台 塑 公 司 新 聞 稿

Formosa Plastics Corp.

105 年 8 月 23 日

針對媒體報導政府將依一項待確認之研究成果報告，決定麥寮許厝分校遷校乙事，本企業鄭重聲明，麥寮氯乙烯(VCM)廠自運轉迄今嚴格管制各污染源排放，且依主管機關長期監測結果均遠低於國內外管制標準，未對周界環境造成影響，同時本企業重視國民健康遠勝於公司盈虧，我們有信心，歡迎各界關心人士蒞臨麥寮廠實地檢視，且希望學界公正人士本於高學術標準共同審視居民健康及相關研究報告。有關許厝分校遷校爭議乙事，本企業謹說明如下：

一、許厝分校場址乃由雲林縣政府選定，台塑基於社會公益回饋建置。

二、本企業為確保第一線作業員工健康，每年並額外執行作業員工暴露監測，監測結果遠低於管制標準

本企業除法令規定每半年執行作業環境監測外，並自101年起委託台灣職業衛生學會實施麥寮廠區員工暴露監測，由作業員工背負呼吸採樣器，實際檢測一天工作8小時在其作業場所所吸入的氯乙烯濃度，迄105年6月計執行氯乙烯該項2,055人次，最大值為58ppb(10億分之一)，遠低於法定管制標準3,000ppb，僅3人有檢出，其餘均低於極限值3ppb。第一線作業員工的監測值都這麼低，更可確保周遭居民之健康。

三、學童尿中代謝產物TdGA(硫代二乙酸)來源多元，TdGA不代表氯乙烯

根據美國政府工業衛生協會(ACGIH)文獻資料，當作業環境中的氯乙烯濃度低於5ppm(佰萬分之一，附件一)時，則無法驗證代謝物TdGA與氯乙烯的相關性；另根據美國有毒物質及疾病登記局國際文獻報告(ATSDR,2006)，尿液中TdGA的來源，也可能來自於乙烯基化合物的暴露，如2,2二氯乙醚(2,2-dichloroethylether)等，以及清潔劑、殺蟲劑之原料二氯乙醚(BCEE)(如附件二)；此外，根據研究，一般民眾暴露於二手菸、汽機車排氣、維他命B群等，其尿中所產生的TdGA代謝產物都可能遠高於氯乙烯暴露的影響，所以取尿液時應同步檢測作業環境氯乙烯濃度，數值始具有參考價值。

四、許厝分校環境監測數據均遠低於國家標準

104年9月許厝分校學童遷回原址就讀後，雲林縣環保局及本企業均已裝設傅立葉轉換紅外線光譜儀(FTIR)長期監測氯乙烯，其中本企業執行至105年6月之測值均低於儀器偵測極限值10ppb，另國衛院於許厝分校現場採樣時，本企業亦同步採樣，經實驗室檢驗其測值均低於極限值0.24ppb，所以我們希望國衛院能夠公佈其在許厝分校檢測的氯乙烯濃度資料，並說明氯乙烯檢測濃度與學童尿液中TdGA之關係，互為驗證，才是符合學術專業倫理的作法。

五、國衛院研究報告數據前後不一且推論相互矛盾

在國衛院幾次公開發表的報告，其樣本數不一且數值差異明顯。於國際期刊資料中，許厝分校學童在103年8月份暑假返校測得學童TdGA值為52.3 ppb(居家距離六輕平均2.8公里)、豐安國小學童102年11月TdGA值為95.5(距離六輕2.7公里)，皆低於距離六輕較遠之橋頭國小的115.5(距離六輕5.5公里)，由該等資料可看出，距離六輕越遠卻反而濃度越高(如附件三)，且學童寒暑假亦多居住於學校附近，並未遠離六輕所在地，顯示報告推論有互相矛盾之處，尚待驗證。

六、國際期刊論文並未認同TdGA來自於氯乙烯

有關國衛院表示報告已刊登在國際研究期刊，但該期刊報告內容自述其研究有下列限制條件：(如附件四)

