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Investigation of environmental fate, photo-transformation and metabolism of triclosan

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Investigation of Environmental Fate, Photo-transformation and Metabolism of Triclosan

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Abstract

Triclosan, 5-chloro-2-(2,4-dichlorophenoxy)phenol, is an active ingredient in many household disinfectants and has been extensively used in improving environmental hygiene. The chemical can be found as an antiseptic component in medical products such as hand disinfecting soaps, medical skin creams, dental products and many household cleansers. Triclosan has been found as a contaminant of rivers, lakes, costal water, breast milk and human urine and so on. In Europe, about 350 tonnes of triclosan are produced annually for commercial applications. Recent studies suggested that triclosan can be undergone cyclization to form 2,8-dichlorodibenzo-p-dioxin (2,8-DCDD) in aqueous solution under UV irradiation. In order to understand triclosan and its relative components of photo-transformation and metabolism in environmental water, mouth wash, toothpaste, breast milk, rat urine and plasma comprehensively, we have performed several projects and their main results are shown as below.

In this thesis, triclosan in the waste, river and coastal water samples collected in Hong Kong was analyzed by GC-ITMS. $^{13}C_{12}$-triclosan was used as internal standard in the quantitative analysis. Water samples were extracted and cleaned-up with a C18 solid-phase extraction cartridge. The recoveries of triclosan in spiked coastal water at three different concentrations were 83 % to 110 %. The method detection limit was 0.25 ng/l for triclosan in one-liter water, and the relative standard deviation and relative error were less than 11.0 % and 12.3 %, respectively (n = 3). The method was successfully applied to analyze water samples collected from rivers, coastal water bodies and wastewater treatment plants at ng/l levels.

The formation of dioxins including 2,7/2,8-dichlorodibenzo-*p*-dioxin (2,7/2,8-DCDD), 2,3,7-trichlorodibenzo-*p*-dioxin (2,3,7-TrCDD), 1,2,8-trichlorodibenzo-*p*-dioxin

(1,2,8-TrCDD), 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TeCDD), 1,2,3,8-tetrachlorodibenzo-*p*-dioxin (1,2,3,8-TeCDD) and chlorinated triclosan were studied in the presence of low concentration of active chlorine in filtered seawater under UV irradiation (365nm) and dark condition. 2,3,7,8-TeCDD was not detected under dark condition when concentration of triclosan was 0.2 mg/ml and active chlorine was 2.0 mg/ml while 2,7/2,8-DCDD, 2,3,7-TrCDD, 1,2,8-TrCDD, 1,2,3,8-TeCDD and chlorinated trilosan were determined. Under the same concentration of triclosan and active chlorine, 2,3,7,8-TeCDD was detected after the UV irradiation from 120 to 960 min. Formation rate and levels of dioxins and chlorinated triclosan were compared for the experiments with different concentration of triclosan and active chlorine.

A GC-MS method was developed for the analysis of 2,8-DCDD in toothpaste and mouthwash. After liquid-liquid extraction of aqueous phase with n-hexane, the extract was cleaned by a silica-bonded C18 solid-phase extraction (SPE) cartridge and analyzed. The detection limit was 0.96 ng/g and 0.83 ng/g for 1.0 g toothpaste and mouthwash, respectively. The recovery of 2,8-DCDD ranged from 87.5% to 104.2%. The relative errors were less than 12.5 %, and the intra-day as well as inter-day precisions represented by RSD were less than 11.2 % and 10.6 %, respectively. The highest concentration of 2,8-DCDD was 56.3 ± 8.5 ng/g in toothpaste and 180.6 ± 19.2 ng/g in mouthwash. Photo-degradation of spiked triclosan to 2,8-DCDD in toothpaste and mouthwash under UV irradiation was performed to validate the formation mechanism of 2,8-DCDD in toothpaste and mouthwash.

A method involving liquid-liquid extraction, gel permeation chromatography clean up and GC-MS analysis was developed for the determination of triclosan in the breast milk. The calibration curve gave a linear dynamic range of 1.0 to 150 ng/g with correlation coefficient of 0.9996 and the recoveries ranged from 86.2 % to 96.6 % for

the spiked milk samples containing triclosan at three different concentrations. The relative standard deviation and relative error were 0.75% to 9.0% and -7.2 ± 3.4% to 9.7 ± 0.9%, respectively. The limit of quantification of the method was 0.15 ng/g milk weight or 4.8 ng/g lipid. The method was successfully applied for the determination of triclosan in human breast milk. The results of triclosan concentration in 148 breast milk samples were ranged from not detected to 53.04 ng/g (lipid based).

In vitro metabolic study of triclosan was performed using Sprague-Dawley (SD) rat liver S9 and microsome, while the oral metabolism was investigated on SD rat. Twelve metabolites were identified by using in-source fragmentation from HPLC-APCI/ITMS. Compared to ESI/MS and tandem mass spectrometry that gave little fragmentation for ctriclosan and its metabolites, the in-source fragmentation under APCI provided intensive fragmentations for structural identifications. The obtained results indicated that the glucuronidation and sulfonation was the major pathway of phase II metabolism and the hydroxylated products were the major phase I metabolites. Glucose, mercapturic acid and cysteine conjugates of triclosan were also observed in the urine samples of rat oral administrated with triclosan. The *in vitro* metabolic rates of triclosan and its major glucuronidation metabolite were determined.

Plasma samples from the SD rats after oral administration of 5 mg/kg triclosan were analyzed by ultra performance liquid chromatography-triple quadrupole mass spectrometry methods for pharmacokinetic study of triclosan. The limit of quantification of the developed analytical method was 10.8 ng/ml. The recovery, accuracy, precision and repeatability were satisfactory. The half time of elimination was 48.5 ± 10.5 hours. Triclosan and its metabolites, including two hydroxylated and sulfated triclosan, one glucuronidated triclosan and one sulfated triclosan were detected in rat plasma.

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