SO_2、NO_2、O_3及其复合物对水稻体内乙烯释放的影响*

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摘要　乙烯是植物体内的一种内源激素,当植物受到环境污染时,体内乙烯的释放量将发生变化。本文主要报道了水稻受SO_2、NO_2、O_3单一及其复合物熏气对体内乙烯释放的影响。结果表明,水稻受SO_2、NO_2、O_3单一及其复合物熏气后,体内乙烯释放量增加,在一定条件下反应出环境污染的程度;当O_3浓度不变时,水稻体内乙烯释放量与SO_2、NO_2熏气浓度成正比,其中,O_3+SO_2对水稻体内乙烯释放量的影响程度大于O_3+NO_2;当SO_2+NO_2两种气体熏气浓度之和一定时,提高相同比例的SO_2浓度,对水稻体内乙烯释放量的增加作用大于NO_2;水稻经$4.0\times10^{-6}NO_2$熏气2h,叶片出现漂白斑或黄色斑,此时,乙烯、乙烷的释放量分别为7.70 nl/(g·F·W·h^{-1})和2.30nl/(g·F·W·h^{-1})。

关键词　水稻,SO_2,NO_2,O_3,熏气,乙烯,乙烷,释放。

SO_2、NO_2、O_3都是大气中常见的污染物,它们单独作用对植物生长产生的影响已有很多报道[1~3],而其复合物对植物生长造成的危害国内却研究较少。乙烯作为植物体内的一种内源激素,具有一定的信使功能,对植物的生命活动起着重要的调节作用。当植物受到空气污染时,在其表面尚未出现可见伤害症状时,体内乙烯的释放情况已经发生变化[4]。因此,研究植物在大气复合污染条件下体内乙烯的释放情况,将可能揭示大气污染与乙烯释放的相互关系。本文主要报道了水稻经SO_2、NO_2、O_3单一及复合物熏气后体内乙烯的释放情况及其与大气污染的相互关系,旨在为环境监测及植物在大气复合污染条件下抗性生理方面的研究提供科学依据。

1　实验材料和方法

1.1　植物栽培

水稻(*Oryza Sativa* L.),品种为南粳36号,在正常生长季节育苗,盆栽(φ25cm×20cm),每盆2穴,常规水肥管理,露天放置。待水稻长至分裂盛期时选长势均匀的样品供熏气实验。每个处理各选5盆供试。

1.2　熏气系统

采用田间开顶式熏气装置,SO_2、NO_2分别从钢瓶内经稳压、稳流后放出;O_3由电离空气发生,其浓度通过调节输出电压控制。上述3种气体经碳滤空气稀释后由鼓风机鼓入熏气罩内,罩尺寸为(φ3m×3m),外罩聚乙烯塑料薄膜,罩内各气体浓度分别用ML-8850,ML-8840、ML-8810气体荧光分析仪测定,浓度变异控制在±5%以内。对照组只输入碳滤空气。

1.3　样品采集及乙烯测定方法

将水稻从水面以上部分剪断,去其自然黄烂叶,每处理各选10株,每2株为一个样品,称重后装入50ml比色管中,用反口橡皮塞封口后放入30℃±0.5℃生化培养箱内保温2h[5]。从培养箱中取出比色管,用医用注射器吸1ml瓶内气体经气相色谱仪测定乙烯含量。

气相色谱仪分析条件:

Varian GC-3760,F1D,配HP-3390A数据处理机;

载气:N_2(99.999%);

T_c=200℃,T_i=230℃,T_d=280℃;

分析柱:0.9M聚四氟乙烯塑料管,$\varphi_{内}$=0.3cm,内填60—80目601碳分子筛;

定量方法:外标法。

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2 实验结果与讨论

2.1 O_3 对水稻的影响

O_3 通过气孔进入植物体内刺激乙烯产生。实验表明，随着熏气罩内 O_3 浓度的不断增加，虽然水稻表面尚未出现可见伤害症状，但体内乙烯释放量却逐渐增加，结果见图 1。Tingey 等首先

