Emission characteristics of polychlorinated dibenzo-p-dioxins and dibenzofurans in the stack flue gases of electric arc furnaces

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Electric arc furnaces (EAFs) are extensively employed to produce carbon and steel alloys. In Taiwan, 24 EAFs are presently in operation. Some studies indicated that PCDD/F (polychlorinated dibenzo-p-dioxin and dibenzofuran) emission from EAFs was even higher than that from municipal waste incinerators (MWIs) (Chen, 2004; Sakai, 1999). The current study mainly reported the concentrations, congener profiles, and emission factors of PCDD/Fs in the stack flue gases of electric arc furnaces. The effects of PCDD/F emission from EAFs on the ambient air quality were also evaluated.

The PCDD/F samples from stack flue gas were collected according to US EPA modified Method 23. The sampling train adopted in this study was comparable with that specified by the US EPA modified Method 5. Prior to sampling, XAD-2 resin was spiked with PCDD/F surrogate standards prelabeled with isotopes. Each stack flue gas sampling lasted approximately 3 h. To ensure that the collected samples were free of contamination, one field blank was always taken when the field sampling was conducted.

Analyses of PCDD/Fs samples followed the US EPA modified Method 23, and were performed in the Super Micro Mass Research and Technology Center in Cheng Shiu University. This center is the first lab certified by the Taiwan EPA to analyze PCDD/Fs in Taiwan and passes the international inter-calibration on PCDD/Fs in fly ash, sediment, mother’s milk, human blood and cod liver (Wang et al., 2003).

A high-resolution gas chromatography (HRGC), coupled with a high-resolution mass spectrometer (HRMS), were used for PCDD/Fs measurements. The HRGC is a Hewlett Packard 6970 Series gas chromatography, equipped with a DB-5 (J&W Scientific, CA, USA) fused silica capillary column (60 m, 0.25 mm ID, 0.25 μm film thickness), and splitless injection. An initial oven temperature was 150 °C and the electron energy was set at 35 eV.

Figure 1. shows the congener profiles of PCDD/Fs in the stack flue gas of electric arc furnaces. 2,3,4,7,8 PeCDF and 1,2,3,4,6,7,8-HpCDF were the top two predominant species. Total PCDD/F concentrations ranged from 5.49 to 6.15 ng/Nm$^3$ (mean = 5.81 ng/Nm$^3$). With regard to toxicities, the ratios of PCDDs/PCDFs (I-TEQ) were less than unity, indicating that PCDFs were the primary toxicity distributors for PCDD/Fs. The mean total PCDD/F concentration in the stack flue gas of EAFs was 0.757 ng I-TEQ/Nm$^3$, which was much lower than that regulated by the Taiwan EPA [5 ng I-TEQ/Nm$^3$].

The emission factors of total PCDD/Fs in the stack flue gas from EAFs ranged from 21.6 to 24.4 μg/ton-feedstock (mean = 23.0 μg/ton-feedstock). Based on the approximate evaluation, the annual emission of PCDD/Fs in the stack flue gas from EAFs was several times higher than those from other emission sources (e.g. large-scale MWIs), indicating the importance of the PCDD/F emission from EAFs on the ambient air quality.