

# 细菌发光试验及 Ames 试验检测工业废水急性毒性及致突变性的研究

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**摘要** 应用细菌发光试验及 Ames 试验对比研究了武汉市易家墩、黄孝河污灌区工业废水的急性毒性及致突变性, 同时应用色谱(GC/MS)分离鉴定技术测定了工业废水中有机污染物的化学组成。结果表明, 罗家渠废水的急性毒性、致突变活性在所研究废水中最为严重, 废水中急性毒性物质主要包括苯酚、苯甲酸苯甲酯等, 致突变致癌物包括联苯、萘等。

**关键词** 急性毒性, 致突变性, GC/MS 分析。

利用城市工业废水与生活污水进行农田灌溉或水产养殖是一条适合国情、行之有效的综合利用资源化途径, 但必须对工业废水在生态环境中引发的各种急性、慢性危害引起足够重视。武汉市易家墩、黄孝河 2 片地区是重要的农业、渔业基地, 每日受纳工业废水数万吨, 分别汇于罗家、新墩、禁口、黄孝河等干渠, 污灌污养面积达数万亩。本文应用细菌发光试验及 Ames 试验结合 GC/MS 技术检测污灌区工业废水的急性毒性及致突变性, 分析有机污染物的化学本质, 查明重点污染区及主要有毒有害物质。

## 1 实验部分

### 1.1 样品采集与处理

选取 4 条排污干渠中段, 定点采工业废水 30L。各水样均用甲醇处理过的多层纱布过滤除去悬浮物, 取 20ml 水样备用细菌发光试验, 其余水样参照王家玲报道的方法<sup>[1]</sup>提取水样中的有机物。采用 H-103 大孔树脂吸附浓缩水样中的有机物, 然后用有机溶剂洗脱, 洗脱液经浓缩、干燥等过程而得干品, 此干品用二甲基亚砷溶解、定容, 在 2—4℃ 下避光保存, 供 Ames 试验及 GC/MS 分析用。

### 1.2 水样的细菌发光试验

参照 Bulich A. A. 报道的方法<sup>[2]</sup>进行。测试菌株为明亮发光杆菌(*Photobacterium phosphoreum*), 测试仪器为 SHG-1 生物化学发光测量仪, 每个

样品水样量为 4ml, 菌液量为 0.5ml, 混合后在 20℃ 条件下作用 15min。测试温度 20℃, 甄别电压 0.2V, 发光强度以 6s 光子累计计数表示。以蒸馏水作空白对照计算发光抑制率 IR。IR =  $(1 - \frac{\text{样品管发光强度}}{\text{空白管发光强度}}) \times 100\%$ , IR 值越大即样品急性毒性越大, 试验重复 2 次。

### 1.3 水样的 Ames 试验

各有机物样品储备液用二甲基亚砷(DMSO)稀释成相当于不同水样量的待测液梯度, 即剂量为水样 ml/皿。试验方法参照标准的 Ames 法<sup>[3]</sup>进行, 采用平皿掺入法, 测试菌株为鼠伤寒沙门氏菌(*Salmonella typhimurium*) TA98 和 TA100, 在不加 S<sub>9</sub> 条件下进行, 结果以突变率(MR)表示, 凡 MR ≥ 2 并呈剂量反应关系的样品即为致突变阳性结果。

### 1.4 GC/MS 分析条件

色谱分析: 在 VG-70/OE-HF 气相色谱/质谱仪上, 用 DB-5 弹性石英毛细管柱, φ0.315mm × 30m, 柱温初温 100℃, 以 10℃/min 的升温速度升至 220℃; 气化室温度为 280℃; 色谱接口温度 230℃, 载气为高纯氮气, 流量 30ml/min; 分流比 1:30; 进样量 0.5μl。

质谱分析: 电子轰击源, 轰击能量为 70eV; 离子源温度 200℃, 扫描范围 40—400amu; 扫描时间 0.80s; 电离方式 EI<sup>+</sup>。

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2 结果和讨论

2.1 工业废水的急性毒性

图 1 表明,4 条排污干渠工业废水对细菌发光均有不同程度的抑制作用,以罗家渠废水的抑制作用最强,急性毒性最大。这片地区发生的一些鱼塘鱼体中毒死亡可能与此有关,应采取针对性措施控制污灌带来的负面环境效应。