1. 研究期間並沒有針對任何一個學童或學校周遭環境進行氯乙烯空氣濃度採樣，因此無法認定學童尿液中TdGA的確切來源。
2. 雖然就讀同一間國小的學童尿液是一起蒐集的，但各校之間的 尿液卻沒有在同一天內蒐集完成。
3. 在5間學校的比較時，採樣季節是秋天和春天，其風向較相似，但在做許厝分校的重覆採樣比較時，採樣季節一個是秋天，一個是夏天。
4. 我們並沒有執行一個完整的飲食問卷來排除容器或食物中的 影響。
5. 我們無法排除飲水中可能的暴露來源。

同時，環保署李署長於7月22日表示：「尿液取樣當時，未同時執行大氣採樣，且各校學童尿液樣本取樣也非同一時間進行，另在不同風速風向下，對同一地點影響會有不同檢驗結果；會產生TdGA也不只是VCM造成」。

當地風向、風速在不同季節間有相當大的變異，在無氯乙烯暴露資料佐證及單次採樣的限制下，論文於學術及實務參考價值有限，如此之相關分析確實有待學界未來再加以驗證，現階段更不適宜政府政策制定之參考。

七、國衛院研究報告顯示各校學童肝功能無顯著差異

國衛院103年8月14日於立法院公開資料顯示，雲林縣麥寮鄉4間國小學童肝功能，各校無顯著差異，許厝分校肝功能GOT指數26.9甚至低於距離六輕較遠之麥寮國小(距離六輕6.7公里)的27.2(附件五)。此次部份媒體報導「許厝分校學童肝功能異常」，實應詳加查證數據之真實性並確認因果關係，研究單位應公開數據接受檢視。

台塑企業一向本著善盡社會責任的經營理念，在兼顧經濟成長與環境保護下，維護並營造當地居民良好的生活環境，歡迎各界關心人士蒞臨麥寮廠實地檢視。同時，建議政府召開國際委員會，提出客觀、公正、公開的作業方式，共同以更審慎的科學態度釐清事實真相，以昭公信，並安民心。

新聞連絡人：林勝冠副總經理
電　　話：02-2717-8100

各國 VCM 廠周界標準

國家	台灣	美國德州	美國路易斯安那州	歐盟	法國	中國大陸	新加坡
周界標準 (ppb)	200	150	150	未規定	未規定	235	未規定

致癌物是氯乙烯，測量它的暴露是關鍵。
若沒有暴露，測量TdGA沒有意義。

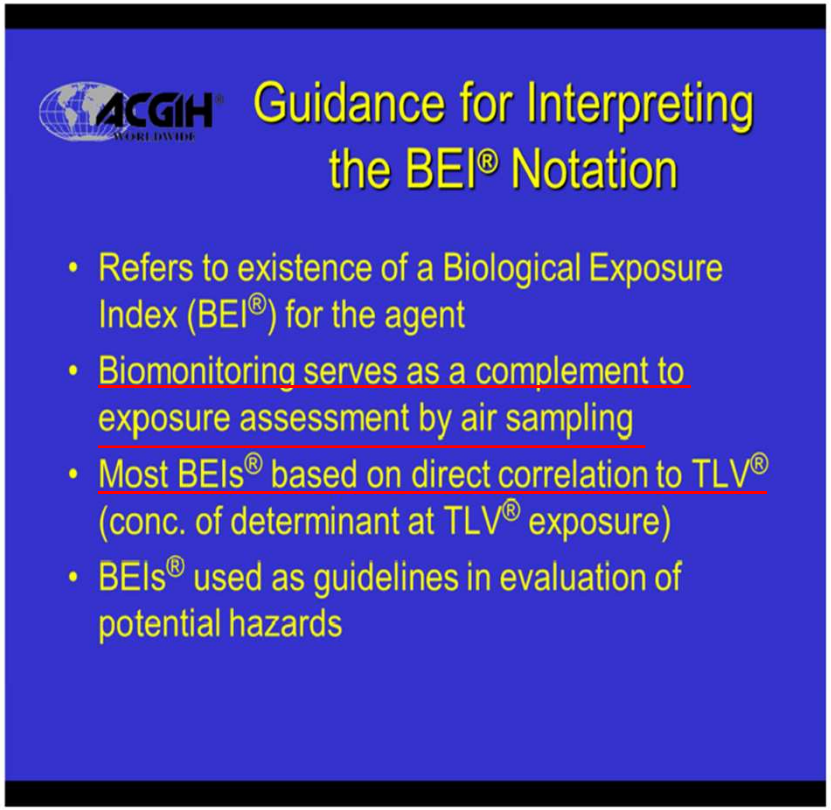
- 以往研究及ACGIH提出建議，當環境中氯乙烯濃度低於恕限值時，代謝物TdGA與氯乙烯之相關性是不具任何探討意義。

Urinary Thiodiglycolic Acid Levels for Vinyl Chloride Monomer-Exposed Polyvinyl Chloride Workers

Tsun-Jen Cheng, MD, ScD
Yu-Fang Huang, MS
Yee-Chung Ma, PhD

Thiodiglycolic acid (TdGA) is the major metabolite of vinyl chloride monomer (VCM) detected in human urine. Although urinary TdGA has been reported to be associated with ambient VCM exposure, the relationship between urinary TdGA and a low level of air VCM is not clear. Questionnaires were administered to 16 polyvinyl chloride manufacturing workers to obtain a detailed history of occupation and lifestyle. For each worker, personal air monitoring for VCM was performed and a time-weighted average for VCM exposure was calculated. The urinary TdGA levels at the end of a work shift, and at the commencement of the next shift, were also assessed for each worker. Urine analysis revealed that TdGA levels at the beginning of the next shift were higher than those at the end of that shift. Workers experiencing a VCM exposure greater than 5 ppm in air revealed a urinary TdGA level significantly greater than those experiencing a VCM exposure of less than 5 ppm ($P < 0.05$). The best fit of regression for urinary TdGA on air VCM was $Y = 1.06 + 0.57X$ for urine collected at the commencement of the following work shift, where X is the air VCM concentration and Y is the urinary TdGA concentration ($r^2 = 0.65$, $P < 0.01$). We conclude that the urinary TdGA level is best detected at the commencement of the next shift and that it can be used as an exposure marker for polyvinyl chloride workers when the air VCM level to which they are exposed is greater than 5 ppm. (J Occup Environ Med. 2001;43:934–938)

Vinyl chloride monomer (VCM) exposure has been associated with angiosarcoma of the liver and is classified as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC).[1] To protect VCM-exposed workers from developing diseases associated with their VCM exposure, the environmental VCM level to which they are (occupationally) exposed is periodically monitored to ensure that the air concentrations are below permissible levels.[2] Environmental monitoring, however, may not reflect the actual worker exposure level because of differences in VCM levels for individual workers. To measure the actual dose of VCM absorbed by a worker, methods to detect urinary TdGA, a major metabolite of VCM in human urine, have been developed.[3–6] Although a VCM-exposed worker's urinary TdGA level has been reported to be associated with his or her air VCM exposure level, these studies have focused on the procedures necessary for detecting the presence of TdGA in urine, and they provide limited information in

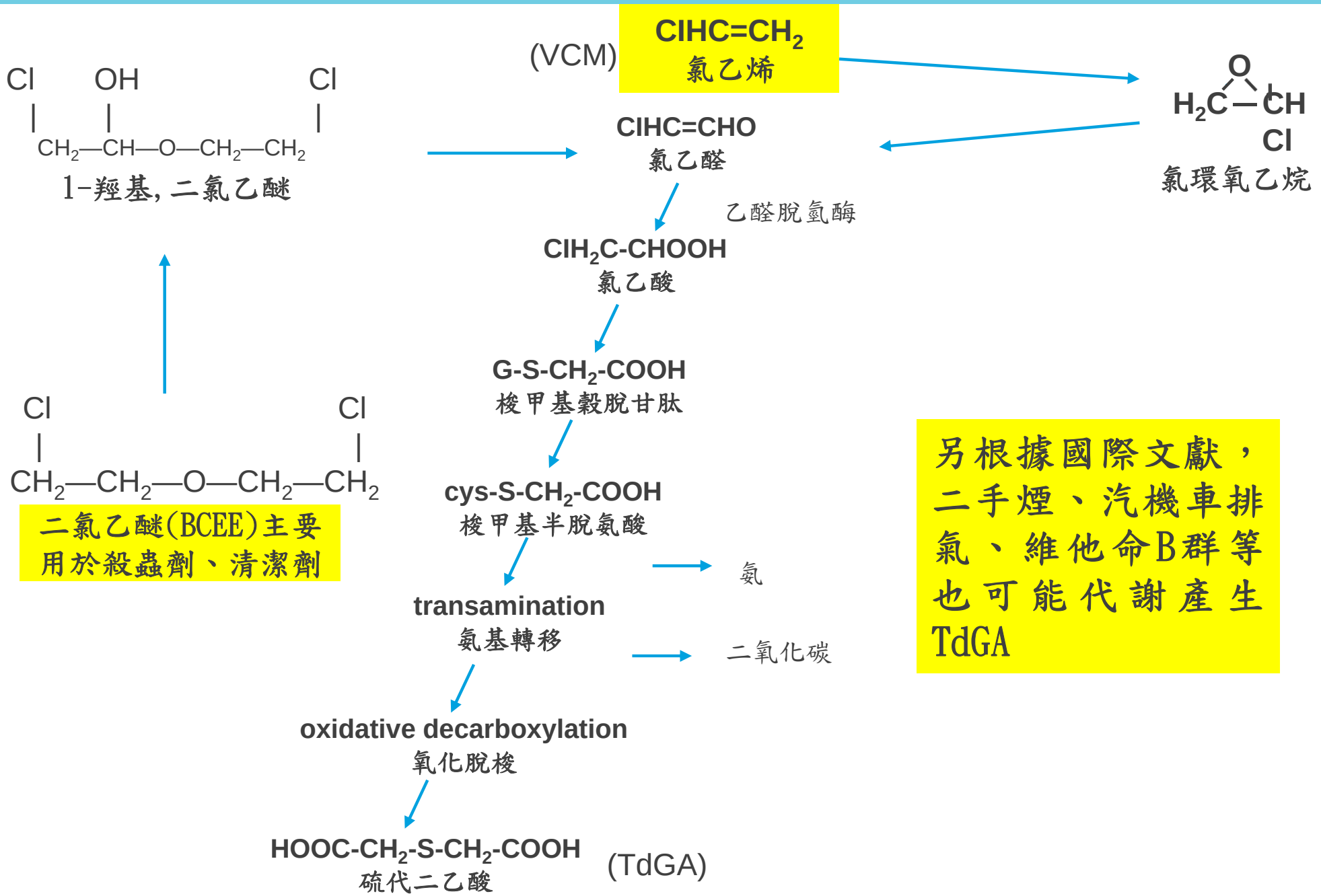


資料來源:https://www.acgih.org/tlv/TLVNotsDesig.pps

化學物質在人體內代謝過程中產生TdGA之路徑

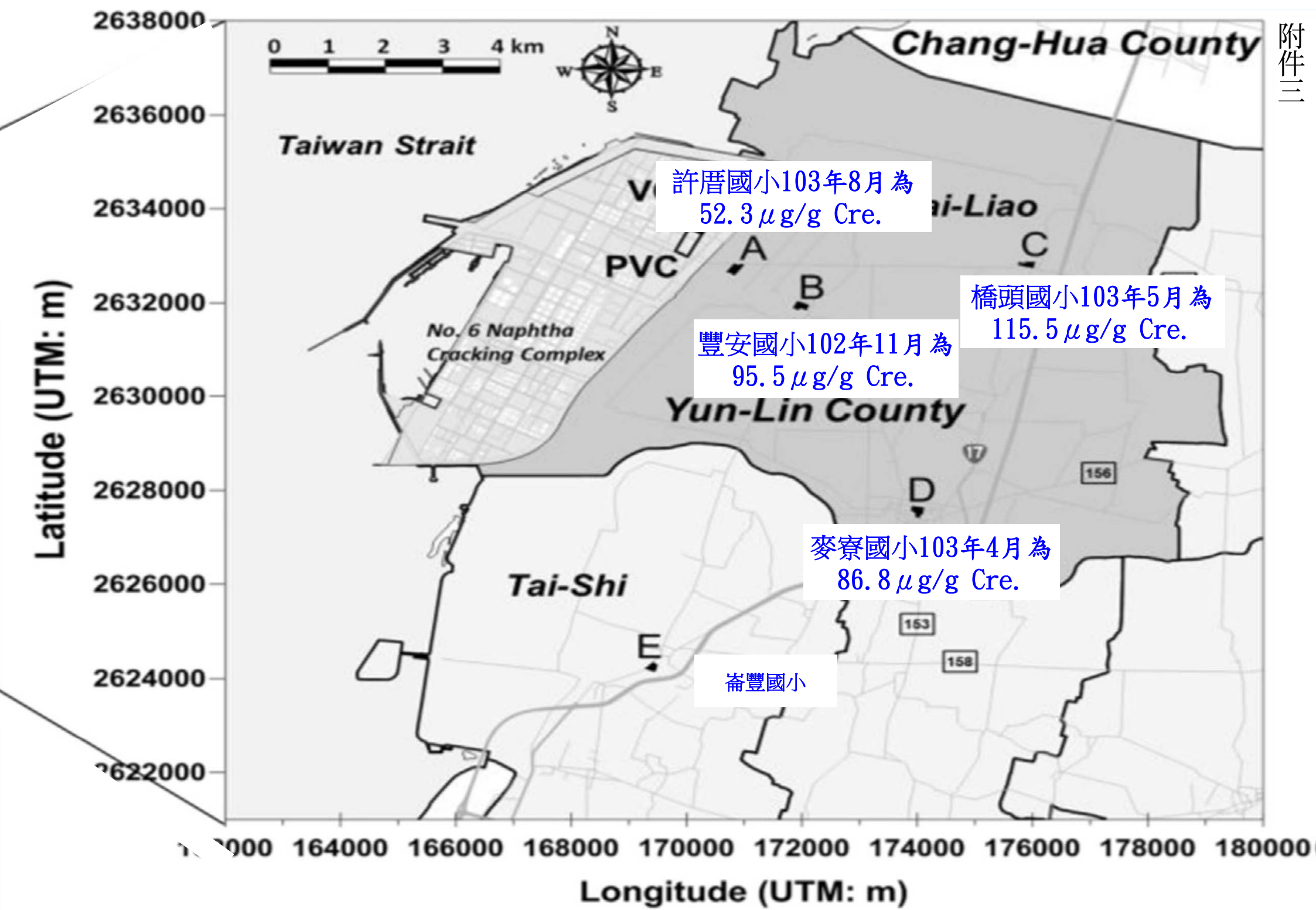
台塑關係企業
FORMOSA PLASTICS GROUP

附件二



另根據國際文獻，二手煙、汽機車排氣、維他命B群等也可能代謝產生TdGA

附件三


Chang-Hua County
Taiwan Strait
0 1 2 3 4 km
N
W
E
S
許厝國小103年8月為
52.3μg/g Cre.
PVC
A
B
C
橋頭國小103年5月為
115.5μg/g Cre.
No. 6 Naphtha
Cracking Complex
豐安國小102年11月為
95.5μg/g Cre.
Yun-Lin County
D
麥寮國小103年4月為
86.8μg/g Cre.
Tai-Shi
E
崙豐國小
156
153
158
17
Latitude (UTM: m)
2638000
2636000
2634000
2632000
2630000
2628000
2626000
2624000
2622000
164000
166000
168000
170000
172000
174000
176000
178000
180000
Longitude (UTM: m)

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附件四

Assessment of urinary thiodiglycolic acid exposure in school-aged children in the vicinity of a petrochemical complex in central Taiwan

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ABSTRACT

Background: School-aged children living in the vicinity of vinyl chloride (VCM)/polyvinyl chloride (PVC) factories may have an increased risk of exposure to hazardous air pollutants.
Objectives: We aimed to evaluate the urinary thiodiglycolic acid (TDGA) level, as TDGA is a major metabolite of VCM, for students at elementary schools near a petrochemical complex in central Taiwan.
Methods: We recruited 343 students from 5 elementary schools based on distance to the VCM/PVC factory. First-morning urine and blood samples were obtained from our subjects from October 2013 to September 2014. Urine samples were analyzed for urinary creatinine and TDGA using LC/MS–MS. Hepatitis virus infection were assessed using blood samples. We determined their vitamin consumption, resident location, parent's employment, and other demographic or lifestyle characteristics using a questionnaire.
Results: Median urinary TDGA levels for 316 students at 5 elementary schools from the closest (< .9 km) to the farthest (~8.6 km) with respect to the petrochemical complex were 147.6, 95.5, 115.5, 86.8, and 17.3 μg/g creatinine, respectively. After adjusting for age, gender, hepatitis virus infection, vitamin B consumption, passive smoking, and home to source distance, we found that urinary TDGA levels for the closest students was significantly higher than those at other schools. Further, median urinary TDGA levels for students during school time were 4.1-fold higher than those during summer vacation.
Conclusions: After adjusting for confounders, urinary TDGA levels for the school-aged children decreased with increasing distances between the elementary schools and the petrochemical complex.

1. Introduction

Vinyl chloride monomer (VCM) is a colorless gas at room temperature and the major material used to produce ethylene dichloride (EDC) or polyvinyl chloride (PVC) (Sherman, 2009). VCM is less likely to occur naturally or to be present in food and cosmetic products, but it is mostly found in the ambient air in VCM/PVC factories or contaminated ground water (ATSDR, 2006). The No. 6 naphtha cracking complex (namely a petrochemical complex) is owned by the Formosa Petrochemical Corporation (FPC) and is situated in the Mai-Liao Township in central Taiwan (Shie and Chan, 2013; Yuan et al., 2015). For this petrochemical complex, the estimated annual production of VCM and PVC was around 2.76 and 2.93 million tons, respectively, and the estimated annual emission of VCM and 1,2-dichloroethane from the stack and equipment was 24.9 and 11.5 t, respectively.

Since 1987, VCM has been classified as a group 1 human carcinogen by IARC (IARC, 2007). Occupational studies suggested

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0013-9351/

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Table 4
Multiple regression[a] of urinary TDGA levels for the participating students attending 5 elementary schools in central Taiwan ($N=315$).

Variables[b]	TDGA ($n=315$)					TDGA ($n=310$)[c]				
	β	SE	95% CI	P value	R^2	β	SE	95% CI	P value	R^2
Intercept	2.55	.50	(1.57–3.53)	<.001	.191	2.48	.50	(1.50–3.47)	<.001	.189
Elementary school[d]	−.20	.04	(−.27 to −.13)	<.001		−.20	.03	(−.27 to −.13)	<.001	
Gender[d]	.06	.06	(−.06 to .18)	.344		.07	.06	(−.05 to .18)	.282	
Vitamin B consumption	−.05	.24	(−.52 to .41)	.831						
Passive smoking[d]	−.07	.06	(−.19 to .06)	.283		−.07	.06	(−.19 to .06)	.275	
Father ever employed by a petrochemical complex[d]	.03	.06	(−.09 to .15)	.591		.04	.06	(−.08 to .16)	.525	
Age (y)	−.23	.39	(−.98 to .53)	.558		−.23	.39	(−.99 to .53)	.556	
BMI (kg/m^2)	−.22	.36	(−.92 to .48)	.542		−.17	.36	(−.87 to .54)	.638	
Distance of home to the petrochemical complex (km)	.26	.23	(−.18 to .71)	.246		.26	.23	(−.19 to .71)	.254	

Abbreviation: TDGA, thiodiglycolic acid

[a] Multiple regression adjusted for gender, vitamin B consumption, passive smoking, father ever employed in the petrochemical complex, age, BMI, and distance of home to the petrochemical complex.

[b] Variables were logarithm transformed for TDGA, age, BMI, and distance of their home to the petrochemical complex; 1 subject who had a hepatitis B infection was excluded.

[c] Five participating children had taken vitamin B and were excluded.

[d] Dummy variables: We used school A as a reference and the order of other schools were increased by the increasing distance to the source (km); we also used girl, non-smoker and never served in petrochemical complex as a reference of gender, passive smoking and father's job, respectively.

BMI, vitamin B consumption, passive smoke exposure, their father's employment history, and home to source distance, we found that the median urinary TDGA level for school-aged children was significantly increased with shorter distances of the elementary schools to the VCM/PVC factories. The median urinary TDGA level for the children during school time was significantly 4 times higher than that of summer vacation.

Many studies have indicated that urinary TDGA was a good biomarker of VCM for workers (Heger et al., 1982; Cheng et al., 2001; Kim et al., 2006). However, some confounders should be noted if applying to a general population. The exposure sources for the presence of urinary TDGA in children could result from different exposure routes including inhalation and ingestion. Some studies revealed that VCM, EDC, and ethylene oxide were possible sources for subjects having the presence of TDGA in their urine (ATSDR, 2006). We examined the annual monitoring data from the local EPA for air pollution inside and outside the petrochemical complex. We found that the annual mean VCM level was 2.2 ppb, with a maximum level of 165 ppb at school A. The EDC level in ambient air was around one-fifth that of the VCM level at school A. Some air monitoring stations near schools C, D, and E also indicated a similar phenomenon (supplementary Table 3 and supplementary Fig. 1). Although we could not rule out the possibility of exposure from other air pollution sources, it is less likely that our subjects were exposed to those chemical compounds in a special location, such as ethylene oxide, in the hospital. Reports have indicated that frequent and constant VCM and EDC emissions occurred in the surrounding area of the petrochemical complex and could possibly lead to our subjects' urinary TDGA levels.

Occupational studies indicated that a hepatitis virus infection and active or passive cigarette smoking might affect the metabolism of VCM and TDGA in male VCM and PVC employees (Cheng et al., 2001; Kim et al., 2006). Our subjects were tested for HBV and HCV infections using blood examinations and a questionnaire, and we found only 1 student who was positive for HBV and was excluded from further analysis. Although low VCM levels have been reported in tobacco smoke (5–30 ng/cigarette) (ATSDR, 2006), no participant was an active smoker, but a number of our participants reported passive smoking. Therefore, we included passive smoking in our statistical model; passive smoking did not significantly affect the urinary TDGA level in the children. It is possible that our subjects did not reside with smokers or avoided them. Therefore, a hepatitis virus infection and smoking status were less likely to bias our results. Some studies reported that consumption of specific anti-tumor medications or nutritional supplements in humans or rodents, such as ifosfamide, cyclophosphamide (the oxazaphosphorine class of chemotherapeutics), vitamin B, folate, and creatine, increased the urinary TDGA level (ATSDR, 2006; Li et al., 2010, 2011; Navrátil et al., 2007, 2010). None of our subjects were undergoing cancer treatment; their medical history was confirmed using a questionnaire. We found that only 5 subjects had consumed vitamin B the month prior to the survey and were excluded from further analysis; none were taking any specific medications, folate, creatine, or any other nutrition supplement. Hence, it is less likely that the source of TDGA exposure for our subjects was the consumption of a specific medication or nutritional supplement.

We found that the median level of urinary TDGA for the children during school time was significantly *higher* (4-fold) than that of summer vacation. The exposure scenario for the students was quite different between school time and summer vacation. During school time, the elementary school students regularly attended school on weekdays, while they did not attend school during summer vacation. Therefore, the TDGA exposure leading to the urinary TDGA levels observed in our participants on summer vacation should be close to the background level of the study area. Our data indicated that students might be exposed to certain chemicals, possibly VCM and PVC or related VOCs, and experienced increased exposure levels, leading to urinary TDGA excretion. Because of the results of our investigation, Yun-Lin County Government (the local authority), the Ministry of Health, Welfare, and Ministry of Education in Taiwan (central governments) decided to temporarily relocate the students attending elementary school A to school C, which is located about 5.5 km from the petrochemical complex, on September 2014. Further study is ongoing to assess the changing exposure profile of TDGA in these students.

The current study had some interesting findings, in our opinion. We investigated and controlled or adjusted for several important confounders such as HBV, smoking status, vitamin B, and medication consumption to elucidate the potential sources of urinary TDGA in school-aged children. We used a relatively specific biomarker, urinary TDGA, to evaluate the potential exposure of children to certain VOCs. Further, we assessed different exposure scenarios for the urinary TDGA levels between school time and summer vacation in a subgroup of students.

There were some limitations in the current study regarding data interpretation. First, we did not measure the ambient air levels of VCM or EDC in any subject during our sampling period. Further, we cannot provide direct evidence regarding the sources

of TDGA in the school-aged children. Secondly, although we collect urine samples of our subject at the same time of individual elementary school, we did not collect all the urine sample at the same day. Third, the wind direction during our sampling period, autumn and spring, was similar, and we used repeated sampling for TDGA in a subgroup of participating children to compare differences in TDGA exposure between school time and vacation. Fourth, we did not utilize a detailed food questionnaire to evaluate the possible effects of food products or containers. Fifth, we could not rule out potential exposure from drinking water. Drinking water might contain VCM released from contact with polyvinyl pipes, from contaminated underground water, or a microbial degradation product of trichloroethylene in groundwater. Lastly, the air inside new cars could emit trace levels of VCM, mainly from the new plastic parts. However, it is less likely that this was the major source for urinary TDGA in our subjects.

5. Conclusions

We concluded that a majority of children living and studying in the neighborhood of about 9 km away from the petrochemical complex have been possibly exposed to VCM, a class I carcinogen, to some extent. We concluded there is an environmental injustice issue related to children's exposures to the industrial carcinogen as children of poor family tend to live near the pollution source and possibly experience higher VCM exposures than those living farther away. Action has been taken by the authorities to relocate children of School A to School C in September, 2014 as our preliminary data surfaced in July, 2014. A follow-up study is on-going to further investigate exposure levels and potential health effects of VCM after such relocation for School A children, in particular, and for all children of all schools in general.

Conflicts of interest

The authors declare that no competing interests exist.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.envres.2015.11.027.

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附件五

六輕石化工業區附近學童之流行病學研究
—麥寮鄉學童健康狀況及氯乙烯暴露之初步調查結果

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日期：103.8.14

表2-3.雲林縣麥寮鄉四間國小腹部超音波/肝功能

腹部超音波/肝功能	許厝分校 (N=69)		豐安國小 (N=59)		橋頭國小 (N=65)		麥寮國小 (N=75)		P-Value[a]
脂肪肝									
正常	56	(81.2)	27	(45.8)	44	(67.7)	43	(57.4)	0.002*
輕微	12	(17.4)	27	(45.8)	16	(24.6)	28	(37.3)	
中度	1	(1.4)	5	(8.4)	5	(7.7)	4	(5.3)	
AST/GOT(U/L)									0.308
平均值	26.9		26.6		25.2		27.2		
標準差	9.8		4.9		6.1		4.7		
ALT/GPT(U/L)									0.885
平均值	17.6		16.9		18.9		18.4		
標準差	23.9		6.7		15.8		6.7		

a：統計方法：Chi-square test/ ANOVA,** ≦0.01; *<0.05; #<0.1

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