台灣氣膠研究學會學生出席國際會議補助申請表

106年6月草擬

申請人姓名	中文：	會員編號	
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會議正式名稱	中文：2017 T&T 國際氣膠研討會		
	英文：2017 T&T IAC International Aerosol Conference		
會議時間(西元年)	起 2017 年 8 月 7 日	會議地點	國家 泰國
	迄 2017 年 8 月 7 日		城市 合艾
會議主辦單位名稱	(中文) 宋卡王子大學		
	(英文) Prince of Songkla University, Songkhla, Thailand		
擬發表論文題目	(中文) 一個用於即時量測10 μm 至32 nm 間微粒數目濃度的電子式微孔多階衝擊器之開發		
	(英文) The development of a ten-stage electrical micro-orifice cascade impactor (EMCI) for the real-time monitoring of aerosol size distribution from 32 nm to 10 μm		
論文所屬領域	1. Aerosol 2. instrumentation and measurement	專長學科	1. aerosol measurement 2.
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有無向其他機構申請補助	□ 已獲申請； 機構名： 獲補助金額： □ 申請中； 機構名： 申請補助金額： ■ 無		
過去3年曾獲得校內補助(請詳列出)	□ 有；會議名稱： (年) 獲補助金額： ■ 無		
另請檢附右列文件各乙份隨同本申請表送國際事務處辦理	1. 國際會議主辦單位致申請人**本人**之正式邀請函或論文被接受之證明文件影本 2. 擬發表之論文摘要，英文論文全文影本（論文以在國內完成而尚未發表者為限） 3. 申請人近三年內參與國際會議獲得補助資料（請註明會議名稱、時間、補助機關，由最近參加者填起） 4. 國際會議日程表，會議有關資料及其他有助審查之資料		

茲證明本申請案及相關資料皆屬實，論文之共同作者同意本人於會中發表。

申請人：________2017 年 7 月 11 日

指導教授：________2017 年 7 月 11 日

申請人近三年內曾參加在國外舉辦之國際學術會議

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The development of a ten-stage electrical micro-orifice cascade impactor (EMCI) for the real time monitoring of aerosol size distribution from 32 nm to 10 μm

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Abstract

In this study, an electrical micro-orifice cascade impactor (EMCI) with the operating flowrate of 16.7 L/min was developed for size distribution monitoring in real-time using the electrometers. The EMCI consists of a NCTU micro-orifice cascade impactor (NMCI), a NCTU unipolar charger and a Keithley 6514 electrometer. To reduce signal noise, the main body of the impactors is designed to have a 3-layer structure based on the concept of a faraday cage. Inside the unipolar charger, a Pt wire with 6 mm in length and 100 μm in diameter was used as the charging needle. Aerosol particles are charged first when passing through the charger. After the charged particles are collected on the impaction plates, the low current signal from each of all stages is detected using the electrometer and the measured currents are then converted to size-classified number concentrations by the theoretical equation corrected for the particle charging efficiency. The impactor and the unipolar charger were calibrated first. The calibration results of the impactor showed that the cut-off aerodynamic diameters (d_{pa50}) of 9.92, 5.62, 2.48, 1.02, 0.563, 0.321, 0.178, 0.097, 0.056 and 0.032 μm, which are very close to the design values at the operating flow rate of 16.7 L/min. The operating voltage of the unipolar charger ranged between +2.6 to +3.8 kV with the optimal charging efficiency found at +3.6 kV. Comparing with the ELPI+ charger, the charging efficiency is nearly the same when the particle size is greater than 56 nm up to 10 μm. However, the charging efficiency in the size range of 10 to 56 nm is higher than that of the ELPI+ charger by as much as 93 to 11 %. The signals of the EMCI were compared with those of the TSI Aerosol Electrometer (AE) and found that the bias of the EMCI is less than 15 % in the range of 3-1500 fA. Finally, the EMCI was used for the size distribution measurement of laboratory generated aerosols. Test results showed that the size distribution measured by EMCI agrees well with that of the SMPS in nanoparticle size range. More calibration studies and comparison tests are under way using multiple electrometers installed at all stages.

Keywords*: *impactor, micro-orifice cascade impactor, unipolar charger, electrostatic effect, aerosol measurement

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1. Introduction

Cascade impactors are used to measure aerosol mass distributions and the collected samples can further be analyzed for chemical compositions (Chen et al. 2010; Kim et al. 2012; Kudo et al. 2012; Wang et al. 2010; Zhu et al. 2010; Zhu et al. 2012). Traditionally, the smallest cutoff aerodynamic diameter (d_{pa50}) of a cascade impactor is around 0.5 µm, which leads to a poor size resolution of submicron particles and nanoparticles. To obtain a lower d_{pa50}, improved cascade impactors have been developed. For example, Hering et al. (1979) have designed and tested a 8-stage low pressure impactor (LPI) with 4.0, 2.0, 1.0, 0.5, 0.26, 0.11 0.075 and 0.05 μm of cut-off aerodynamic diameter (d_{pa50}) for each stage impactor under 1.0 L/min of operating flowrate. The operating pressure was controlled from 8 to 150 mmHg at last four stage impactor for ultrafine particle collection. The 8-stage Micro-orifice uniform deposit impactor (MOUDI) was developed by Marple et al., (1991). The range of d_{pa50} of 10-stage MOUDI is between 0.056 to 18 μm. To collect nanoparticles, the nozzle diameter has to be as small as 52 μm and there are 2000 nozzles in the last stage to increase the inertial impaction force of nanoparticle. However, some practical problems such as solid particle bounce, overloading of collected particles on the impaction plate and nozzle clogging which may cause sampling bias. Many efforts have been made to resolve these problems. For example, different types of impaction substrates such as oil-coated substrates (Turner and Hering, 1987; Pak et al. 1992; Peters et al. 2001; Liu et al. 2011; Tsai et al. 2012), porous substrates (Huang et al. 2005; Huang et al. 2001) and specially designed substrates (Chang et al. 1999; Tsai and Cheng, 1995) were used to reduce solid particle bounce. For increasing the particle loading capacity on impaction substrates, rotating substrates (Marple et al. 1991; Tsai et al. 2012), oil-soaked Teflon filters (Turner and Hering 1987; Tsai et al. 2012) and impaction plates of special designs (Tsai and Cheng, 1995) provide possible solutions. To avoid nozzle clogging during long-term or high aerosol concentration sampling, new-type of micro-orifice nozzle plate with stronger and smoother structure of nozzles as compared to that of the MOUDI was developed by Liu et al. (2013). However, the long-term ambient sampling is necessary for ensuring the weight of the collected particle is higher than the minimum detected limit of the micro-balance. Due to the issue, the aerosol distribution can only be monitored in daily. To monitor the variations of the aerosol distribution in real-time, the electrical low pressure impactor (ELPI) was developed. The operation principle of the ELPI is that the particle will be charged first by a charger before introducing into the impactor. The low current signal will then be detected by an electrometer when the charged particle is collected on the impaction plate. After that, the current will be transported to number concentration using the theoretical equation in every 1 sec of frequency. However, even though the ELPI can be used on measuring the aerosol size distribution in real-time, the concern in the traditional LPI still exist, the solid particle bounce. Moreover, the study have displayed that the relatively larger interstage pressure drop as compared to MOUDI, reduces potential evaporation of volatile aerosol species (Chow and Watson, 2007). Furthermore, the charging efficiency of the ELPI charger was tested and showed the very low efficiency for particle size less than 30 nm in previous study.

The aims of this study is to develop an Electrical micro-orifice cascade impactor (EMCI) which can be used to measure the size distribution in real-time and solve the most practical concerns in traditional cascade impactor with 16.7 L/min of operating flowrate. The EMCI consists of the NCTU unipolar charger, the NMCI and the Keithley Electrometer (EM-K, model 6514, Keithley Instrument Inc). The NCTU unipolar charger which showed the higher charging efficiency for nanoparticle as compared to ELPI charger was designed and tested under 16.7 L/min operating flowrate and +3.6 kV of supplied voltage in previous study. The casing and the nozzle plate of the NMCI was redesigned for avoiding the environmental noise which induce the measurement bias on low current detection and reducing the flowrate from 30 to 16.7 L/min, respectively. After fabrication, the particle collection efficiency, electrometer comparison and number concentration were tested.

2. Experiment Methods

Modification of the impactor

The casing was redesigned refer to the design of the ELPI (Keskinen et al., 1992) and the Faraday Cup (FC) to make sure the noise was blocked effectively on EMCI. The design values of d_{pa50} from first to last stage impactor were 10.0, 5.6, 2.5, 1.0, 0.56, 0.32, 0.18, 0.1, 0.056 and 0.032 μm, respectively. The after filter stage was placed behind the 10th stage impactor for collecting the particle size less than 32 nm. The schematic diagram of the bottom casing is shown as the Fig 1 (a), and the upper casing for nozzle plate of the NMCI (Chien et al., 2016) is still used on the EMCI. The bottom casing consists of four parts, from inside to outside are the inner casing, insulator layer, outer casing and a pin, respectively. The stainless steel was used as the material for inner and outer casing; the peek was used for insulator layer and the pin was fabricated by copper (Cu). The conductive filter is placed nearing the insulator of the after filter stage which have the similar structure to the bottom casing shown in Fig 1(b). In this system, when the charged particle was collected on the impaction plate, the low current signal will be transported and detected using the electrometer via the pin. The main function of the outer casing with metal as material is to build the electrostatic shielding effect for noise prevention; and the insulator layer is used to block the inner and outer casing to avoid the current loss.

To reduce the flowrate from 30 to 16.7 L/min, the nozzle size and number of the nozzle for each stage impactor were also redesigned based on the parameters of the NMCI and Stokes number at 50 % of particle collection efficiency (S_{tk50}). For 0-5$^{\mathrm{th}}$ stage impactor, the nozzle sizes were re-calculated and the number of the nozzle were maintained. For 6-10$^{\mathrm{th}}$ impactor, the nozzle plate of the NMCI were used by adding the nozzle mask on the nozzle inlet to reduce the number of the nozzle and maintain the nozzle size because of the high cost of the LIGA process for micro-orifice nozzle plate. The size of the nozzle mask was designed using the continuously equation to maintain the pressure drop of each stage impactor comparing with NMCI. Therefore, the jet-to-plate distance was the only parameter to be adjusted for ensuring the d_{pa50} were same as the design value due to the bias during manual cutting of the nozzle mask.

Particle collection efficiency and electrometer comparison

The low current signal was compared using aerosol electrometer (AE, TSI) and Keithley electrometer (EM-K) for measurement accuracy verification. Polydisperse particles were first generated by the constant output atomizer (TSI Model 3076) from the DOS solution with the concentration of 0.001 % (v/v). The aerosol flow was passed through a tubular furnace (Lindberg/Blue, Model HTF55322C, USA) at a fixed temperature of 300 ^{0}C to produce a relatively narrow size distribution by the evaporation-condensation process. Monodisperse, singly charged particles were then generated by the electrostatic classifier (EC, TSI Model 3080) equipped with the nano-differential mobility analyzer (DMA, TSI Model 3085). To minimize the effect of multiple charges on the monodispersity of the classified particles (Pui and Liu, 1979), only particles larger than the count median diameter (CMD) were classified. After the downstream of the EC, the aerosol flow was introduced into the AE and the after filter stage equipped with the EM-K under same operating flowrate, respectively. The more comparison of the electrometer was tested in further experiment.

The experimental setup for particle collection efficiency calibration of 5-10th stage impactor was refer to Liu et al. (2013). Moreover, after the electrometer comparison, the collection efficiency of nanoparticle was also measured using the electrometers detection is shown in Fig. 2. The low current signal generated when the charged particle was collected on the impaction plate was monitored using the EM-K. The other particle which pass through the impactor was collected by AE. The collection efficiency that measured by two electrometers ($\eta_{\mathrm{AE\ +\ EM\text{-}K}}$) was then calculated by the following equation:

$$\eta_{AE+EM} = \left(\frac{I_{EM-K}}{I_{down} + I_{EM-K}}\right) \times 100\% \tag{1}$$

where the I_{down} is the aerosol currents at the outlet of the tested impactors measured by the AE equipped with a home-made faraday gage (fA). $I_{\mathrm{EM\text{-}K}}$ is the aerosol currents that detected using the EM-K when the charged particle was collected (fA).

The micron and sub-micron monodisperse aminefluoresc (AF) particles from 0.6-11 μm of range were generated using the Vibration Orifice Monodisperse Aerosol Generator (VOMAG, TSI model 3450) for 0-4$^{\mathrm{th}}$ stage impactor calibration. The calibration was conducted on two parts, with Aerodynamic Particle Sizer (APS, TSI model 3321) and the system that combining with the charger and the EM-K, for particle collection efficiency comparison as shown in Fig 3(a) and 3(b), respectively. The particles were introduced to the Neutralizer (TSI model 3054) first for electrical neutrality. The mixing chamber was used to dry the particle before introducing into the tested impactor or charger. For the APS system, the particle collection efficiency (η_{APS}) was then calculated by the following equation:

$$\eta_{APS} = (1 - \frac{N_{down}}{N_{up}}) \times 100\% \tag{2}$$

where the N_{up} and N_{down} are the number concentrations of the upstream and downstream impactor that measured by APS, respectively. For the charger and electrometer system, the monodisperse particle was charged before introducing into the tested impactor equipped with after filter stage. Two electrometers (EM-K1 and EM-K2) were used to detect the signals from the tested stage impactor and after filter stage, respectively. The collection efficiency measured using the electrometer-charger system ($\eta_{\mathrm{EM\text{-}K}}$) was calculated as:

$$\eta_{EM-K} = (\frac{I_{plate}}{I_{filter} + I_{plate}}) \times 100\% \tag{3}$$

where I_{plate} and I_{filter} are the currents that detected by the EM-K1 and EM-K2, respectively. Therefore, the particle collection efficiency of 0-10$^{\mathrm{th}}$ stage impactor measured using electrometer as well as EM-K or APS was compared. The charging efficiency of the NCTU charger from 10 nm to 4.689 μm under +3.6 kV of operating voltage were tested and fitted in previous study. The charging efficiency for particle size ranging from 0.9 to 4.689 μm was increased linearly. The charging efficiency of particle size less than 18 nm, however, was decreased rapidly. Therefore, the particle penetrations (Pn) was fitted in three parts as the follow equation:

$$Pn = \begin{cases} -0.13 + 161D_p - 381D_p^2 & 0.01\mu m \le D_p < 0.018\mu m \\ 50.76D_p^{1.12} \qquad ; & 0.018\mu m \le D_p \le 0.9\mu m \\ 56.08D_p^{1.54} & 0.9\mu m < D_p \le 4.689\mu m \end{cases} \tag{4}$$

However, the particle with larger size agglomerated easily in the chamber. When the particle agglomerated, the charged of the particle will be increased which may cause the current was overestimated and then induce the offset of the collection efficiency curve. Therefore, the overestimated current was calculated as:

$$I_{Dn} = n_p(D_n) \times e \times Q \times N_p(D_n) \times \eta_{Dn} \tag{5}$$

where I_{Dn} is the current overestimated; $n_p(D_n)$ is the elementary units of charge with D_n of particle size; e is the unit charged of the electron; Q is the operating flowrate; $N_p(D_n)$ is the number concentration of the D_n of particle size and η_{Dn} is the particle collection efficiency of the Dn particle. The calibrated current was then calculated based on eq. 5 and the number distribution measured by the APS.

Number concentrations and distributions comparison

After the testing of the particle collection efficiency, the 6-10th stage impactor and after filter stage was series connected for number concentrations and distribution measurement. The polydisperse DOS particle with 133 nm of CMD was generated using the same method as the nanoparticle collection efficiency calibration which was shown above. The generated particle was separated to two aerosol flows after passing through the neutralizer. One of the flow was introduced into the SMPS and the other was introduced into the EMCI. The current of each stage impactor was measured individually because of only one EM-K was used.

3. Results and Discussion.

The design of the nozzle plate

The results of the nozzle diameter and number of each stage impactor were displayed in Table 1. When the operating flowrate was reduced from 30 to 16.7 L/min and the number of the nozzles were maintained, the nozzle size of the 1-5th stage impactor was modified from 0.889, 0.38, 0.247, 0.72 and 0.04 to 0.68, 0.31, 0.18, 0.06 and 0.036 cm, respectively. For 6-10th stage impactor, the nozzle sizes were maintained but the number of the nozzle was reduced by the nozzle masks from 900, 900, 2000 and 2000 to 500, 500, 1110 and 1110, respectively. The last stage impactor with 0.032 μm of d_{pa50} was tested by two designs with different number of the nozzle, 1640 and 2000, respectively.

Electrometer comparison

Fig 4. Shows the result of the electrometer comparison from AE and EM-K. The result displayed that the current measured by the EM-K was about 15% underestimated comparing with that of the AE when the current ranges from 0-900 fA. The bias between the AE and EM-K is due to the different connection of the pin to electrometer. The HEPA filter inside the AE was contacted with the circuit board through the pin directly, but the triaxial cable was used to connect the pin and the EM-K for the EMCI. The used of the triaxial cable which is different from the connection method of the AE was the main concern that induced the measurement bias.

Particle collection efficiency curves

Fig 5 shows the calibrated particle collection efficiency curves of the 1-10th stage of the EMCI measure by AE, equation 1 and compared with those of the MOUDI. The calibration results together with the design parameters are also summarized in Table 1. It shows that after adjusting proper jet to plate distance, the d_{pa50} values of the 1-10th stage of the EMCI are close to the designed values, which are 10, 5.6, 2.5, 1, 0.56, 0.32, 0.18, 0.1, 0.056 and 0.032 μm, respectively. It can be seen that the pressure of the downstream of the 7-9th stages of the EMCI were less than those of the NMCI. This is because the averaged nozzle size of these stages of EMCI were larger than those of the NMCI due to the manual cutting bias of the nozzle mask. Therefore, the jet-to-plate distance of these stages impactor were also reduced as comparing with these of the NMCI. Furthermore, the collection efficiency curves also displayed the good sharpness in EMCI from 1-10th stage impactor, 1.17, 1.17, 1.32, 1.19, 1.33, 1.25, 1.25, 1.34, 1.38 and 1.48, respectively. The both collection efficiency curves of the EMCI measured by AE and equation (2) were agree well with those of the MOUDI when the particle size was less than 1 μm. However, when the particle size was greater than 1 μm, the curves measured by AE were also agree well, but the results measured by AE-EM-K system was offset. The offset curves was then calibrated using the equation (5) as shown in Fig. 6. The result show that after calibrating, the collection efficiency curves were fitted well than those detected by AE/APS.

Number concentration and distribution comparisons

Fig. 7 shows the result of the number distribution measure by EMCI and SMPS. The results shows that the number concentrations measure by EMCI and SMPS were almost the same, 1.83×10^6 and 1.90×10^6 (#/cm^3), respectively with about 3 % of bias. The both distribution were almost agree well with each other, the result of the EMCI was a little bit offset to the left. This is because the frequency of the SMPS was 128, but the EMCI was only measured in 10 frequency. However, these also show the good result on number distribution measurement.

4. Conclusions

In this study, an electrical micro-orifice cascade impactor (EMCI) with the operating flowrate of 16.7 L/min was developed for size distribution monitoring in real-time using the electrometers. The EMCI consists of a NCTU micro-orifice cascade impactor (NMCI), a NCTU unipolar charger and a Keithley 6514 electrometer. To reduce signal noise, the main body of the impactors is designed to have a 3-layer structure based on the concept of a faraday cage. Aerosol particles are charged first when passing through the charger. After the charged particles are collected on the impaction plates, the low current signal from each of all stages is detected using the electrometer and the measured currents are then converted to size-classified number concentrations by the theoretical equation corrected for the particle charging efficiency.

The calibration results of the impactor showed d_{pa50} values are very close to the design values at the operating flow rate of 16.7 L/min. The operating voltage of the unipolar charger ranged between +2.6 to +3.8 kV with the optimal charging efficiency found at +3.6 kV. Comparing with the ELPI+ charger, the charging efficiency is nearly the same when the particle size is greater than 56 nm up to 10 μm. However, the charging efficiency in the size range of 10 to 56 nm is higher than that of the ELPI+ charger by as much as 93 to 11 %. The signals of the EMCI were compared with those of the TSI Aerosol Electrometer (AE) and found that the bias of the EMCI is less than 15 % in the range of 3-1500 fA. The collection efficiency measured by AE/APS, AE+EM-k system and MOUDI were agree well with each other after charging calibration. The results of the collection efficiency curves also showed the great sharpness in this study

Finally, the EMCI was used for the size distribution measurement of laboratory generated aerosols. Test results showed that the size distribution measured by EMCI agrees well with that of the SMPS in nanoparticle size range. More calibration studies and comparison tests are under way using multiple electrometers installed at all stages.

Acknowledgments

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Table

Table 1 Summary of the calibration results and the design parameters of the MOUDI, NMCI and the EMCI

stage	[a]MOUDI				[b]NMCI				EMCI					
	d_{pa50} (μm)	jet-to-plate (mm)	nozzle size (cm)	[c]P/P_0	d_{pa50} (μm)	jet-to-plate (mm)	nozzle size (cm)	[c]P/P_0	designed d_{pa50} (μm)	d_{pa50} (μm)	jet-to-plate (mm)	nozzle size (cm)	[c]P/P_0	σ_g
1	9.9	4.45	0.889	1	9.9	4.45	0.889	1	10	9.92	6.51	0.68	1	1.17
2	6.2	3.73	0.38	1	6.2	3.73	0.38	1	5.6	5.62	5.55	0.31	1	1.17
3	3.1	2.39	0.247	1	3.1	2.39	0.247	1	2.5	2.48	4.37	0.18	1	1.17
4	1.8	1.22	0.137	1	1.8	1.22	0.137	1	1	1.02	3.99	0.06	1	1.19
5	1	0.7	0.072	0.99	1	0.7	0.072	0.99	0.56	0.55	4.35	0.036	0.99	1.2
6	0.56	0.53	0.04	0.97	0.56	0.53	0.04	0.97	0.32	0.32	1.12	0.014	0.94	1.25
7	0.32	0.55	0.014	0.95	0.323	0.55	0.136	0.95	0.18	0.18	0.3	0.011	0.92	1.25
8	0.18	0.58	0.009	0.89	0.179	0.58	0.108	0.89	0.1	0.098	0.63	0.0054	0.74	1.34
9	0.097	0.77	0.0055	0.76	0.102	0.78	0.0054	0.72	0.056	0.05	0.78	0.0054	0.49	1.38
10	0.057	0.68	0.0052	0.53	0.557	0.68	0.0054	0.47	0.032	0.03	0.38	0.0054	0.31	1.48

[a] the data given in Marple et al. (1991)

[b] the data given in Liu et al. (2013) and Chien et al. (2015)

[c] P=absolute pressure at stage exit with all upstream stages in place, P_0=ambient pressure.

Figure captions

Figure 1. The design of (a) each stage impactor and (b) after filter stage of EMCI

Figure 2. Experimental setup to measure the nanoparticle collection efficiency

Figure 3. Experimental setup to measure the micron and submicron particle collection efficiency by (a) APS and (b) charger + EM-K system

Figure 4. The result of electrometer comparison (AE vs. EM-K)

Figure 5. Particle collection efficiency curves of the 1-10th stage of the EMCI

Figure 6. Particle collection efficiency curves for micron particle calibrated by eq. 5

Figure 7. Number distribution comparison of lower stages of EMCI and SMPS

Figures

(a) the design of the impactor (b) the design of the after filter stage

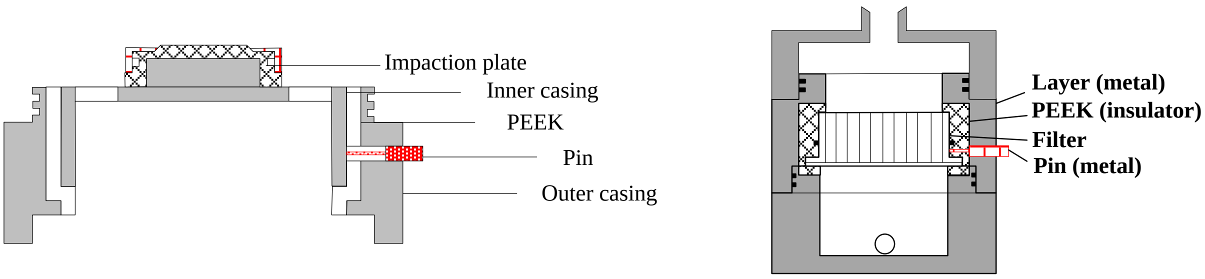

Figure 1

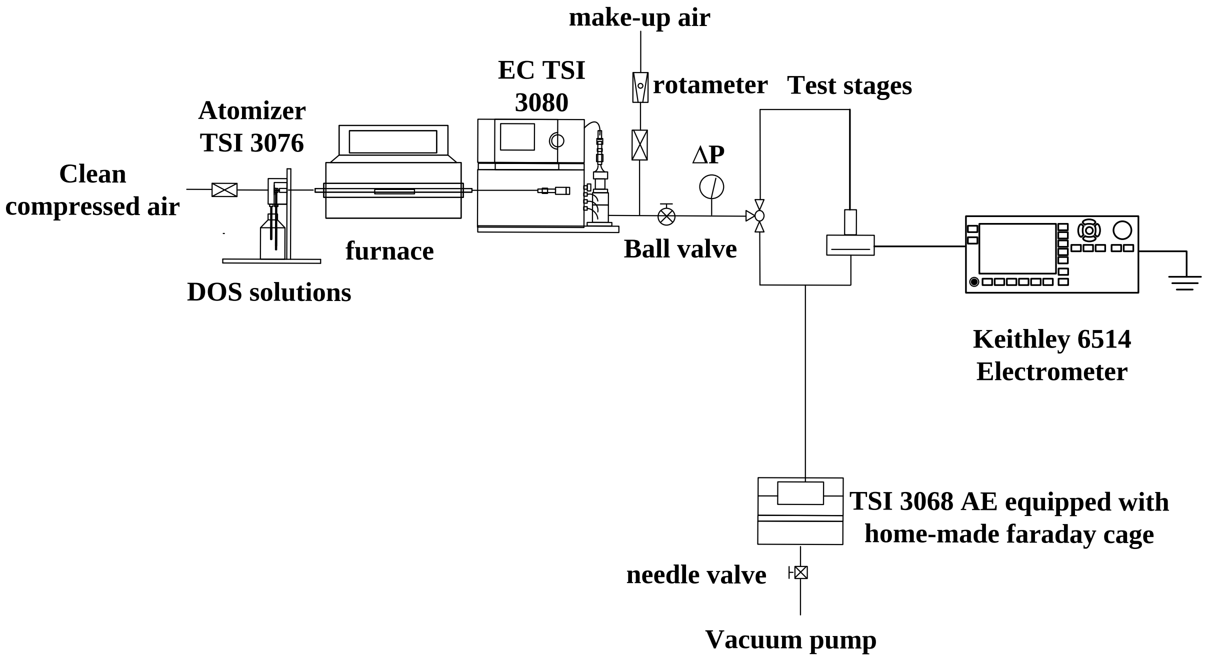
make-up air
EC TSI
3080
rotameter
Test stages
Atomizer
TSI 3076
ΔP
Clean
compressed air
furnace
Ball valve
DOS solutions
Keithley 6514
Electrometer
TSI 3068 AE equipped with
home-made faraday cage
needle valve
Vacuum pump

Figure 2

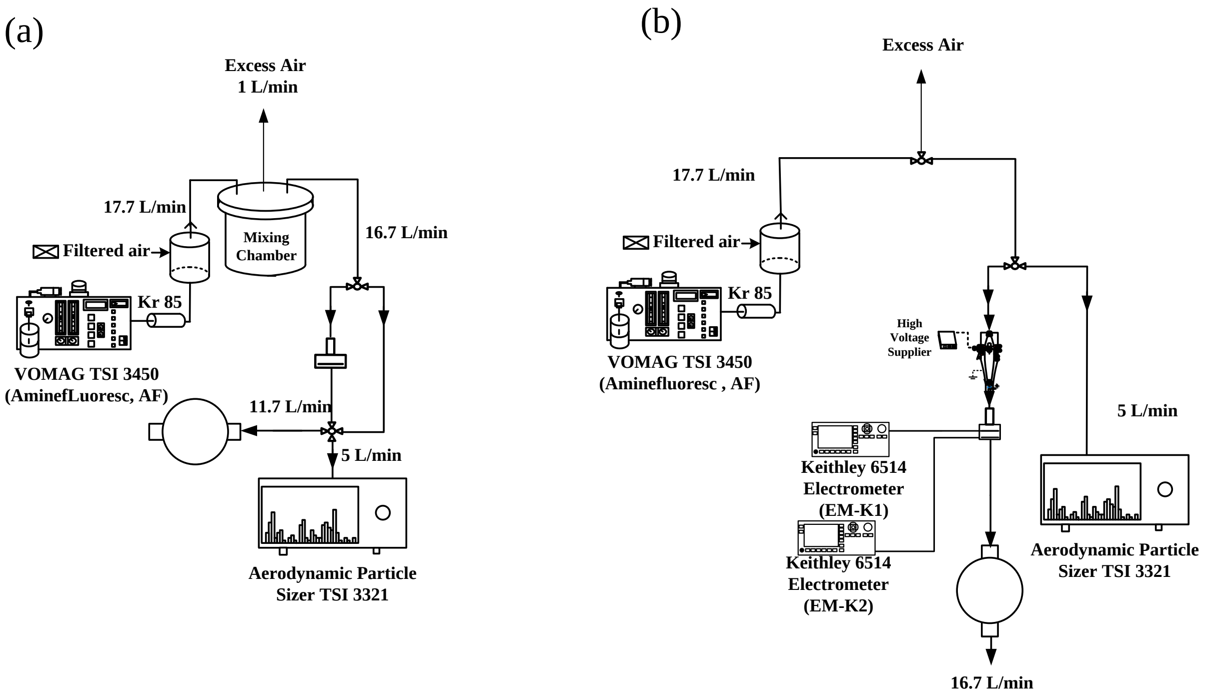
(a)
Excess Air
1 L/min
17.7 L/min
Filtered air
Mixing
Chamber
16.7 L/min
Kr 85
VOMAG TSI 3450
(AminefLuoresc, AF)
11.7 L/min
5 L/min
Aerodynamic Particle
Sizer TSI 3321
(b)
Excess Air
17.7 L/min
Filtered air
Kr 85
VOMAG TSI 3450
(Aminefluoresc , AF)
High
Voltage
Supplier
5 L/min
Keithley 6514
Electrometer
(EM-K1)
Keithley 6514
Electrometer
(EM-K2)
Aerodynamic Particle
Sizer TSI 3321
16.7 L/min

Figure 3

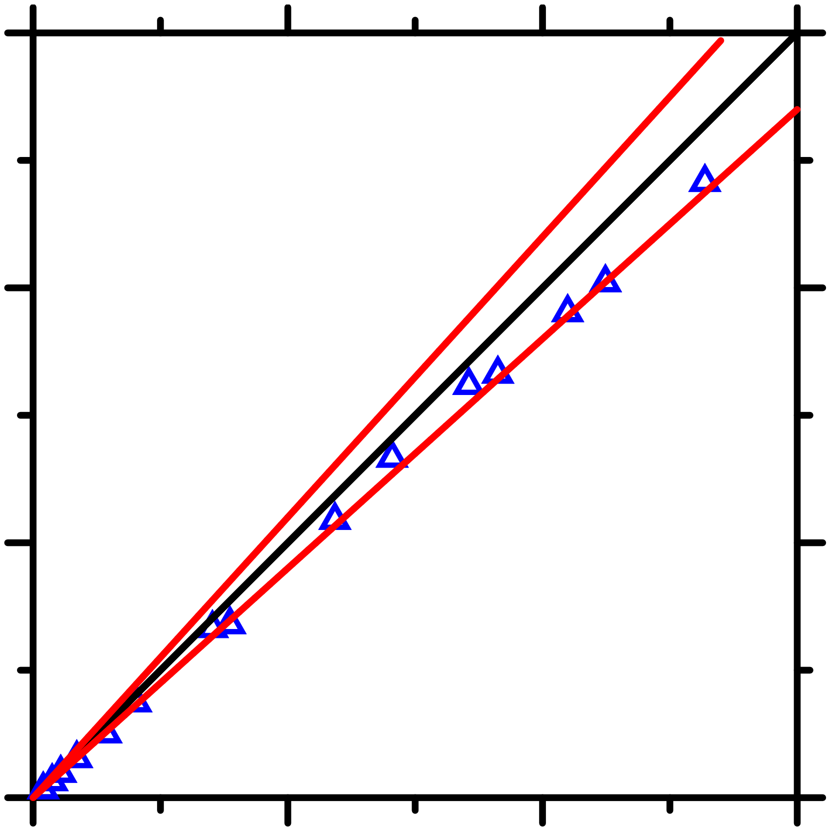

Figure 4

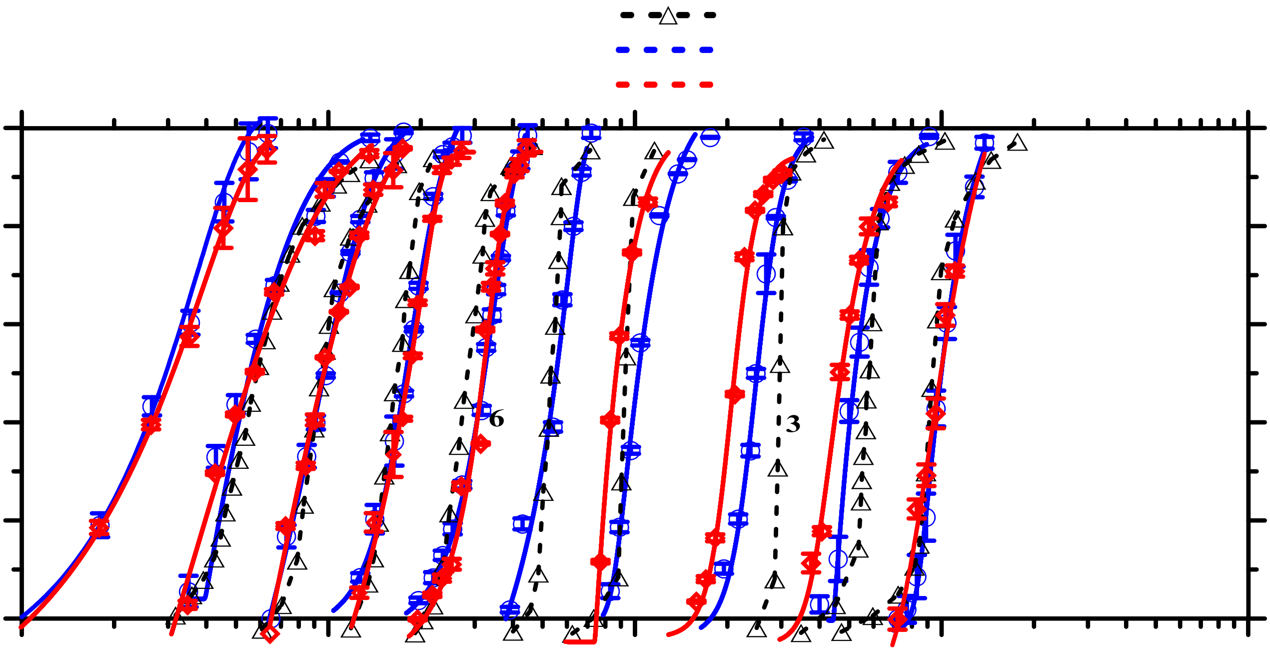

Figure 5

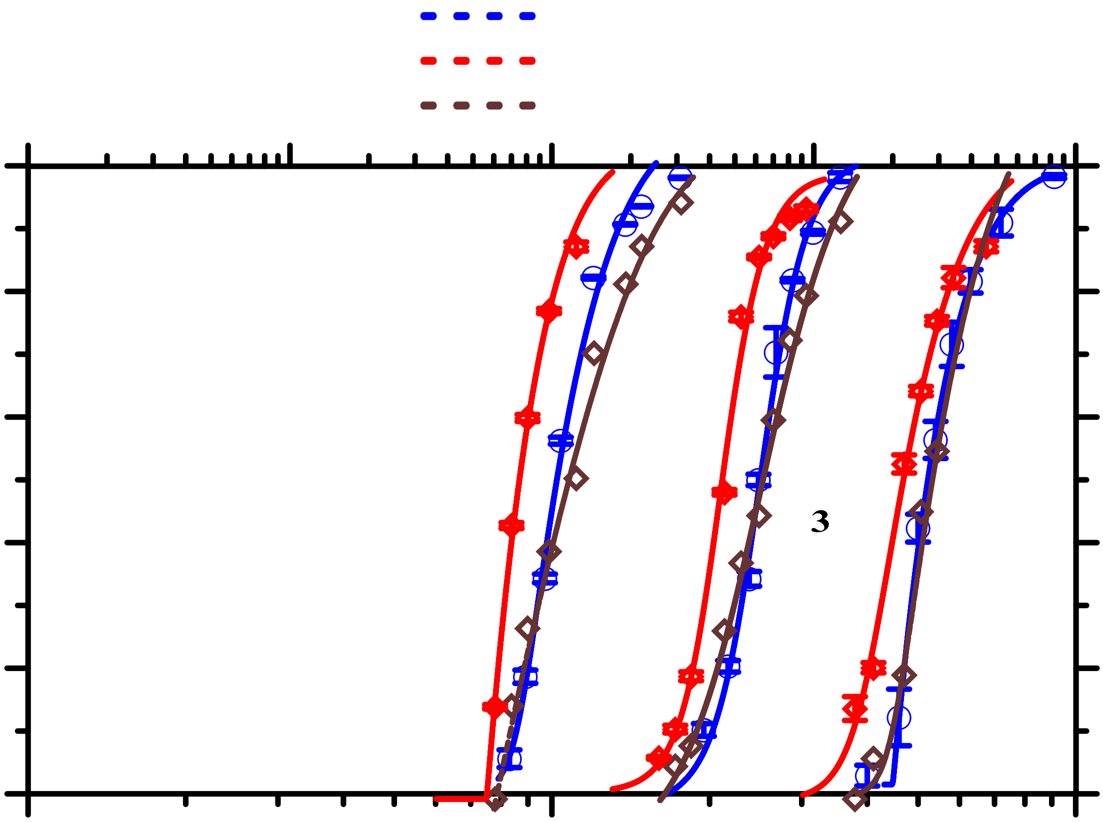

Figure 6

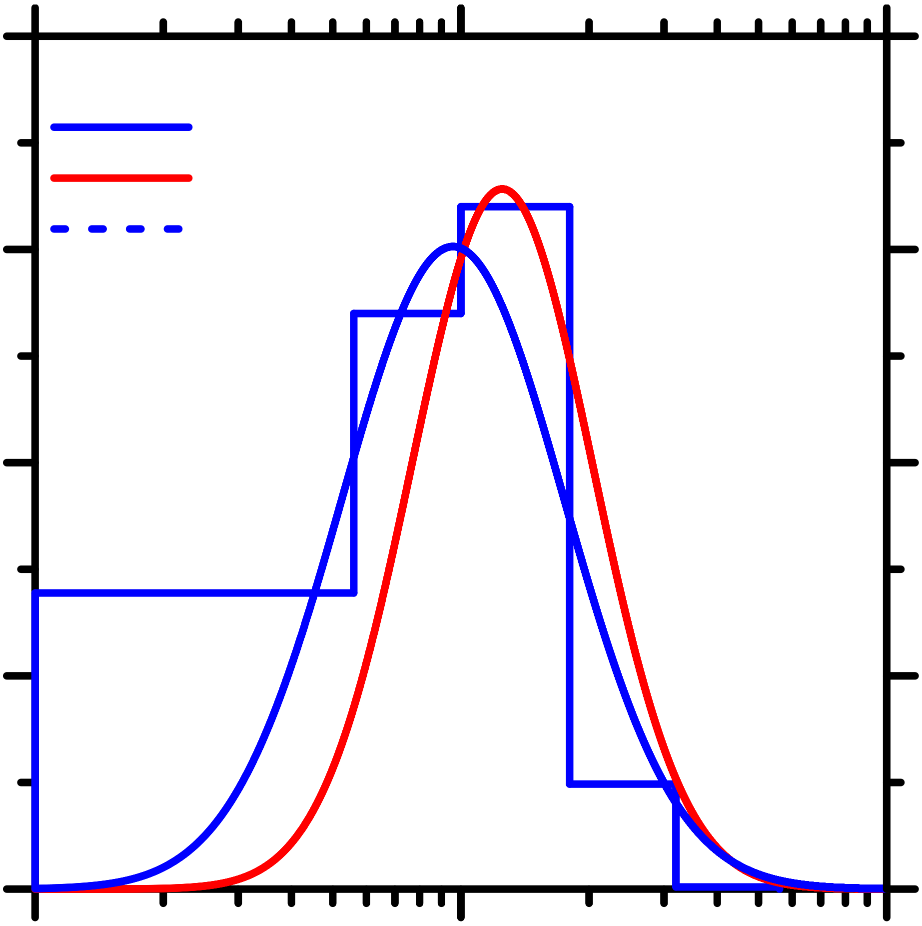

Figure 7

Prince of Songkla University
Thailand
Air Pollution and Health Effect Research Center

Taiwan Association for Aerosol Research
Taiwan

05 July 2017

ACCEPTANCE NOTIFICATION AND OFFICIAL INVITATION

Dear Mr. Chi-Yu Tien,

Thank you for submitting an abstract to the 2017 Theory and Technique, International Aerosol conference in Thailand (2017 T&T IAC-Thailand) which will be held in Hat Yai, Songkhla, Thailand from 7 to 8 August 2017.

On behalf of the 2017 T&T IAC Scientific Committee, we are pleased to inform you that your abstract has been accepted.

Abstract Acceptance Information

・Abstract ID: TW-O009-V

・Author Name: **Chi-Yu Tien**, Michel Attoui, Ran-Hao Ke, Chuen-Jinn Tsai

・Abstract Title: **The development of a ten-stage electrical micro-orifice cascade impactor (EMCI) for the real time monitoring of aerosol size distribution from 32 nm to 10 µm**

・Final Presentation Type: Oral

・Venue: Center for Learning Promotion and Development, Prince of Songkla University, Hat Yai Campus, Songkhla 90112, Thailand
More information on: http://clpd.psu.ac.th/

・Date: 2017-8-07

Please also check the updated version of program on the conference web site:
http://www.tt-iac.psu.ac.th/

In addition to early bird rate of 85.00 USD/student and 100.00 USD/participant before 30 July 2017, all of the presenters should register and pay the registration fee of 100.00 USD/student and 120.00 USD/participant on-site on 7 August 2017. We are looking forward to seeing you in Hat Yai, Songkhla, Thailand.

Yours sincerely,

Wang-kun Chen

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Email: mtsaiyi@mail.cnu.edu.tw (Y.I. Tsai)
Co-Chairs, 2017 T&T IAC-Thailand Scientific Committee

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The development of a ten-stage electrical micro-orifice cascade impactor (EMCI) for the real time monitoring of aerosol size distribution from 32 nm to 10 μm

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Abstract: An electrical micro-orifice cascade impactor (EMCI) with the operating flowrate of 16.7 L/min was developed for real-time size distribution monitoring in this study. The EMCI consists of a unipolar, modified-NMCI (NCTU micro-orifice cascade impactor), and Keithley 6514 electrometer. The calibration results of the impactor showed that the cut-off aerodynamic diameters (d_{pa50}) of 9.92, 5.62, 2.48, 1.02, 0.563, 0.321, 0.178, 0.097, 0.056 and 0.032 μm, which are very close to the design values. The operating voltage of the unipolar charger ranged between +2.6 to +3.8 kV with the optimal charging efficiency found at +3.6 kV. Comparing with the ELPI+ charger, the charging efficiency is nearly the same when the particle size is greater than 56 nm up to 10 μm. However, the charging efficiency in the size range of 10 to 56 nm is higher than that of the ELPI+ charger by as much as 93 to 11 %. Finally, the EMCI was used for the size distribution measurement of laboratory generated aerosols. Test results showed that the size distribution measured by EMCI agrees well with that of the SMPS in nanoparticle size range. More calibration studies and comparison tests are under way using multi-channel electrometer installed at all stages.

Keywords: *impactor, micro-orifice cascade impactor, unipolar charger, aerosol measurement*

1. Introduction

Cascade impactors are widely used to measure aerosol distribution and the collected samples can also be used for chemical compositions analysis. However, the solid particle bounces, overloading effect and nozzle clogging are the main issues that cause the sampling bias. Moreover, even if the ELPI+ can be used to mearsure aerosol size distribution in real-time, the traditional problem in LPI still exist.

The aims of this study is to develop an Electrical micro-orifice cascade impactor (EMCI) which can be used to measure the size distribution in real-time and solve most practical concerns in traditional cascade impactor with 16.7 L/min of operating flowrate.

2. Materials and Methods

2.1 EMCI composition

The EMCI consists of a NCTU unipolar charger, a NMCI and a Keithley 6514 electrometer. The charger shows the greater charing efficiency for nanoparticles as compared to that of the ELPI+ in previous study. The NMCI was re-designed for preventing the environmental noise when using the low current measurement and decreasing the flowrate from 30 to 16.7 L/min.

2.2 Calibration, test and comparison

The current was detected using the after filter stages of the EMCI and the Aerosol Electrometer (AE, TSI 3068) first, to show the accuracy of the low current measurement. The particle collection efficiencies were also be conducted using the methods described in Liu et al. (2013)

and Järvinen et al. (2014) respectively. Finally, the nanoparticle stage impactors were connected for size distribution comparison with SPMS and ELPI+

3. Results & Discussion

In the performance test of the electrometer, the 15 % bias was found in the range of 3-1500 fA as compared to AE. The results of the collection efficiency curves measurement display that the curves measured in two method agree well to each others after multiple charge calibration, with 9.92, 5.62, 2.48, 1.02, 0.563, 0.321, 0.178, 0.097, 0.056, 0.032 µm of cut-off aerodynamic diameter (d_{pa50}).

The result of thes size distribution comparison in nano to submicron particle was shown in Figure 1. The concentrations measured by three divices were very close to each others, about 1.35 $\times 10^5$ #/cm^3. However, in CMD calculaitons, only EMCI and SMPS showed the close values, 70 and 73 nm, respectively, and the ELPI showed the deviated value, 53 nm.

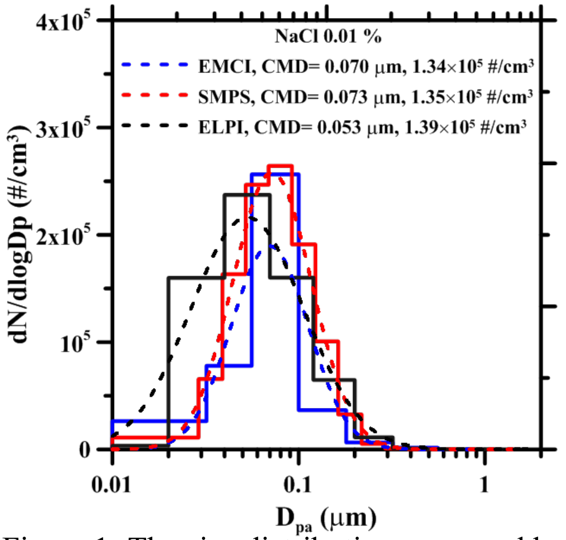

Figure 1. The size distribution measured by EMCI, SMPS and ELPI, respectively.

4. Conclusion

The EMCI which can solve most practical problems in aerosol distribution measurement by cascade impactor was developed successfully in this study. Whether the charging efficiency or the sampling performance of the EMCI are greater than the commercial instruments. However, more calibration studies and comparison tests are neccеary using multi-channel electrometer installed at all stages.

Acknowledgments

The authors would like to express the gratitude to the Taiwan National Science Council for financial support under contract (NSC 102-2221-E-009-008-MY3)

References

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2017 T&T International Aerosol Conference

(2017 T&T IAC)

Air Quality in East Asia

7-8 August 2017

(Prince of Songkla University, Songkhla, Thailand)

Introduction

Taiwan Association for Aerosol Research (TAAR) and Air Pollution and Health Effect Research Center, Prince of Songkla University, Thailand are pleased to invite you to submit papers and participate in the 2017 T&T International Aerosol Conference (2017 T&T IAC), which will be held in Prince of Songkla University, Hat Yai, Thailand from 7 to 8 August 2017. This conference will cover a wide range of fundamental and applied aspects of aerosol science and technology, atmospheric science, air quality and air pollution control. The conference emphasizes interdisciplinary research along with practices and fosters exchanges among researchers, policy makers, corporate managers, practitioners and professionals who are concerned with the above aspects. All interested participants are invited to submit and present the latest results of their scientific and practical work in one of the conference topic areas.

Conference Topics

The 2017 T&T International Aerosol Conference in the theme of Air Quality in East Asia is set during 7-8 August 2017 at Conference Room, 8th Floor, LRC Building 1, Prince of Songkla University, Hat Yai, Songkhla, Thailand. There are 8 topics for oral presentations:

1. Sources, combustion, thermal decomposition, emission, properties, behavior, formation, transport, deposition, measurement and analysis

2. Effects on human health and environment
3. Air pollution and control
4. Invention and improvement of sampling instruments and technologies
5. Nanoparticle and nanotechnology
6. Bioaerosol
7. Indoor air quality
8. Other topics related to aerosol and air quality

The technical program will consist of invited plenary lectures and platform presentations. The exhibition will be in place for organizations and companies to demonstrate their programs, products, and expertises.

Important Dates

Detail	Date
Abstract Submission (Deadline of abstract submission has been extended)	1 April 2017 to 30 June
Acceptance Notification	15 July 2017
Last Day for Early-bird Registration	30 July 2017
On-Site Registration	7 August 2017
Conference Date	7 - 8 August 2017

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