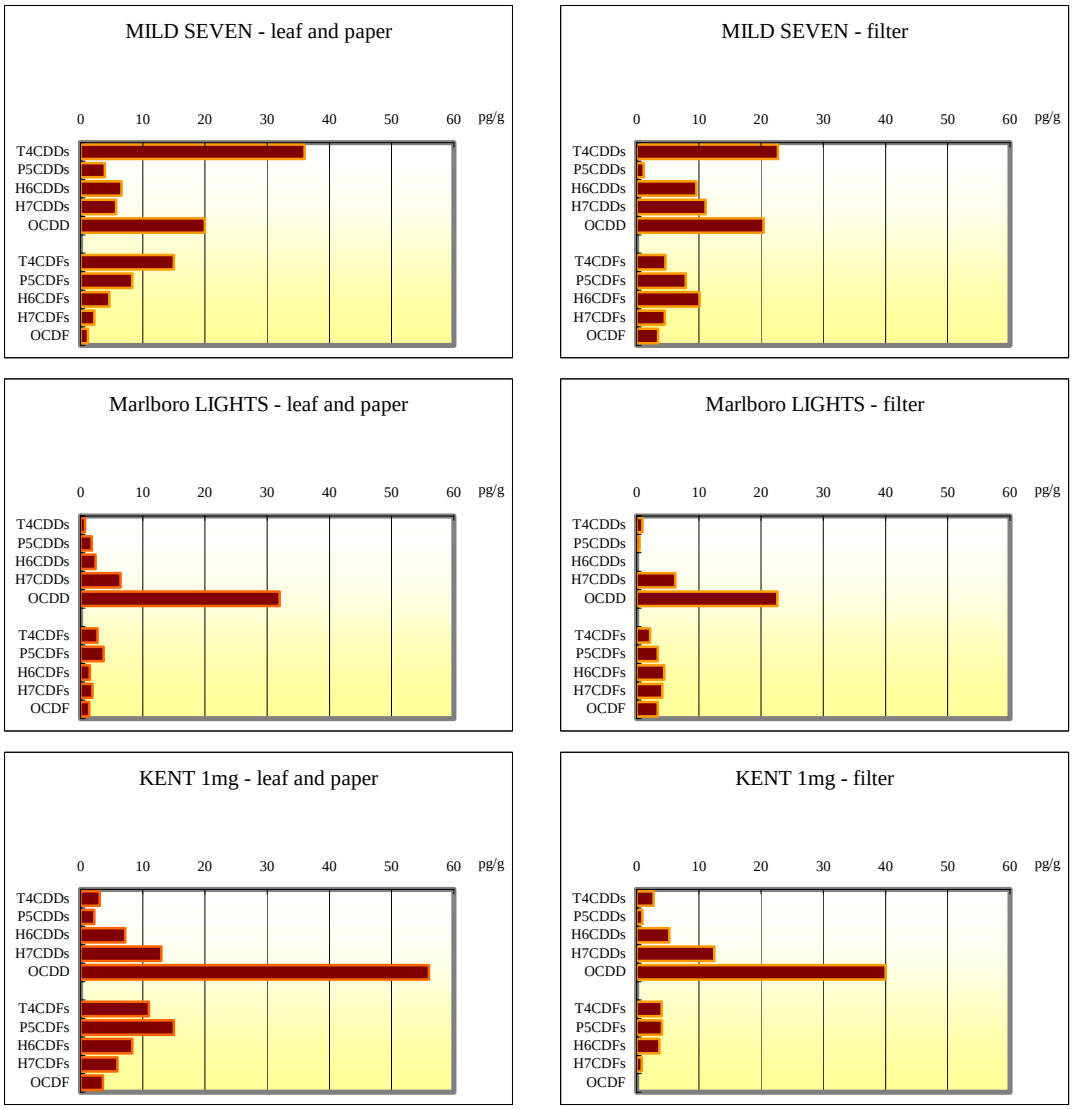


Figure 2 Congeners Pattern of Dioxin Analogues in Cigarette Samples
Comparison of the Main parts and the Filters
(MILD SEVEN, Marlborough LIGHTS and KENT 1mg)

Table 1 is the estimated maximum concentration of dioxins in the mainstream and side stream smoke after smoking one box of each brand of cigarettes (20 cigarettes). The calculations were carried out using Formula 1. As shown in Table 1, the results for different brands differ by a factor of approximately 7, with the lowest being Marlboro LIGHTS (7pg-TEQ/box) and the highest being KENT 1mg (48pg-TEQ/box).

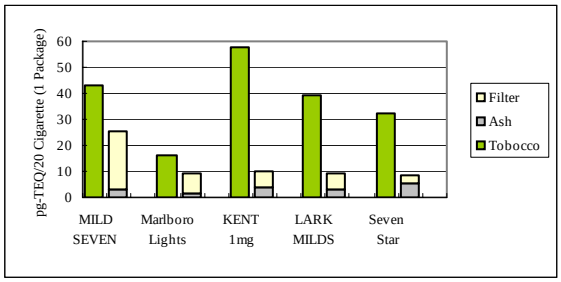


Figure 3 TEQ Levels before and after smoking

(4) Estimation of the human health risk

Based on the estimated amount of dioxins in smoke, the daily intake of total dioxins from mainstream and side stream smoke was calculated. The results are shown in Fig. 4. In the case of KENT 1mg cigarettes, the concentration of dioxins in the mainstream and side stream smoke (0.96pg-TEQ/bwt/day) approaches the minimum TDI value (1-4pg-TEQ/kg body weight/day) proposed by WHO.

Acknowledgments

There are still many unresolved issues concerning dioxins in cigarettes and cigarette smoke. It is important to continue these studies to better understand, and be aware of the risks associated with smoking and exposure to cigarette smoke. We would like to express our gratitude to Mr. Tanaka and Ms. Tsubata of Weekly Friday Magazine for their extensive support of this research project including preparation of the samples.

Table 1 Amount of Dioxins contained in Mainstream and Side Stream of Cigarette

Unit: pg-TEQ/box (20 cigarettes)

	Main Parts (a)	Filter (b)	Ashes (c)	Mainstream + Side stream (d)
MILD SEVEN	43	22	3.3	18
Marlboro LIGHTS	16	7.3	1.7	7.0
KENT 1mg	58	6.2	3.8	48
LARK MILDS	39	5.8	3.1	30
Seven Star	32	3.4	5.2	23

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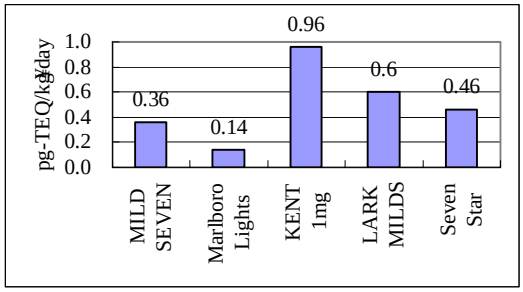

Figure 4 Estimation of Human Risk