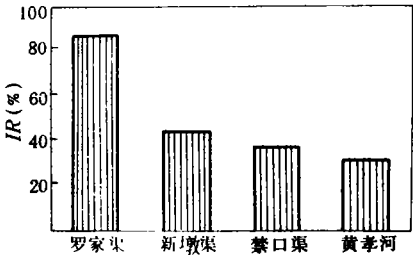


图 1 工业废水急性毒性试验结果比较

2.2 工业废水的致突变性

表 1 为 4 条排污干渠工业废水 Ames 试验结果。各工业废水均具有致突变作用,以罗家渠废水的致突变活性最强,这与唐非等 1988 年的检测结果<sup>[4]</sup>一致,说明几年来工业废水排放质量没有明显改善,由于致突变物质因长期污灌可在土壤中蓄积,这对农作物食用的安全性形成威胁。

2.3 罗家渠废水有机污染物的 GC/MS 分析

罗家渠废水主要来自制药、制漆、印染、有机合成、食品等行业,多年监测表明以有机污染为主。表 2 为 GC/MS 对有机污染物的分析鉴定结果。由表 2 可知,废水中有机物种类复杂、数量多。结合现有资料<sup>[5]</sup>分析,主要急性毒物有苯酚、苯甲醛、苯甲酸苯甲酯等,主要致突变致癌物有萘、联苯、4-溴苯酚。有关部门应对排放这些物质的单位进行重点管理。

3 小结

本文应用细菌发光试验及 Ames 试验研究了武汉市易家墩、黄孝河污灌区工业废水,发现急性毒性及致突变性均以罗家渠废水最强,GC/MS 分析发现其中有多种有机污染物质,包括苯酚、苯甲酸苯甲酯等已知急性毒物及联苯、萘等已知致突变致癌物。

表 1 工业废水中有机物 Ames 试验结果

采样点	水样 (ml/皿)	突变率(MR)		致突变性
		TA98	TA100	
罗家渠	1	1.21	0.99	+
	5	3.57	1.40	
	10	8.33	1.56	
	25	15.68	2.15	
	50	23.48	3.82	
新墩渠	5	2.54	1.24	+
	10	5.08	1.68	
	25	6.87	2.54	
	50	14.68	4.81	
	100	25.15	9.65	
禁口渠	5	1.90	1.17	+
	25	6.80	2.08	
	50	10.29	3.47	
	250	18.06	17.98	
	500	42.41	33.72	
黄孝河	5	0.92	0.85	+
	50	1.32	1.05	
	500	3.18	1.69	
	1000	3.40	2.59	
敌克松 <sup>1)</sup>	(8μg/皿)	++++	++++	+
DMSO <sup>1)</sup>	(0.1ml/皿)	1.02	0.98	-

1) 阳性对照

表 2 罗家渠废水中有机物 GC/MS 分析结果

化合物类型	种数	主要物质	LD <sub>50</sub> (mg/kg) <sup>1)</sup>	致突变 致癌性 <sup>1)</sup>
酚	6	苯酚	530	+
		4-溴苯酚		
醛	5	苯甲醛	1300	
酯	5	苯甲酸苯甲酯	1700	
酸	2	苯甲酸	1300	
多环芳烃	6	联苯	3280	+
		萘	1780	+
硝基化合物	4	4-硝基苯		
醇	3	苯甲醇	3100	
杂环	5	吡啶		

1) 引自参考文献<sup>[5]</sup>

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# Abstracts

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of Huhhot and the grassland belt in Siziwan Qi (a county), Inner Mongolia, as a control site in both winter and summer with a sampler using a polyurethane foam plug and a glass-fiber filter, both of which were then extracted with solvents. The extracts were analyzed with GC/MS, GC and HPLC to identify the organic pollutants in both vapor phase and particulate phase. Eighty eight pollutants in three kinds of organic compounds (n-alkanes, aromatic hydrocarbons and phthalate esters) were qualitatively identified and 45 of them were quantified. The results show that the Huhhot City is an area polluted with higher concentrations of organic pollutants in the atmosphere in its urban area.

**Key words:** atmospheric pollution, organic pollutant, vapor phase, particulate phase.

**Study on the Assay of the Acute Toxicity and Mutagenicity of Industrial Wastewaters by Using the Bacterial Luminescence Test and the Ames Test.** Huang Zheng and Wang Jialing (Institute of Environ. Medicine, Tongji Medicine University, Wuhan 430030); *Chin. J. Environ. Sci.*, **15**(6), 1994, pp. 70—71

The industrial wastewaters from the Yijiadun and Huangxiaohe Wastewaters Irrigated Areas in Wuhan City were comparatively investigated for their acute toxicity and mutagenicity by using the bacterial luminescence test and the Ames test. At the same time, the composition of organic pollutants in the wastewaters was determined with the GC/MS technique. The results show that, of four channels studied, the Luojiaqu Channel has the strongest acute toxicity and mutagenicity in its wastewater flow. The pollutants responsible for the acute toxicity of the wastewater mainly include phenol, benzyl benzoate, etc., and the pollutants responsible for the mutagenicity and carcinogenicity of the wastewater were found to be biphenyl, naphthalene, etc.

**Key words:** industrial wastewater, acute toxicity, mutagenicity, GC/MS.

**Validity of the Data from Automatic Air Quality Monitoring Systems.** Fan Shaojia et al. (Dept. of Atmospheric Sciences, Zhongshan University, Guangzhou 510275); *Chin. J. Environ. Sci.*, **15**(6), 1994, pp. 72—73

Based on the theory of statistics, a theoretical formula in which the acceptable missing hours and acceptable errors of validable daily averages are related to the variance of daily hourly averages has been derived. The monitored data on hourly concentrations of sulfur dioxide in winter from the Beijing Automatic Air Quality Monitoring System

were taken to perform a calculation based on the derived formula and it was found that at a confidence of 95% the maximum random missing 6 hours were acceptable and in compliance with 75% of data captured as required by the National Environmental Protection Agency for a data validity check.

**Key words:** automatic air quality monitoring system, validity of monitored data, Beijing.

**Homogeneous Reaction Mechanisms of Nitrous Oxide Formation and Decomposition in the Fluidized Bed of Coal Combustion.** Chen Hongwei, Jin Baoshen et al. (Institute of Heat Energy, Southeast University, Nanjing 210018); *Chin. J. Environ. Sci.*, **15**(6), 1994, pp. 74—78

The homogeneous reaction mechanisms of nitrous oxide formation and decomposition in the fluidized bed of coal combustion were studied, indicating that the paths of nitrous oxide ( $N_2O$ ) formation from nitrogen contained in fuel mainly include:  $NCO + NO \rightarrow N_2O + CO$  and  $NH + NO \rightarrow N_2O + H$ ; and the main reaction of  $N_2O$  decomposition are:  $N_2O + H \rightarrow N_2 + OH$ . An analysis was also made for the effects of the factors such as composition of fuel-bounded nitrogen compounds in volatiles, kinds of coal, temperature in the fluidized bed, coefficient of excess air, number of stages, and the combustion pattern in a single stage, on the emission of  $N_2O$  from the fluidized bed coal combustor.

**Key words:** fluidized bed combustion, coal, nitrous oxide, reaction mechanism.

**Advance in the Study on Compound Pollutions.** He Yongtian and Xiong Xianzhe (Institute of Applied Ecology, Chinese Academy of Sciences, Shen'yang 110015); *Chin. J. Environ. Sci.*, **15**(6), 1994, pp. 79—83

Based on reviewing the current status of domestic and international research efforts in the field of compounded pollutions as a universal phenomenon of environmental pollution, this article dealt with the concepts and classifications of compounded pollutions, and the types of interactions of compounded pollutions and the criteria for their judgements, focusing on the factors affecting the ecological effects of compounded pollutions (i.e., pollutants factors, biological factors, and environmental factors) and the action mechanisms of compounded pollutions (i.e., influencing the structures of biotic cells, disturbing physiological activities and functions, competing for active sites, and complexing or chelating).

**Key words:** compounded pollutions, environmental pollution, ecological effects, review.