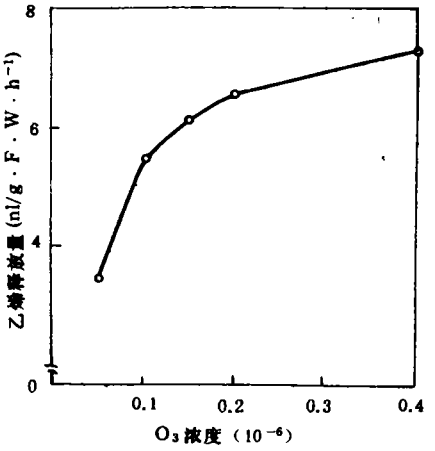

图 1 O_3 熏气浓度与乙烯释放量的关系

建议把植物在逆境条件下所释放的乙烯作为环境污染的指标，他们指出，低浓度的 O_3、Cl_2 等在引起植物出现可见伤害症状之前，乙烯已经增加，在一定浓度范围内，污染物浓度与乙烯释放量成正比[6,7]，其结论与本实验结果相近似。值得注意的是，处于大气污染条件下的植物，在其表面尚未出现可见伤害症状时，体内乙烯的释放量已发生变化。因此，笔者建议在一定条件下，可将植物在环境污染状态下产生的乙烯量作为判断污染物对植物污染的程度和筛选不同植物对该污染物相对敏感性的生理指标。

2.2 O_3+SO_2，O_3+NO_2 对水稻的影响

图 2 给出了水稻经 $0.1\times10^{-6}O_3$ 分别与浓度范围为 0.25×10^{-6}—2.0×10^{-6}的 SO_2 和 NO_2 混合熏气后体内乙烯的释放情况，结果表明，当 O_3 浓度不变时，水稻体内乙烯释放量与 SO_2 和 NO_2 熏气浓度成正比，其值分别是单一 O_3 熏气组的 1.75—5.32 倍和 1.24—3.86 倍。另外，低浓度 SO_2、NO_2 与 O_3 相混合对水稻的影响程度是不同的，如以乙烯释放量为标准来衡量它们对水稻污染的影响程度，则 O_3+SO_2 大于 O_3+NO_2。

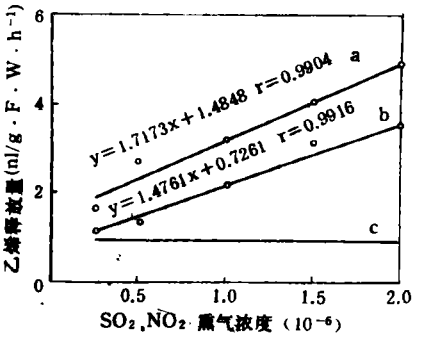

图 2 O_3 存在时 SO_2、NO_2 熏气浓度与乙烯释放量的关系
a. $0.1\times10^{-6}O_3+SO_2$ b. $0.1\times10^{-6}O_3+NO_2$ c. $0.1\times10^{-6}O_3$

2.3 SO_2+NO_2 对水稻的影响

国内有人研究过水稻受 SO_2 单一污染后体内乙烯的释放情况[8]，但对其受 SO_2+NO_2 复合污染的情况却鲜有研究。笔者在实验中发现，水稻受 SO_2+NO_2 复合熏气时，体内乙烯释放量随复合物熏气浓度的增加而增大。但是，当 SO_2+NO_2 两种气体熏气浓度之和一定时，谁对乙烯释放量影响作用更大？为解决这一问题，笔者曾用 $1.0\times10^{-6}NO_2+(1.0—2.0)\times10^{-6}SO_2$ 和 $1.0\times10^{-6}SO_2+(1.0—2.0)\times10^{-6}NO_2$ 两组不同的复合方式对水稻进行了熏气实验，结果表明，当

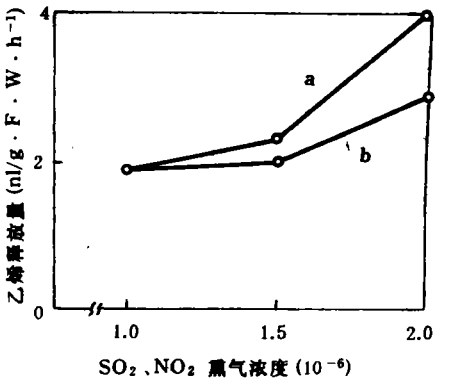

图 3 SO_2、NO_2 熏气浓度与乙烯释放量的关系
a. $1.0\times10^{-6}NO_2+SO_2$ b. $1.0\times10^{-6}SO_2+NO_2$

SO_2+NO_2 两种气体熏气浓度之和一定时，提高相同比例的 SO_2 浓度，对水稻体内乙烯释放量的增加作用大于 NO_2，见图 3。刘恩、Elstner 等人曾

提出乙烯的产生是植物对刺激和伤害的响应，而乙烷的产生是伤害的后果[9,10]。笔者曾用不同浓度的 NO_2 对水稻进行了熏气实验，发现水稻体内乙烯释放量随 NO_2 熏气浓度的上升而增大，当乙烷释放时，水稻表面已出现明显的伤害症状，结果见表1。本结论与上述论点相一致。

表1　熏气浓度与乙烯、乙烷释放量及叶片伤害情况

NO_2 浓度 ($\times10^{-6}$)	乙烯释放量 ($nl/(g \cdot F \cdot W \cdot h^{-1})$)	乙烷释放量 ($nl/(g \cdot F \cdot W \cdot h^{-1})$)	叶片伤害症状
0.25	2.27	—	无
1.0	2.72	—	无
2.0	3.45	—	无
4.0	7.70	2.30	叶片上半部出现漂白斑、黄色斑

导致水稻叶片出现伤害症状后体内乙烷释放的原因，主要与膜脂成分的破坏有关[11]。值得注意的是，水稻经 $4.0\times10^{-6}NO_2$ 处理后，体内乙烯、乙烷释放量与间隔时间成正比，结果见图4。此结果可用于空气污染后期植物受害情况的参考分析。

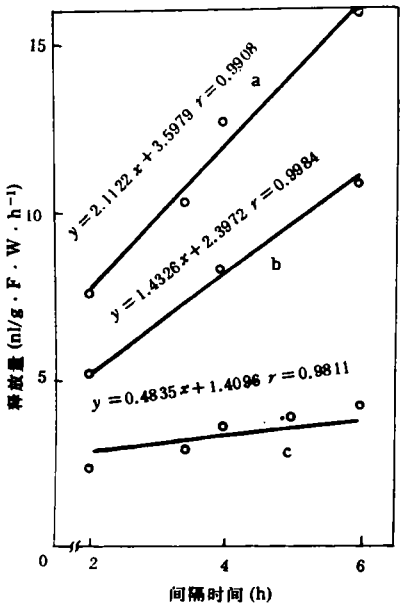

图4　熏气后间隔时间与乙烯、乙烷释放量的关系

a. 处理组乙烯　b. 对照组乙烯　c. 处理组乙烷

3　结论

(1)水稻受 SO_2、NO_2、O_3 单一及复合物熏气之后，体内乙烯释放量增加，在一定条件下反应出环境污染的程度。

(2)当 O_3 浓度不变时，水稻体内乙烯释放量与 SO_2、NO_2 熏气浓度成正比，在一定浓度范围内，O_3+SO_2 对水稻体内乙烯释放量的影响程度大于 O_3+NO_2。

(3)当 SO_2+NO_2 两种气体熏气浓度之和一定时，提高相同比例的 SO_2 浓度，对水稻体内乙烯释放量的增加作用大于 NO_2。

(4)可将植物在环境污染条件下产生的乙烯量作为判断植物受污染的程度和筛选不同植物对该污染物的相对敏感性的生理指标。

(5)水稻经 $4.0\times10^{-6}NO_2$ 熏气 2h，叶片出现漂白斑或黄色斑，此时，乙烯、乙烷的释放量分别为 $7.70nl/(g \cdot F \cdot W \cdot h^{-1})$ 和 $2.30nl/(g \cdot F \cdot W \cdot h^{-1})$

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An anomalous phenomenon was discussed, in which it was found from a calculation of the allowable discharge levels of water pollutants in the Huainan reaches of the Huaihe River that there was a large flow of water with a small allowable capacity of pollutant discharge. A quantitative analysis for the causes of this problem was made, based on the mechanism of forming the capacity of the river to receive pollutants and on the equations for calculating the discharge of pollutants. Finally, the reaches of the Huaihe River in Huainan city were taken as an example to preliminarily study how can identify and determine the design flow of a river.

Key words: allowable discharge level, water pollutants, design flow.

Grey Systems Analysis of the Factors Affecting the Efficiency of Wastewater Treatment in Anearobic Reactors. Guo Jingsong, Long Tengrui (Dept. of Urban Construction, Chongqing Institute of Architecture and Engineering, Chongqing 630045): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 62—65

The methods for grey systems analysis have been applied to studying the significance of each of major factors that would affect the efficiency of anearobic reactors in treating wastewater. The data from the experiments in an anearobic fluidized bed reactor were taken as an example to make a calculation analysis, resulting in a conclusion which was consistent with that based on a theoretical analysis. The results show that the use of a grey systems analysis for the factors affecting the efficiency of a biological reactor has the advantage of requiring relatively less data, as compared with other methods.

Key words: grey system, interference analysis, efficiency of wastewater treatment, anaerobic reactor, fluidized bed.

Accelerated Simplex Algorithm to Determine the Longitudinal Dispersion Coefficient in a River by Tracer Test. Zhang Jiangshan (Institute of Environmental Science, Fujian Normal University, Fuzhou 350007): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 66—68

The accelerated simplex algorithm has been used to calculate the longitudinal dispersion coefficient in a river, as an example for which the Ynagkou reaches of the Futunxi River, a mainstream of the Minjiang River in Fujian province, was found to have a longitudinal dispersion coefficient D_2 of 2.62 m^2/s. The results show that the accelerated simplex algorithm was more effective to be used for evaluating the parameters for a nonlinear model than the nonlinear approach algorithm. This was simply because the accelerated simplex algorithm had a process of optimization in which it was not necessary to calculate the partial derivative of the goal function and was not limited by the complexity of a model so that it was easy to be calculated and widely applicable. This algorithm could be widely used to fit environmental and ecological models and to make parameters evaluation.

Key words: river water quality model, parameter estimation, longitudinal dispersion coefficient, accelerated simplex algorithm.

Effects of Fumigation with sulfur Dioxide, Nitrogen Dioxide, Ozone and Mixtures Thereof on Ethylene Emissions from Rice. Yu Fei et al. (Nanjing Institute of Environmental Sciences, NEPA, Nanjing 210042): *Chin. J. Environ. Sci.*, **15**(4), 1993, pp. 69—71

A study was carried out on the effects of fumigation with sulfur dioxide (SO_2), nitrogen dioxide (NO_2), ozone (O_3) and mixtures thereof on the release of ethylene from rice plant being fumigated. It was found that the emission of ethylene as an internal hormone of plant increases when the crop rice is fumigated with SO_2, NO_2, O_3, or mixtures thereof. This can be considered as an indicator for the level of environmental pollution. If the O_3 level is constant, the emission of ethylene from rice is directly proportional to the levels of SO_2 and NO_2 in fumigating gases, where $O_3 + SO_2$ have a greater effect on the emission of ethylene from rice than $O_3 + NO_2$. If the total level of both SO_2 and NO_2 altogether is kept constant, an increased level of SO_2 can lead to a higher emission of ethylene than an increased level of NO_2. A fumigation with NO_2 at a concentration of 4 ppm for 2 hours has caused the leaves of rice to have bleached or yellow spots when ethylene and ethane are released at 7.70 and 2.30 $nl/g \cdot F \cdot W \cdot h$, respectively.

Key words: rice, sulfur dioxide, nitrogen dioxide, ozone, fumigation, ethylene, ethane, release.

Watercolumn Barometer without Mercury Contamination. Zhang Xiong (Dept. of Physics, Yunnan Normal University, Kunming 650092): *Chin. J. Environ. Sci.*, **15**(4), 1994, pp. 72—74

A miniatured (1.2 m long) watercolumn barometer has been developed to solve the environmental problem of mercury pollution resulted from the production and opreation of a mercury column barometer. The working principles, use methods and measurement errors of the watercolumn barometer were discussed and some aspects of its application were briefly described. This barometer can work well at 0— 3 km above sea level and at an ambient temperature in the range of 6— 40℃. The results from its measurement have a standard error of less than ± 0.9 mmHg and it can detecct a change in atmospheric pressure of ± 0.1 mmHg. This newly developed barometer is applicable to measure the atmospheric pressure in a room where there will be a less change in ambient temperature. A conventional watercolumn barometer is very difficult to be used to measure the atmospheric pressure because the pressure of saturated water vapor varies largely with a change in room temperature. The use of this new barometer can also solve this problem.