

(HUANJING KEXUE)

ENVIRONMENTAL SCIENCE

第34卷 第5期

Vol.34 No.5

2013

中国科学院生态环境研究中心 主办

斜学出版社出版



ENVIRONMENTAL SCIENCE

第34卷 第5期 2013年5月15日

目 次

基于过氧化物的消毒技术研究进展 对境损害评估:国际制度及对中国的启示 张红振,曹东,於方,王金南,齐霁,贾倩,张天柱,骆永明(165)不同国家基于健康风险的土壤环境基准比较研究与启示 徐猛,颜增光,贺萌萌,张超艳,侯红,李发生(166)蚯蚓堆肥及蝇蛆生物转化技术在有机废弃物处理应用中的研究进展 张志公,刘萌,朱军(167)	5)
环境损害评估:国际制度及对中国的启示 张红振,曹东,於方,王金南,齐霁,贾倩,张天柱,骆永明(165)	3)
不同国家某于健康风险的土壤环境基准比较研究与启示	7)
能创作即及幅相上物柱化技术方方和座交物的理点用由的研究进展	<u>, ,</u>
型场性几次地址主物水化以外任任的L及开创处基应用作用明元近底	フノ コ ト
基于生态分区的我国湖沿宫养监控制目标研究	1)
基于生态分区的我国湖泊营养盐控制目标研究 7晚君,席北斗,何连生,邓祥征,吴锋,王鹏腾 (168) 我国东北地区地表水酸化现状 徐光仪,康荣华,罗遥,段雷 (169) 西安市对渭河水质的影响分析 于婕,李怀思 (170) 极端于旱水文年(2011年)夏季珠江口溶解氧的分布特征及影响因素研究 叶丰,黄小平,施震,刘庆霞 (170)	5)
西安市对渭河水质的影响分析 于婕. 李怀恩 (170)	0)
极端干旱水文年(2011年)夏季珠江口溶解氧的分布特征及影响因素研究 叶丰 黄小平 施震 刘庆霞 (170)	7)
立田相亚新人前达建立·知汀新四巴沼和杨香人居居县甘淮 鼓切声 奏延立 牧五架 火電 曹佳 (171	5)
应用相 例月电台建步和上线中校电影场 ADD THE ADD H	<i>3</i>)
下江口海域底裡生态环境原重评价——AMBI 和M-AMBI 法	3)
极端十旱水文年(2011 年) 夏李珠江口溶解氧的分布特征及影响因素研究	5)
影响悬浮颗粒物吸收系数测量的相关因素研究 余小龙,沈芳,张晋芳 (174:	5)
香溪河库湾春季 pCO、与浮游植物生物量的关系 ················· 袁希功,黄文敏,毕永红,胡征宇,赵玮,朱孔贤(175	4)
紊流脉动强度对藻类生长及水环境的影响研究	1)
直供驗網对水由藻米及甘水上順味运送物。一日其三硫醚同共土除研究 互吃匠 改多化 工行空 相往非 本書板 (176	7)
回り取けれが主条大久夫八主候外行木切。工 $\hat{\Sigma}$ 一、肥肥刊クム家明元 つのに、ホテキ、エユエ、明正文、テモ位(170 $\hat{\Sigma}$ かい。 ロール・カース ナトロー・エー・ルク エー・カー・カー・カー・カー・カー・カー・カー・カー・カー・カー・カー・カー・カー	2)
40 个 F_{03} Q_{1} - G_{1} Q_{2} 于以他 F_{03} G_{1} G_{1} G_{2} G_{2} G_{3} G_{2} G_{3} G_{2} G_{3} G_{3} G_{2} G_{3}	3)
水中奈普生的紫外光降解机制及具产物毒性研究	2)
酸活化赤泥催化臭氧氧化降解水中硝基苯的效能研究 康雅凝,李华楠,徐冰冰,齐飞,赵伦(1790	0)
镉污染应急处置含镉絮体稳定性实验研究	7)
基于光学在线监测及形态学研究的絮凝体强度分析方法	2)
不同中子供休下三旬某些的活面的每和制研究	2)
不问电子 一級不切的是房加級化的的人	5) 5)
元来储学设益 做性 刺起的 制备 及	3)
城市污水——级出水超滤膜污染与膜特性的研究	2)
倒置 A ² /O-MBR 处理城市污水的中试研究 ·················· 张健君,邹高龙,杨淑芳,丁星,王莉,毛乾庄,杨丹(182:	8)
不同电子供体的硫自养反硝化脱氮实验研究	5)
短程同步硝化反硝化过程的脱氢与NO释放特性	5)
世工田山茶的的小山分孙古妻古宝古山污浊肠宫住士还保护。 20日本 本以 10日本 大人 10日本 10日本 10日本 10日本 10日本 10日本 10日本 10日本	1)
签J回相争取的小中多种有母有古有优约朱初苗朱力(宏优化	1)
多外麝香污染胁坦对蚯蚓特异性蛋白基因表达的影响 除春, 刘肃威, 郑顺安, 周后星, 李松(185	1)
浙江省制药行业典型挥发性有机物臭氧产生潜力分析及健康风险评价 徐志荣,王浙明,许明珠,何华飞(186-	4)
苯系物光催化开环降解产物低级醛类的健康效应 赵伟荣,廖求文,杨亚楠,戴九松 (187	1)
四川妇女而清中多溴联苯醚的浓度水平与组成特征	7)
咪唑类离子液体毒性的 OSAR/OSPR 研究	2)
空直云嘴山河滨工业园区丰巨土墙重与屋层边的时穴柱征 ************************************	2) 7)
需流胀动强度对藻类生长及水环境的影响研究 需雨,走天渝。伞嘉、安强、黄宁秋(176高铁酸钾对水中藻类及其次生嗅味污染物二甲基三硫醚同步去除研究 马晓雁,张泽华,王红字,胡仕斐,李青松(176纳米 Fe,O₄ H₂O₂ 非均相 Fenton 反应催化氧化邻苯二酚 何洁,杨晓芳,张伟军,王东升(177水中萘普生的紫外光降解机制及其产物毒性研究 马杜娟,刘国光,吕文英,姚锟。周丽华,谢成屏(1788酸活化赤泥催化臭氧锡架体稳定性实验研究 康雅媛,李华楠,徐冰冰,齐飞,赵伦(179隔污染应急处置含隔絮体稳定性实验研究 楝王荣,就清伟,杨仁斌,许振成,曾东(179隔污染应急处置含隔絮体稳定性实验研究 泰鵬康,冯永宁,王宝宝,王晓昌(180不同电子供体下三氯苯酚的还原脱氯机制研究 万金泉,胡梦蝶,马邕文,黄明智(180克聚糖季铵盐磁性颗粒的制备及其对甲基橙的吸附效果 张聪璐,胡薇敏,芙诗颖,王芳(181班市污水二级出水超滤膜污染与膜特性的研究 孟晓荣,张海珍,王磊,王旭东,赵亮(1827项目电子供体的疏自养反硝化脱氨实验研究 张健君,邹高龙,杨淑芳,丁星,王莉,毛乾庄,杨丹(1827不同电子供体的疏自养反硝化脱氨实验研究 张健君,邹高龙,杨淑芳,丁星,王莉,毛乾庄,杨丹(1827不同电子供体的疏自养反硝化脱氮与N₂O释放特性 梁小玲,李平,吴锦华,王百向德(1845基于固相萃取的水中多种有毒有害有机污染物富集方法优化 张明全,李华民,吴乾元,胡洪曾(185多环麝香污染胁迫对蚯蚓特异性蛋白基因表达的影响 陈春,刘潇威,郑顺安,周启星,李松(1857浙江省制药行业典型挥发性有机物臭氧产生潜力分析及健康风险评价 徐志荣,王浙明,许明珠,何华飞(186本系物光催化开环降解产物低级醛类的健康效应 赵伟荣,廖求文,杨亚楠,戴九松(187四川妇女血清中多溴联苯醚的浓度水平与组成特征 陈春,刘潇成,郑顺安,声明珠,何华飞(1867下夏石嘴山河流工业园区表层土壤重金属污染的时空特征 樊新刚,米文宝,马振宁,王婷玉(1887下夏石嘴山河流工业园区表层土壤重金属污染的时空特征 樊新刚,米文宝,马振宁,王婷玉(1887下夏古哈大自己云鄂博矿区及尾矿区周围土壤稀土污染现状和分布特征	1)
内家古包头日云郭冉伊区及尾伊区周围王壤稀工乃泉现状和分布特征····································	_ 、
福建省重点城市路面尘负荷及化学组成研究	5)
福建省重点城市路面尘负荷及化学组成研究 郑桉,杨冰玉,吴水平,王新红,陈晓秋(190	1)
重金属污染场地电阻率法探测数值模拟及应用研究 王玉玲,能昌信,王彦文,董路(1908	8)
从枝荫根直菌对稀十尾矿中大豆牛长和稀十元素吸收的影响 郭伟, 赵仁鑫, 赵文静, 付瑞英, 郭江源, 张君(191)	5)
海洋细菌 N3 对几种赤潮藻的溶藻效应	2)
1 株分离自煤矿废水的铁硫氧化细菌 LY01 的鉴定及其氧化特性研究 ····································	0)
1 体力内目床型及小的环则型化油图 LIUI 的釜定及共氧化位压则尤	0) 7)
1 株苯并[a] 花高效降解菌的筛选与降解特性 ·················· 蔡瀚, 尹华, 叶锦韶, 常晶晶, 彭辉, 张娜, 何宝燕 (1937	1)
2,2',4,4'-四溴联苯醚的好氧微生物降解	5)
养猪废水培养微生物絮凝剂产生菌群 B-737 及发酵特性 ············ 裴瑞林,信欣,张雪乔,周迎芹,姚力,羊依金 (195	1)
2,2°,4,4°-四溴基苯醛的好氧减生物降解	
黄山降水酸度及电导率特征分析	8)
黄山隆水酸度及由导家特征分析	4)
具川阵小眼又及电寸平行胆力引 直杀共山工目宣帝士与广盗防山盗州南了陆尔八托	+ / 2 \
夏学與山小門间及人工气俗放小俗性离丁付世7州	3)
一) 州秋学水貍污染的 桂天气颗粒物有机酸的污染特值	2)
福建省三大城市冬季 PM _{2.5} 中有机碳和元素碳的污染特征 ········ 陈衍婷,陈进生,胡恭任,徐玲玲,尹丽倩,张福旺(1988	8)
上海市含碳大气颗粒物的粒径分布	5)
上海市浦东城区二次气溶胶生成的估算 崔虎雄、吴迓名、段玉森、伏晴艳、张懿华、王东方、王茜(200	3)
沙尘暴期间上海市大气颗粒物元素地球化学特征及其物源示踪意义	0)
厦门为委诉郊诉抽面 CO 浓度亦少性征研究 参表面 稳规 如牙魚 对功害 4年(2011	Q \
及 17ハナ L か L L M	(1)
- GU-M3 7H GU-EUD 門門 仕续观侧平肽入飞中的 HUFU-142b ······· 郭立峰,姚波,周夜咘,学培旨,许林(202	<i>5</i> \
NARAZBO DEBRUKU BEZZA	5)
城市居家环境空气真菌群落结构特征研究 方治国,欧阳志云,刘芃,孙力,王小勇(203	5)
城市居家环境空气真菌群落结构特征研究 ····································	1)
城市居家环境空气真菌群落结构特征研究	1) 8) 4) 1) 7)

基于过氧化物的消毒技术研究进展

习海玲1,2,赵三平1,周文2

(1. 国民核生化灾害防护国家重点实验室,北京 102205; 2. 防化研究院第六研究所,北京 102205)

摘要:对环境友好消毒技术需求的增长,推动了过氧化物消毒技术的快速发展,并已被广泛应用于反化学和生物恐怖袭击、化生灾害处置、环境污染治理等领域. 在综述了过氧化物消毒剂 α 亲核取代/氧化消毒反应机制研究进展的基础上,介绍了以过氧化物为活性组分的水基消毒溶液、消毒泡沫、消毒乳液、消毒凝胶、消毒气雾、自消毒材料、纳米材料催化消毒技术等典型消毒体系. 针对现有过氧化物消毒技术消毒效率偏低、对个别毒剂消毒效果不理想的缺点,建议在过氧化物消毒技术研究中,加强消毒反应机制、多相体系界面相互作用研究,开发新型催化剂、多功能表面活性剂、自消毒材料和消毒剂缓蚀技术,以实现真正的绿色消毒.

关键词:过氧化物; 化学毒剂; 消毒; 亲核取代; 活性氧

中图分类号: X506 文献标识码: A 文章编号: 0250-3301(2013)05-1645-08

Advances in Peroxide-Based Decontaminating Technologies

XI Hai-ling^{1,2}, ZHAO San-ping¹, ZHOU Wen²

(1. State Key Laboratory of NBC Protection for Civilian, Beijing 102205, China; 2. The 6th Department of the Research Institute of Chemical Defense, Beijing 102205, China)

Abstract: With the boosting demand for eco-friendly decontaminants, great achievements in peroxide-based decontaminating technologies have been applied in countering chemical/biological terrorist attacks, dealing with chemical/biological disasters and destructing environmental pollutants. Recent research advances in α-nucleophilic/oxidative reaction mechanisms of peroxide-based decontamination against chemical warfare agents were reviewed, and some classical peroxide-based decontaminants such as aqueous decontaminating solution, decontaminating foam, decontaminating emulsions, decontaminating gels, decontaminating vapors, and some newly developed decontaminating media (e. g., peroxide-based self-decontaminating materials and heterogeneous nano-catalytic decontamination systems) were introduced. However, currently available peroxide-based decontaminants still have some deficiencies. For example, their decontamination efficiencies are not as high as those of chlorine-containing decontaminants, and some peroxide-based decontaminants show relatively poor effect against certain agents. More study on the mechanisms of peroxide-based decontaminants and the interfacial interactions in heterogeneous decontamination media is suggested. New catalysts, multifunctional surfactants, self-decontaminating materials and corrosion preventing technologies should be developed before peroxide-based decontaminants really become true "green" decontaminants.

Key words: peroxide; chemical warfare agents (CWAs); decontamination; nucleophilic substitution; active oxygen

"化学毒剂"是指通过毒害作用杀伤人畜的有毒化学品,在使用时,一般被分散为液滴、蒸气、气溶胶或粉末状态,使空气、地面、水体和物品染毒,经呼吸道、皮肤、眼等引起人、畜中毒,造成伤亡.东京地铁沙林事件和美国炭疽邮包事件后,人类面临的化学和生物袭击威胁开始由冷战时期的大规模生化战争转向非常规的化生恐怖袭击,化学和生物安全威胁骤然加剧并呈多样化.各国普遍研究和装备的化学毒剂包括含磷毒剂和糜烂性毒剂两类[1,2].含磷毒剂以动物神经系统为作用对象,又称神经毒剂,根据其结构可以分为两类,G类包括塔崩(GA)、沙林(GB)和梭曼(GD),V类包括维埃克斯(VX)(图1).糜烂性毒剂包括氮芥气(HN)、硫芥子气(HD)、路易氏剂(L)等,其中 HD 具有强烈糜烂性,且染毒持久,防护和治疗困难,曾被称为"毒

剂之王",是最常用的糜烂性毒剂之一.

化学毒剂危害的消除有赖于消毒技术的进步. 理想的化学消毒剂应具有高效、广谱、低毒、稳定性好、腐蚀性低等特点^[3]. 含氯消毒剂会对表面产生严重的腐蚀,并有致癌性的副产物产生^[4]. 过氧化物具有强氧化性,特别是过氧化氢(H₂O₂),除H₂O 和 O₂ 外分解不产生其他物质,在 20 世纪 60 年代曾引起研究人员的兴趣,但当时过氧化物反应性和稳定性都存在问题,在消毒剂研制中没有得到重视. 近年来,随着环境保护意识的提高,人们对消毒剂的环境友好性、与设备的相容性提出了更高的要求,过氧化物优势凸显,并在存储性、广谱性、消毒

收稿日期: 2012-08-08; 修订日期: 2012-11-10 基金项目: 总装备部预先研究项目(40407020102)

作者简介: 习海玲(1963~),女,硕士,研究员,主要研究方向为军事 化学与消毒技术,E-mail:fhxihl@163.com

图 1 G 类、V 类和 H 类化学毒剂 Fig. 1 Chemical structures of G-type,

V-type and H-type toxic agents

效率等方面取得了进展,被作为"绿色消毒剂"广泛 应用^[4~9].

笔者领导的消毒技术团队曾较系统地开展了过氧化物消毒技术研究^[10~19],获得了具有自主知识产权的过氧化物消毒剂配方^[20,21]和消毒装备.本文在综述了过氧化物消毒机制最新研究进展的基础上,介绍了国内外典型的以过氧化物为活性组分的消毒体系,并对现有过氧化物消毒技术需要解决的问题和应用前景进行了展望.

1 过氧化物消毒反应机制

过氧化物消毒剂的基本消毒反应机制包括 α 亲核取代和氧化^[6,9],前者对神经毒剂的降解至关重要,后者则是芥子气和生物战剂消毒的关键. 两种反应机制在消毒体系中的协同,构成了过氧化物消毒剂对各种化学毒剂和生物战剂广谱消毒的基础.

1.1 α 亲核取代消毒机制

作为二元弱酸,在碱性条件下, H_2O_2 能电离产生具有很强亲核性的过氧酸根离子(OOH^-)^[8],与含磷毒剂发生 α 亲核取代反应,生成低毒或无毒的过氧膦酸/过氧膦酸酯中间产物^[1,3,5,7],G 类毒剂与 OOH^- 亲核取代的过氧酸中间产物已被 ^{l}H 和 ^{3l}P 核磁共振(NMR)实验证实^[2,7,18]. 过氧膦酸中间产物与 H_2O_2 进一步反应生成膦酸并放出 O_2 ^[6].

碱溶液中 OH⁻水解是含磷毒剂重要的消毒机制,但在 pH≤9 的过氧化物溶液中,OOH⁻的浓度和亲核性都远强于 OH⁻[22,23],含磷毒剂直接经 OH⁻水解而降解的比例小于 5% [9]. 另外,OOH⁻亲核取代与 OH⁻水解的部位也有差异. OOH⁻亲核取代时,含磷毒剂的 RS—、F—或 NC—被取代,而 P—O 键不会断开,避免了有毒产物如 S—(二异丙基氨基乙

基)甲基硫代膦酸(EA-2192)的生成(图 2),而用碱溶液消毒时, EA-2192 占了 VX 降解产物的约 $22\%^{[6]}$.

图 2 VX 在 H_2O_2 溶液中的亲核取代/氧化反应^[7]

Fig. 2 Nucleophilic/oxidative decontamination ${\rm of}\ VX\ in\ H_2O_2\ solution$

过氧酸盐或 H_2O_2 加合物溶于水可以释放出 H_2O_2 并进一步电离产生 OOH^- ,因此其亲核取代消毒机制与 H_2O_2 类似. 过碳酸钠 $(2Na_2CO_3\cdot 3H_2O_2)$ 与 H_2O_2 对 GD、VX消毒的反应机制及产物基本一致,只是由于过碳酸钠溶液具有较高的 pH 值 $(10\sim11)$,水解反应对 G 类毒剂消毒的贡献增加了.

对 VX 而言,OOH⁻ 亲核取代生成的甲基膦酸乙酯(EMPA)能质子化 VX 生成 VX-H⁺. 失去质子的 EMPA 具有亲核性,能与 VX-H⁺继续发生亲核取代 反应生成 VX-pyro 和 RSH^[7], VX-pyro 水解重新生成 EMPA(图 2),即 VX 的亲核取代具有自催化作用^[22].

1.2 氧化反应消毒机制

以 S、N 为中心原子的化学毒剂,例如 HD、HN,在弱碱性溶液中水解缓慢,过氧化物对这类毒剂的消毒主要是通过对中心原子的氧化实现的. 在 H₂O₂溶液中,HD 被选择性地氧化为非糜烂性的芥子亚砜(HDO),延长反应时间则可以被进一步氧化为具有糜烂性的芥子砜(HDO₂)(图 3)^[7]. H₂O₂对HN中心 N 原子的氧化产物,因 N 原子烷基化水平的不同而异^[24]. 在过氧化物消毒体系中,VX 在发生亲核取代反应的同时也有 N、S 原子的氧化,亲核取代生成的 RSH 容易发生二聚形成连硫化合物(RSSR)并最终氧化为 RSO₃H(图 2),避免了 RSH的累积,推动了 EMPA 的自催化循环^[7,22],使 VX 被

彻底消毒,体现了两种消毒机制的协同效应. 对 VX 中 N 原子的氧化会生成含有 N—O 键的 VX-NO^[7],但因为不够稳定难以使用 GC-MS 检出^[18],需要使用电喷雾 LC-MS 才能够表征^[24].

CI S CI
$$\xrightarrow{H_2O_2}$$
 CI $\xrightarrow{H_2O_2}$ CI $\xrightarrow{H_2O_2}$ CI $\xrightarrow{H_2O_2}$ CI \xrightarrow{O} CI \xrightarrow{O}

图 3 HD 在H₂O₂溶液中的氧化反应^[7]

Fig. 3 Oxidation of HD in H₂O₂ solution

不同的过氧化物消毒体系,氧化反应中 O 原子转移机制存在很大差异,导致氧化反应的效率和产物也存在差异.一些反应体系 O 原子的转移是通过单线态氧($^{1}O_{2}$)[17]、羟基自由基($^{\cdot}OH$)[125 ~ 27]等活性氧中间体完成的,这些体系有机物的矿化程度较高,但氧化产物的选择性往往较差. Bach 等[28]提出的溶剂参与O 转移机制认为,反应体系中存在由目标物、 $H_{2}O_{2}$ 、 $H_{2}O$ 分子组成的环状过渡态以实现H、O 的迁移,关键是参与反应的溶剂分子个数以及H与O 迁移的顺序[29 , 30]. 不同 $H_{2}O_{2}$ / MoO_{4}^{2} 一配比时,氧化反应则既有 $^{1}O_{2}$ 中间体也有活性 $Mo(OO)_{4}^{2}$ 一介导的直接O 转移机制[6].

2 典型的过氧化物消毒体系

消毒性能是消毒剂活性组分、溶剂/助剂等各组分综合协同的结果.常用作消毒剂活性组分的过氧化物包括H₂O₂、无机过氧酸盐、有机过酸/盐等.根据过氧化物消毒剂剂型、使用状态的不同,又可以分为消毒水溶液、消毒泡沫、消毒乳液、消毒凝胶、消毒气雾等.近年来,基于过氧化物的自消毒材料和纳米材料消毒技术也成为关注的热点.

2.1 过氧化物水基消毒溶液

过氧化物水基消毒溶液是最普通的过氧化物消毒技术,可用于一般硬表面染毒时消毒. 根据其活性组分又可分为 H_2O_2 复配体系、过氧酸盐和有机过酸等.

2.1.1 H,O,复配溶液

单一的H₂O₂水溶液反应性较弱,和毒剂反应缓慢,只有与催化剂/活化剂组成复配溶液时,才能够

用于化学毒剂的消毒.

(1)金属离子活化H,O,

Fenton 体系是典型的金属离子活化 H_2O_2 溶液的例子,其反应性主要与酸性条件下 (pH 2~4) Fe²+活化 H_2O_2 产生大量的·OH有关.·OH对底物没有选择性,一些有机物在 Fenton 体系中能完全矿化为 CO_2 和 H_2O ,管臣等[12,13] 以联吡啶铁为光助 Fenton体系的催化剂,在可见光下照射下实现了芥子气模拟剂 2-氯乙基乙基硫醚(2-CEES) 和 VX 的完全矿化.一些改进的 Fenton体系[25~27,31] 用于有机污染物的处理效果良好,但化学消毒效果还有待验证. Cu^2 +存在时, H_2O_2 将 CN^- 氧化为 CNO^- 的速度加快[32]. Cu^2 +、 Fe^2 +还是常用的过氧化物凝胶消毒剂的催化剂[33].

(2)盐活化H₂O₂

碳酸氢根(HCO_3^-)与 H_2O_2 的醇/水溶液形成了"碳酸氢根活化 H_2O_2 "(BAP)体系,反应中生成的 HCO_4^- 对硫化物的二级氧化反应速率常数是 H_2O_2 的 300 倍,对 VX、GD 也有良好的消毒效果^[34]. BAP体系氧化反应是通过溶剂参与的 O 转移完成的(图4). 在过量氧化剂的作用下,HD 或其他硫醚会生成有一定糜烂性的砜^[35].

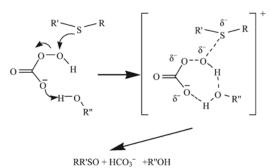


图 4 溶剂参与的 HCO₄ 氧化硫醚机制^[34]

Fig. 4 Solvent aided oxidation of sulfide by ${\rm peroxymonocarbonate}~(~{\rm HCO_4^-}~)$

Decon Green® 是美国陆军装备的一种以 35% H_2O_2 为活性组分的水基消毒剂,使用钼酸钾 (K_2MoO_4) 作催化/活化剂,催化效率比 HCO_3^- 高一个数量级 $[^{4\sim6,36]}$. 当 $H_2O_2/MoO_4^{2^-}$ <4 时, $^{1}O_2$ 是氧化消毒反应主要的活性物种,由 $MoO(OO)_3^{2^-}$ 产生,反应时有 HDO_2 的生成; 当 $H_2O_2/MoO_4^{2^-}$ > 4 时, $Mo(OO)_4^{2^-}$ 通过溶剂参与的 O 原子迁移,将 HD 选择性氧化为 $HDO^{[6]}$ (图 5). $MoO_4^{2^-}$ 作催化剂的另一个优点是,反应中形成的 $Mo(OO)_4^{2^-}$ 使消毒液显示出琥珀红色,可以据此判断消毒剂的活性 $^{[5]}$.

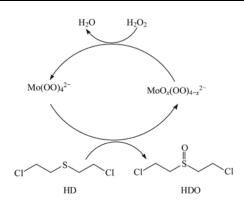


图 5 钼酸盐催化H₂O₂氧化 HD^[6]

Fig. 5 Oxidation of HD by molybdate-catalyzed H₂O₂

(3) 仿生催化活化H₂O₂

Fe、Cu、Mn、Co 等过渡金属离子的有机络合物用作 H_2O_2 的催化剂时,呈现了仿生催化的一些性质[33]. 四苯基卟啉铁的醇溶液能加速 H_2O_2 对硫醚的氧化,唯一产物为砜,95%的活性氧得到了利用,而以四苯基卟啉锰为催化剂时,产物则为亚砜和砜的混合物,对 H_2O_2 的利用率也低[37]. 金属-Schiff 碱配合物也是常用的 H_2O_2 体系仿生催化剂[38]. 由美国卡内基梅隆大学科研人员设计的铁四氨基大环配位体(Fe-TAML),能在宽泛的 pH 值范围内催化活化 $H_2O_2^{[39]}$,有望用作 H_2O_2 消毒活化剂.

2.1.2 无机过氧酸盐

过一硫酸氢钾复合盐($2KHSO_5$ - $KHSO_4$ - K_2SO_4 , Oxone)理论的活性氧含量为 5.2%,其水溶液在酸性 ($pH\approx2$)时,可以对 VX 和 HD 进行氧化消毒,但对 G 类毒剂的消毒效果不理想 [40]. Oxone 水溶液消毒 HD 的产物有二乙烯基砜、氯乙基乙烯基砜、芥子砜 [41]. Oxone 的稳定性好,使用方便,也被用作凝胶消毒剂的活性组分 [42,43].

过碳酸钠俗称固体双氧水,其水溶液($pH\approx11$)能自发分解产生 H_2O_2 .单一过碳酸钠溶液对 HD 消毒不理想,过碳酸钠/钼酸钠复配溶液则对 HD 较好的消毒效果,过碳酸钠分解产生的 H_2O_2 首先与 MoO_4^{2-} 反应生成 MoO_x (OO) $_{(4x)}^{2-}$,再由 MoO_x (OO) $_{(4x)}^{2-}$ 氧化 HD 为 HDO 和 HDO $_2$ [16].

一些无机过氧酸盐、 H_2O_2 加合物存储时间短,容易板结,但过硼酸钠($NaBO_3 \cdot n HO_2$)具有较好的稳定性.使用硫酸盐、表面活性剂在过氧酸盐颗粒表层形成包覆膜结构,可延长过氧酸盐的有效期.

2.1.3 有机过氧酸/盐

过氧乙酸(CH₃CO₃H)氧化性比H₂O₂强,对 HD、 VX、GD 和炭疽芽孢的消毒性能良好. 过氧乙酸可 由乙酸与H₂O₂反应制备,也可通过乙酰化反应由四乙酰乙二胺(TAED)与过碳酸钠反应发生. 1:1的 TAED/过碳酸钠组成的过氧乙酸固体发生剂^[44]是专利产品,使用硅酸镁、硫酸铵等包衣处理可改善固体发生剂的贮存稳定性.

过碳酰胺[$CO(NH_2)_2 \cdot HO_2$]又称过氧化尿素,是尿素和 H_2O_2 的加合物,其水溶液兼有尿素和 H_2O_2 的性质,但 pH 值从 2 提高到 4 左右,对 G 类、V 类和 H 类毒剂都有良好的消毒效果^[6]. 过碳酰胺消毒 2-CEES 时,产物以亚砜为主,仅有少量砜^[15].

单过氧邻苯二甲酸镁(MMPP)稳定性较好,其醇溶液对VX的消毒半衰期为42s,对HD的消毒半衰期只需14s,但对G类毒剂效果不理想^[45].HD在MMPP的水溶液作用下生成了6种氧化产物^[41].

2.2 过氧化物消毒泡沫

泡沫效应可以提高毒剂在消毒剂中的溶解度, 增加消毒剂与毒剂的接触面积和接触时间,具有用 量小、后勤保障负担小等优点[3]. 20 世纪 90 年代 末,美国 Sandia 国家实验室发展的以H,O,为活性组 分的泡沫消毒剂配方 DF200,对 GD、VX 的消毒性 能与非水消毒剂 DS, 相当,对光气、氰化物也有较 好的效果,但对 HD 的效果则较差[46]. 由 13% 苄基 三甲基氯化铵 + 20% 异丁醇胺 + 27% 甲苯磺酸 + 20% H₂O₂ + 20% 发泡剂组成的泡沫消毒体系(pH≥ 8),可对 HD、GD、VX 快速消毒[46], 十二烷基二甲 基苄基氯化铵、阿拉伯胶、H,O,组成的泡沫消毒 液,对枯草杆菌黑色变种芽孢、炭疽杆菌芽孢、金 黄色葡萄球菌等有较好的杀灭作用[47]. 王琦[14]优 选的一种过氧化物泡沫消毒剂配方,比单一过氧化 物水溶液对 HD 的降解率高 8.9%, 比水中 HD 的降 解率高 6.2%.

2.3 过氧化物消毒乳液

一些化学毒剂如 HD,在水中溶解度很小,但渗透性极强,能够穿透乳胶制品或深入各种涂层、塑性材料,对其消毒极为困难. 在消毒剂配方中加入表面活性剂、相转移催化剂和共溶剂组分,可增加毒剂的溶解度,强化对多孔介质表面沾染毒剂的提取效果,从而形成了乳化消毒剂. H₂O₂、过碳酰胺等活性组分与季胺盐类阳离子表面活性剂的醇-水溶液组成的复配型乳液,对化学毒剂和生物战剂都有较好的消毒效果,但稳定性较差^[48].

在乳化消毒液中增加表面活性剂用量,并加入相应的辅助剂如短链醇,可使普通乳状液转变为各向同性的热力学稳定体系——微乳体系.由H₂O₂、

聚氧乙烯-10-月桂醇醚与1:1 丙二醇/水溶液组成的抗低温微乳消毒液,在-18℃下对3种神经毒剂模拟剂和2种 HD 模拟剂仍然可以消毒,但对 VX的消毒性能及对 HD 的过度氧化尚需改进^[49]. Wagner等^[50]对 Decon Green®进行了改进,加入表面活性剂和助剂以提高消毒体系对毒剂分子的增溶效果,制成了新型微乳消毒液. Fallis等^[38]以 Mn-Schiff 碱配合物作为H₂O₂微乳液氧化 HD 的催化剂,避免了将 HDO 进一步氧化为 HDO₂. 由过碳酰胺、十六烷基三甲基溴化铵(CTAB)、正丁醇、正己烷、水组成的微乳消毒液,对 2-CEES 的溶解度是纯水的 60 倍以上,消毒速率提高了 2~5 倍^[15].

2.4 过氧化物消毒凝胶

消毒凝胶由氧化性消毒剂和凝胶组成,常用的凝胶包括硅凝胶、铝矾土、硅铝酸盐黏土等. 在胶体成分低于 30% 时,氧化消毒剂可与胶体成分形成稳定的凝胶^[1,10].

美国 Lawrence Livermore 国家实验室的研究人员将 Oxone 与二氧化硅白炭黑 EH-5(Cab-O-Sil EH-5)混合,以 Cu^{2+} 作为催化剂,制成了酸性(pH=2.6)硅凝胶消毒剂 L-Gel,对 V 类和 H 类毒剂具有很好的消毒效果,对生物战剂的模拟剂及其孢子也有很好的杀灭效果,但对 GD 效果较差,60 min 仅达到 $55\%^{[42,43]}$.

 H_2O_2 -Oxone-FeSO₄ 与气相硅胶组成的硅凝胶消毒剂,对芥子气模拟剂 2-CEES、沙林模拟剂甲基膦酸二乙酯(DEMP)消毒迅速,但对沙林的模拟剂甲基膦酸二甲酯(DMMP)、VX 模拟剂马拉硫磷(MAL)消毒不彻底^[33]. H_2O_2 -Oxone-FeSO₄-NaBO₃-CuSO₄ 组成的消毒凝胶,对 2-CEES、HD、VX 的消毒时间不超过 3 min,消毒效价达到 10 g·L^{-1[10]}.

2.5 H,O,消毒气雾

H₂O₂气雾(VHP)是成熟的生物制药、生物安全实验室熏蒸消毒方法^[3],也用于住宅^[51]和建筑物^[52]消毒.VHP对生物战剂和HD、VX效果很好,但对GD无效^[7].2002年,美国STERIS公司和埃奇伍德生化中心(Edgewood Chemical Biological Center)开始联合研制可用于生物和化学战剂广谱消毒的改性 VHP消毒技术.2003年,Wagner等^[7]报道在VHP中加入少量氨气(NH₃)后的改性 VHP(mVHP),对GD的反应活性大大增强,可以作为广谱的化学/生物战剂消毒技术.mVHP与H₂O₂水溶液消毒机制类似^[7],包括亲核取代和氧化两类.作者用¹H和³¹PNMR、LC-MS等技术也证明了NH₃改

性使 H_2O_2 溶液中大量生成 OOH - ,提高了对 G 类毒剂的亲核取代反应速率.

目前, mVHP 消毒技术已在飞机及大型装备^[53,54]的内部空间消毒实验中得到了验证,其消毒循环包括"除湿———气雾注人———消毒保持———尾气处理"这 4 个步骤,消毒时 NH₃ 浓度一般维持在 20 $\text{mg}\cdot\text{m}^{-3}$ 左右, H_2O_2 浓度为 400 ~ 800 $\text{mg}\cdot\text{m}^{-3}$ [7,53,54].

2.6 基于H₂O₂的自消毒材料

具有层状结构的聚合物涂层,利用电驱动的蒽醌类氧化/还原反应循环,能将空气中 O_2 转化为 H_2O_2 ,继而在金属离子、有机金属络合物、Fe-TAML 等过氧化物催化/活化剂的作用下,对表面沾染的化 学毒剂和生物战剂进行消毒 [55]. Amitai 等 [56] 通过电纺丝技术将葡萄糖氧化酶、辣根过氧化物酶、卤素氧化酶和葡萄糖、碘化钠嵌入聚氨酯纤维滤网,通过原位酶促反应生成 H_2O_2 及对卤素离子的串联氧化,制备了对化学毒剂和生物战剂有良好抗性和消毒性能的多功能材料.

一种电活化产 H_2O_2 的新型自消毒材料,由产 H_2O_2 电极、含电解液聚合物凝胶及含催化剂的聚合物覆盖层组成,产 H_2O_2 电极与传感器相连,当传感器检测到空气中的化生战剂时,电极产生的 H_2O_2 在催化剂作用下对生物和化学毒剂实时消毒,已经在对部分化生战剂的消毒实验中得到了验证[57].

2.7 纳米材料催化消毒技术

纳米材料具有比表面积大、吸附性强、产物选择性好等特点,在消毒上有着广阔的应用前景^[58]. HD 的模拟剂氯乙基乙基硫醚(CEES),在钒酸铵掺杂的纳米多孔硅催化下,能被 H_2O_2 选择性氧化为亚砜^[59]. Wagner 等^[60]以 H_2O_2 为氧化剂,以纳米 Pd/C作催化剂在常温下实现了对 GD、VX 和 HD 的完全矿化. Fe₃O₄纳米颗粒具有催化活化 H_2O_2 的作用被称为纳米材料模拟酶^[61],也有望用于 H_2O_2 消毒.负载型光催化剂/ H_2O_2 体系克服了 Fenton 体系催化剂损失的缺点,提高了活性氧的利用率和对底物的选择性^[26],也是可选的 H_2O_2 消毒催化剂.

3 展望

(1)人类环境保护意识的提高和对消毒技术的 多方面需求,推动过氧化物消毒技术取得了长足的 进步,应用也越来越广泛.同时也应该看到,现有的 过氧化物消毒体系,消毒速率、广谱性与传统的含 氯消毒剂还存在差距,对个别毒剂的消毒效果还不 理想,对材料的腐蚀^[19]还没有完全消除. 各种过氧化物消毒技术的成熟度也不一致,许多创新消毒技术还处在实验研究阶段,有待实际消毒的检验,与消毒剂配套的分散技术与装备也有待完善和多样化.

(2)由于氧化反应机制、多相体系的界面相互作用将直接影响消毒速率和产物的选择性,因此新型催化剂、多功能表面活性剂和活性氧调控技术、消毒液缓蚀技术的开发,仍将是过氧化物消毒技术的基础研究内容,仿生催化、纳米催化和负载型催化剂则提供了解决现有过氧化物消毒体系效率和产物选择性缺点的可能途径.如 Love 等[62]所指出的,单一的消毒剂配方通常难以实现理想消毒剂的所有特征,对不同装备和场景的消毒需要不同消毒技术的相互协同.随着微乳、凝胶、气雾、自消毒材料等新型消毒技术的日益成熟,过氧化物消毒技术在战场化学毒剂消毒及反化生恐怖袭击、化学救援、卫生防疫等非战争军事行动中的应用将越来越广泛,并实现真正的绿色消毒.

参考文献:

- [1] Singh B, Prasad G K, Pandey K S, et al. Decontamination of chemical warfare agents[J]. Defence Science Journal, 2010, 60 (4): 428-441.
- [2] Kim K, Tsay O G, Atwood D A, et al. Destruction and detection of chemical warfare agents [J]. Chemical Reviews, 2011, 111 (9): 5345-5403.
- [3] Richardt A, Blum M M. Decontamination of warfare agents: enzymatic methods for the removal of B/C weapons [M]. Weinheim: Wiley-VCH, 2008. 55-66.
- [4] Wagner G W. Hydrogen peroxide-based decontamination of chemical warfare agents[J]. Main Group Chemistry, 2010, 9(3-4): 257-263.
- [5] Wagner G W, Yang Y C. Universal decontaminating solution for chemical warfare agents [P]. United States Patent: US6245957B1, 2001-06-12.
- [6] Wagner G W, Yang Y C. Rapid nucleophilic/oxidative decontamination of chemical warfare agents [J]. Industrial and Engineering Chemistry Research, 2002, 41(8): 1925-1928.
- [7] Wagner G W, Sorrick D C, Procell L R, et al. Decontamination of VX, GD, and HD on a surface using modified vaporized hydrogen peroxide[J]. Langmuir, 2007, 23(3): 1178-1186.
- [8] Popov A F. Design of green microorganized systems for decontamination of ecotoxicants [J]. Pure and Applied Chemistry, 2008, 80(7): 1381-1397.
- [9] Vakhitova L N, Matvienko K V, Taran N A, et al. Nucleophilic oxidizing systems based on hydrogen peroxide for decomposition of ecotoxicants[J]. Russian Journal of Organic Chemistry, 2011, 47(7): 965-973.
- [10] 陈飞龙. 过氧化物硅凝胶催化消毒技术的研究[D]. 北京: 防化研究院, 2006. 1-72.

- [11] 李增沛. 三种过氧化物消毒芥子气产物的气相色谱-质谱检测方法研究[D]. 北京: 防化研究院, 2006. 1-83.
- [12] 管臣, 习海玲, 乔江波, 等. 可见光助 Fenton 体系降解芥子 气机理研究[J]. 防化研究, 2007, (1): 24-29.
- [13] 管臣, 习海玲, 赵进才, 等. 联吡啶铁/ H_2O_2 体系在可见光下降解芥子气模拟剂 2-CEES[J]. 分子催化, 2007, **21**(2): 162-167.
- [14] 王琦. 过氧化物泡沫消毒剂及其对芥子气消毒性能研究 [D]. 北京; 防化研究院, 2007. 1-52.
- [15] 雷美玲. O/W 型微乳液消毒体系构建及其对芥子气模拟剂的消毒反应研究[D]. 北京: 防化研究院, 2009. 1-95.
- [16] 张磊, 习海玲, 王琦, 等. 过碳酸钠/钼酸钠体系对 2-氯乙基乙基硫醚的降解机理与动力学研究 [J]. 环境化学, 2011, **30**(10): 1695-1699.
- [17] 张磊."过氧化物/钼酸盐"体系对芥子气及其模拟剂消毒反应动力学与机理研究[D].北京:防化研究院,2011.1-62.
- [18] 袁铃. 毒剂与表面活性剂作用机理的 NMR 研究[D]. 北京: 防化研究院, 2012. 1-112.
- [19] 朱晓明. 几种过氧化物对金属材料的腐蚀机理及其缓蚀剂研究[D]. 北京: 防化研究院, 2012. 1-102.
- [20] 习海玲, 王琦, 陈立坤, 等. 水基过氧化物复合消毒剂[P]. 中国国防专利: ZL200910121033.0, 2011-08-03.
- [21] 陈立坤, 习海玲, 王琦, 等. 一种过氧化物硅凝胶消毒剂 [P]. 中国国防专利: ZL200910121031.1, 2011-08-24.
- [22] Yang Y C, Szafraniec L L, Beaudry W T, et al. Autocatalytic hydrolysis of V-type nerve agents [J]. The Journal of Organic Chemistry, 1996, 61(24): 8407-8413.
- [23] Vakhitova L N, Matvienko K V, Skrypka A V, et al. Kinetic regularities of micellar catalysis in the dephosphorylation with peroxide anion [J]. Russian Journal of Organic Chemistry, 2009, 45(8): 1128-1136.
- [24] Sridhar L, Karthikraj R, Murty M R V S, et al. Mass spectral analysis of N-oxides of chemical weapons convention related aminoethanols under electrospray ionization conditions[J]. Rapid Communications in Mass Spectrometry, 2011, 25(4): 533-542.
- [25] Tao X, Su J, Chen J, et al. A novel route for waste water treatment: photo-assisted Fenton degradation of dye pollutants accumulated in natural polyelectrolyte microshells [J]. Chemical Communications, 2005, (36): 4607-4609.
- [26] 马万红,籍宏伟,李静,等.活化H₂O₂和分子氧的光催化氧化反应[J].科学通报,2004,49(18);1821-1829.
- [27] Sun C Y, Chen C C, Ma W H, et al. Photodegradation of organic pollutants catalyzed by iron species under visible light irradiation[J]. Physical Chemistry Chemical Physics, 2011, 13 (6): 1957-1969.
- [28] Bach R D, Su M D, Schlegel H B. Oxidation of amines and sulfides with hydrogen peroxide and alkyl hydrogen peroxide, the nature of the oxygen-transfer step [J]. Journal of the American Chemical Society, 1994, 116(112): 5379-5391.
- [29] Chu J W, Trout dt B L. On the mechanisms of oxidation of organic sulfides by H₂O₂ in aqueous solutions[J]. Journal of the American Chemical Society, 2004, 126(3): 900-908.

- [30] 常刚, 王斌举, 张俊, 等. 缔合水分子对H₂O₂ + NH₃—H₂O + ONH₃ 反应机理的影响[J]. 高等学校化学学报, 2010, **31**(9): 1820-1826.
- [31] Ma J, Ma W H, Song W J, et al. Fenton degradation of organic pollutants in the presence of low-molecular-weight organic acids: cooperative effect of quinone and visible light[J]. Environmental Science and Technology, 2006, 40(2): 618-624.
- [32] Beattie J K, Polyblank G A. Copper-catalyzed oxidation of cyanide by peroxide in alkaline aqueous solution [J]. Australian Journal of Chemistry, 1995, 48(4): 861-868.
- [33] Giletto A, White W, Cisar A J, et al. Reactive decontamination formulation [P]. United States Patent: US 6569353B1, 2003-05-27.
- [34] Richardson D E, Yao H R, Frank K M, et al. Equilibria, kinetics, and mechanism in the bicarbonate activation of hydrogen peroxide; oxidation of sulfides by peroxymonocarbonate [J]. Journal of the American Chemical Society, 2000, 122(8); 1729-1739.
- [35] Fakhraian H, Valizadeh F. Activation of hydrogen peroxide via bicarbonate, sulfate, phosphate and urea in the oxidation of methyl phenyl sulfide [J]. Journal of Molecular Catalysis A: Chemical, 2010, 333(1-2): 69-72.
- [36] Wagner G W, Procell L R, Yang Y C, et al. Molybdate/ peroxide micro-emulsions useful for decontamination of chemical warfare agents[P]. United States Patent: US 6723891B1, 2004-04-20.
- [37] Marques A, Marin M, Ruasse M F. Hydrogen peroxide oxidation of mustard-model sulfides catalyzed by iron and manganese tetraarylporphyrines. Oxygen transfer to sulfides versus H₂O₂ dismutation and catalyst breakdown[J]. The Journal of Organic Chemistry, 2001, 66(23): 7588-7595.
- [38] Fallis I A, Griffiths P C, Cosgrove T, et al. