

## 「104 年度雲林縣離島工業區紅外線連續監測及有害污染物調查計畫」

## 報告基本資料表

|                                              |                              |                                                                  |                                          |                                            |
|----------------------------------------------|------------------------------|------------------------------------------------------------------|------------------------------------------|--------------------------------------------|
| 甲、委辦單位                                       | 雲林縣環保局                       |                                                                  |                                          |                                            |
| 乙、執行單位                                       | 祥威環境科技股份有限公司                 |                                                                  |                                          |                                            |
| 丙、年 度                                        | 104 年度                       | 計畫編號                                                             | 104-044                                  |                                            |
| 丁、專案性質                                       | 應用研究                         |                                                                  |                                          |                                            |
| 戊、專案領域                                       |                              |                                                                  |                                          |                                            |
| 己、計畫屬性                                       | <input type="checkbox"/> 科技類 |                                                                  | <input checked="" type="checkbox"/> 非科技類 |                                            |
| 庚、全程期間                                       | 104 年 8 月～105 年 8 月          |                                                                  |                                          |                                            |
| 辛、本期期間                                       | 104 年 8 月～105 年 8 月          |                                                                  |                                          |                                            |
| 壬、本期經費                                       | 17100 千元                     |                                                                  |                                          |                                            |
|                                              | 資本支出                         |                                                                  | 經常支出                                     |                                            |
|                                              | 土地建築_____千元                  |                                                                  | 人事費 1123.2 千元                            |                                            |
|                                              | 儀器設備 13,908 千元               |                                                                  | 業務費_____千元                               |                                            |
|                                              | 其 他_____千元                   |                                                                  | 材料費_____千元                               |                                            |
|                                              |                              |                                                                  | 其 他 2068.8 千元                            |                                            |
| 癸、摘要關鍵詞（中英文各三則）                              |                              |                                                                  |                                          |                                            |
| 紅外線連續監測 Open-path Fourier transform infrared |                              |                                                                  |                                          |                                            |
| 揮發性有機物 Volatile organic compounds(VOCs)      |                              |                                                                  |                                          |                                            |
| 多環芳香烴 Polycyclic Aromatic Hydrocarbons       |                              |                                                                  |                                          |                                            |
| 參與計畫人力資料：（如僅代表簽約而未參與實際專案工作計畫者則免填以下資料）        |                              |                                                                  |                                          |                                            |
| 參與計畫人員姓名                                     | 工作要項或撰稿章節                    | 現職與簡要學經歷                                                         | 參與時間(人月)                                 | 聯絡電話及 e-mail 帳號                            |
| 曹志成                                          | 計畫主持人<br>報告審核及督導整合           | 1.臺灣大學大氣科學所<br>2.副總<br>3.行政院環保署「103 年度雲林縣離島工業區紅外線連續監測及有害污染物調查計畫」 | 2 人月                                     | (02)8227-2200<br>terence.tsao@leder.com.tw |
| 趙君平                                          | 協同主持人                        | 1.中興大學環工所<br>2.新北市『102 年新北市工業區 FTIR 監測』                          | 2 人月                                     | (02)2793-8646<br>kevin@feat.com.tw         |

|     |                       |                                                                         |       |                                           |
|-----|-----------------------|-------------------------------------------------------------------------|-------|-------------------------------------------|
| 李居昌 | 計畫經理<br>報告撰寫及工作協調控管   | 1. 中山大學海環所<br>2. 總經理室專案經理<br>3. 行政院環保署「103 年度雲林縣離島工業區紅外線連續監測及有害污染物調查計畫」 | 8 人月  | (07)553-0122<br>collen.lee@sunnway.com.tw |
| 陳怡安 | 專責人員<br>各項現場監測作業及報表填寫 | 1. 高醫公衛所<br>2. 工程師                                                      | 12 人月 | (07)553-0122<br>annchen@leder.com.tw      |

## 雲林縣環境保護局計畫成果中文摘要(簡要版)

### 一、中文計畫名稱：

104 年度雲林縣離島工業區紅外線連續監測有害污染物調查計畫

### 二、英文計畫名稱：

The Infrared continuous monitoring and the survey of harmful air pollutions in Yunlin County on 2014

### 三、計畫編號：

YLEPB-104-044

### 四、執行單位：

祥威環境股份科技公司

### 五、計畫主持人（包括共同主持人）：

曹志成

### 六、執行開始時間：

104/08/26

### 七、執行結束時間：

105/08/25

### 八、報告完成日期：

105/08/13

### 九、報告總頁數：

本文 305 頁

### 十、使用語文：

中文，英文

十一、報告電子檔名稱：

YLEPB-104044.DOC

十二、報告電子檔格式：

WORD 2003

十三、中文摘要關鍵詞：

揮發性有機物，多環芳香族化合物，開徑式霍式紅外光譜儀，懸浮微粒，細懸浮微粒

十四、英文摘要關鍵詞：

VOCs, PAHs, OP-FTIR, PM<sub>10</sub>, PM<sub>2.5</sub>

十五、中文摘要（約三百至五百字）

本計畫於 104 年 8 月 26 日開始執行，計畫內容包括紅外線連續監測作業、調查離島工業區廠區中 PM<sub>2.5</sub> 及金屬元素之濃度變化趨勢及分布特性、調查雲林地區鄰近工業區及遠離工業區 PM<sub>2.5</sub> 及金屬元素之濃度變化趨勢及分布特性及於離島工業區及附近地區進行 VOCs 之監測，以瞭解雲林地區 VOCs 之濃度變化趨勢。本年度計畫各工作項目執行成果，主要分述如下：

一、完成紅外線紅外線連續監測作業共 390 天次

1. 南門及許厝測線最常出現物種皆為乙烯、丙烯，當風向為北風到東北風夾角時，較易測得高值。
2. 超出嗅覺閾值之物種：南門測線為丁酮及乙醇；許厝測線為氨及乙醇。

二、完成揮發性有機氣體採樣分析 56 點次

(一) 第一次採樣：104 年 9 月 24 至 25 日

檢測 8 測點均測得丙酮及甲醇，均為空氣中常見污染物種之一；廠區外測點以崙豐國小及四湖國中測得 5 種物種為較多，且均以崙豐國中的濃度相對較高，其中甲醇有最高濃度

(18.9 ppb)；廠區內三測點中以 VCM 廠測得的物種較多，共測得 9 種物種，且該測點主要測得物種為烷類化合物，其中以甲醇有最高的濃度(14.3 ppb)；K8400 樓頂則測得 8 種物種，其中以甲醇濃度最高為 13.4 ppb。

(二) 第二次採樣：104 年 10 月 7 至 8 日

檢測 8 點均測得丙酮、甲醇；廠區外測點中豐安國小及崙背國中均測得 7 種物種，以豐安國小所測得甲醇有最高濃度(30.9 ppb)、丙酮有最高濃度(11.4 ppb)，而其他採樣點的丙酮均為 10 ppb 以下；廠區內 K8400 及 AROMA-2 均各測得 9 種物種，但以 VCM 廠所測得丙酮有最高濃度(14.9 ppb)、K8400 所測得甲醇有最高濃度(20.8 ppb)。

(三) 第三次採樣：104 年 12 月 15 至 16 日

檢測 8 點均測得丙烷、氯甲烷、丙酮、甲醇、甲苯、異丁烷；廠區外測點中新興國小及崙背國中均測得 7 種物種，以豐安國小所測得甲醇有最高濃度(17.6 ppb)；廠區內 AROMA-2 測得 8 種物種，但以 VCM 廠所測得丙酮有最高濃度(13.7 ppb)、K8400 所測得甲醇有最高濃度(142.0 ppb)。

(四) 第四次採樣：105 年 01 月 14 至 15 日

檢測 8 點均測得丙烷、丙酮、甲醇、甲苯、正丁烷、異丁烷；廠區外測點中均測得 7 種物種，以豐安國小所測得甲醇有最高濃度(34.4 ppb)；廠區內 VCM 測得 10 種物種，以 VCM 廠所測得丙酮有最高濃度(40.5 ppb)、K8400 所測得甲醇有最高濃度(235.0 ppb)。

(五) 第五次採樣：105 年 3 月 17 至 18 日

檢測 8 點均測得丙烷、甲醇、丙酮、甲苯、正丁烷及異丁烷；廠區外以豐安國小及新興國小均測得 6 種物種，以豐安國小所測得甲苯有最高濃度(8.10 ppb)；廠區內 AROMA-2 測

得 9 種物種，廠區內各測點物種濃度差異不大。

(六) 第六次採樣：105 年 5 月 26 至 27 日

除新興國小外，檢測 8 點均測得丙酮；廠區外以豐安國小及崙背國小均測得 2 種物種；廠區外各測點物種濃度差異不大；廠區內 K8400 測得 13 種物種，以 K8400 所測得異戊烷有最高濃度(28.00 ppb)。

(七) 第七次採樣：105 年 6 月 27 至 28 日

檢測 6 點均測得甲醇及丙酮；廠區外以新興國小測得 5 種物種為最多，廠區外各測點物種濃度差異不大；廠區內 K8400 測得 25 種物種，以 K8400 所測得異戊烷有最高濃度(86.50 ppb)。

三、完成懸浮微粒及相關分析 90 點次

PM<sub>2.5</sub> 之平均濃度，第一次檢測日間以近程(離島工業區內)最高，中程(鄰近工業區)次之，遠程(遠離工業區)最低。夜間則因受到東北風之影響，以中程最高、近程次之，而以遠程最低；第二次檢測日夜間濃度以遠程最高、中程次之、近程最低，可能為因強烈東北風將近程或內陸之污染帶至所致；第三次檢測日夜間濃度以遠程最高、中程次之、近程最低，可能為因西南氣流將近程或內陸之污染帶至所致。

PM<sub>2.5</sub> 中 PAHs 濃度部分，第一次及第二次檢測呈現近程與中程高於遠程之情形，顯示近程及中程仍受到工業排放之影響。夜間之濃度皆呈現較日間濃度為高，可能為夜間風速較日間低，故 PAHs 較易附著於 PM<sub>2.5</sub> 上，導致夜間有較高濃度。第三次檢測日間呈現遠程最高、近程次之、中程最低，可能受西南氣流導致遠程有較高濃度。

PM<sub>2.5</sub> 中重金屬濃度部分，第一此檢測日夜間總重金屬濃度均為近程最高、中程次之、遠程最低，三區間日間濃度皆高於夜間，顯示日間人為活動對 PM<sub>2.5</sub> 中金屬濃度有影響；第二次檢測日夜間



工業重金屬濃度皆為遠程最高、中程次之、近程最低，此現象可能是近程地區風速明顯較其他兩區為高，造成近程地區  $PM_{2.5}$  形成不易，而低濃度  $PM_{2.5}$  則導致其金屬濃度偏低；第三次檢測日間工業重金屬為遠程最高、中程次之、近程最低，此現象可能是西南風吹拂，將近程之污染帶至遠程所至。

$PM_{2.5}$  中離子濃度部分，日夜間以  $SO_4^{2-}$  為佔總離子最多，其次為  $NH_4^+$ ，由於  $SO_4^{2-}$  其主要來源多為石化燃料燃燒所形成之衍生性鹽類，如燃煤發電或重油燃燒之鍋爐等，故日間之比例較夜間高。

$PM_{2.5}$  中總碳濃度部分，第一次檢測為近程與中程高於遠程之情形，且日間高於夜間，顯示工業區及日間人為活動對  $PM_{2.5}$  中碳濃度有貢獻；第二次檢測為遠程最高、中程及近程次之推測原因仍為各區受東北季風之影響，近程工業區與內陸之污染源被風帶至中程及遠程地區，故遠程有較高濃度；第三次檢測為遠程最高、近程次之、中程最低，推測原因為遠程除受近程影響外，亦受到內陸其他污染源導致。

氣態 PAHs 濃度部分，第一次檢測日間濃度高低為近程及中程高於遠程之情形，顯示近程地區日間可能受工業源之影響，有較高濃度且對近程地區有影響；第二次檢測，日間以近程為最低，此現象應是近程風速較其他兩區為高之影響；第三次檢測日夜間皆以遠程最高、中程次之、近程最低，此現象應為遠程受西南氣流影響，使氣態 PAHs 由近程傳輸到中程及遠程。

## 十六、英文摘要：

The project started on Aug 26th, 2015, which includes FTIR monitoring, offshore island industrial zones (in the factory), and Yunlin area near the industrial zones and away from the industrial area (outside the factory) for pollutant monitoring works. The pollutants include volatile contaminants (VOCs),  $PM_{2.5}$ , and metal elements. Through the effective implementation of this plan, it can grasp the offshore island industrial zone preceding the sources of pollution, establish background of concentrations for the key site of industrial zone, and then clarify the

impact from the Yunlin area offshore island industrial zones. The outcome of projects as follows:

I. The completion of FTIR monitoring in 390 times.

1. Nan-Man and Shu-Tzu measuring line often measured species are ethylene, propylene. When the wind direction was from the north to northeasterly angle, and more easily measured the high value.
2. The species of exceeding odor threshold : Nan-Man measuring line is butanone and ethanol; Shu-Tzu measuring line is ammonia and ethanol.

II. The completion of sampling and analysis for volatile organic gases in 56 times.

i. The first sampling period: Sep 24th, 2015 - Sep 25th, 2015

Detection 8 measuring points had measured acetone and methanol, they were the kinds of common air pollutants. Measuring points outside of the factory as Lunfeng elementary school and SiHu junior high school had measured the highest quantities of 5 species, and the concentration of Lunfeng was relatively higher, which was the highest concentration of methanol (18.9 ppb). Three measuring points in the factory which VCM plant had measured more species as 9. The measuring point had measured main species were alkyl compounds, which was the highest concentration of methanol (14.3 ppb); K8400 measuring point had measured species as 8, which was the highest concentration of methanol as 13.4 ppb.

ii. The second sampling period: Oct 7th, 2015 - Oct 8th, 2015

Detection 8 measuring points had measured acetone and methanol, measuring points outside of the factory as Fengan elementary school and Lunbei junior high school had measured 7 species, and the concentration of methanol (30.9 ppb) and acetone (11.4 ppb) of Fengan was the highest. The concentrations of acetone at other measuring points were less than 10 ppb; K8400 and AROMA-2 in factory area had measured 9 species, but the concentrations of acetone (14.9 ppb) of VCM plant was the highest, and the concentration of methanol (20.8 ppb) of K8400 was the highest.

iii. The third sampling period: Dec 15th, 2015 - Dec 16th, 2015

Detection 8 measuring points had measured propane, chloromethane, acetone, methanol, toluene and isobutane, measuring points outside of



the factory as Xinxing elementary school and Lunbei junior high school had measured 7 species, and the concentration of methanol (17.6 ppb) of Fengang was the highest. AROMA-2 in factory area had measured 8 species, but the concentrations of acetone (13.7 ppb) of VCM plant was the highest, and the concentration of methanol (142.0 ppb) of K8400 was the highest.

iv. The fourth sampling period: Jan 14th, 2016 - Jan 15th, 2016

Detection 8 measuring points had measured propane, acetone, methanol, toluene, n-butane and isobutane, measuring points outside of the factory had measured 7 species, and the concentration of methanol (34.4 ppb) of Fengang elementary school was the highest; the VCM plant had measured 10 species, and the concentration of acetone (40.5 ppb) was the highest. The concentration of methanol (142.0 ppb) of K8400 was the highest.

v. The fifth sampling period: Mar 17th, 2016 - Mar 18th, 2016

Detection 8 measuring points had measured propane, methanol, acetone, toluene, n-butane and isobutane, measuring points outside of the factory as Fengang and Xinxing elementary school had measured 6 species, and the concentration of toluene (8.10 ppb) of Fengang elementary school was the highest; AROMA-2 in factory area had measured 9 species and the species of each measuring points were a little difference in factory area.

vi. The sixth sampling period: May 26th, 2016 - May 27th, 2016

Detection 8 measuring points had measured acetone except Xinxing elementary school. Measuring points outside of the factory as Fengang and Lunbei elementary school had measured 2 species, the concentration of measuring points outside of the factory were a little difference. The K8400 in factory area had measured 13 species, and the concentration of isopentane (28.0 ppb) was the highest.

vii. The seventh sampling period: Jun 27th, 2016 - Jun 28th, 2016

Detection 6 measuring points had measured methanol and acetone, measuring points outside of the factory as Xinxing elementary school had measured 5 species, and it was the most species. The concentration of measuring points outside of the factory were a little difference. The K8400 in factory area had measured 25 species, and the concentration of isopentane (86.5 ppb) was the highest.

III. The completion of relative analysis of particulate matter in 90 times

The average concentration of PM<sub>2.5</sub>, at first test in the day-time(in offshore industrial zone) was the highest followed by short-distance, mid-distance (near industrial zone), and long-distance (away from industrial zone). In the night time, due to the impact of northeast wind, the highest in mid-distance, short-distance, and the lowest in long-distance; At second test, day-night concentration was the highest followed by long-distance, mid-distance, and the lowest in short-distance due to strong northeast wind brought the pollution of inland or proximity; At third test, day-night concentration was the highest followed by long-distance, mid-distance, and the lowest in short-distance due to southwesterly airstream brought the pollution of inland or proximity.

According to the concentration of PAHs among PM<sub>2.5</sub>, at the first and second test mid-distance and short-distance presented higher values than long-distance which showed the short and mid still affected by the industrial emissions. The concentration at night was rendered higher than the day. It may be the wind speed lower at night than day, thus PAHs easily attached to PM<sub>2.5</sub>, leading to the higher concentration at night. At the third test, day-time concentration was the highest followed by long-distance, short-distance, and the lowest in mid-distance due to southwesterly airstream.

The concentration of total metal in PM<sub>2.5</sub>, the first test, the concentration of day and night were the highest equally followed by short-distance, mid-distance and long-distance was the lowest. At day time, the concentration of these three distances were higher than at night. It reveals that human activities affected concentration of metal in PM<sub>2.5</sub>. The second test, the concentration of metal both day and night were the highest followed by long-distance, mid-distance and the lowest were short-distance. The wind speed of short-distance was higher than the other two areas which resulting in the formation of PM<sub>2.5</sub> were not easy to gather. The low concentrations of PM<sub>2.5</sub> had resulted in its low metal concentrations. The third test, the concentration of metal in day-time was the highest followed by long-distance, mid-distance and the lowest were short-distance due to southwest wind brought the short-distance pollution to the long-distance.

The concentration of SO<sub>4</sub><sup>2-</sup> ion in PM<sub>2.5</sub>, the most was SO<sub>4</sub><sup>2-</sup> of total ion during day and night and followed by NH<sub>4</sub><sup>+</sup>. Due to the main source of SO<sub>4</sub><sup>2-</sup> was from fossil fuel combustion, mostly formed by the derivative salts, such as combustion of heavy oil or coal-fired power boilers, etc., thus the proportion of the daytime was higher than at night.

The concentration of total carbon in PM<sub>2.5</sub>, the first detection of

short-distance and long-distance were higher than long-distance and daytime higher at night. It showed that industrial areas and human activities contribute to concentration of carbon in  $PM_{2.5}$ ; the second detection of long-distance was the highest, mid-distance and the lowest short-distance because the northeast monsoon affected. The industrial area and the proximity of pollution sources inland were brought by the wind and to mid-distance and long-distance, so long-distance was the higher concentration. The third detection of long-distance was the highest, short-distance and the mid-distance was lowest because the short-distance and inland affected.

The concentration of gaseous PAHs, the first test, concentration at day for the short and mid-distance were higher than long-distance. It reveals short-distance area may be affected by industrial sources at day; the second test, the concentration of the lowest was short-distance. It reveals wind speed of short-distance was higher than the other two areas; The third test, the concentration at day-night were the highest followed by long-distance, mid-distance and the lowest were short-distance. It reveals the southwesterly airstream affected the gaseous PAHs transmitted by the short-distance to the mid-distance and long-distance.

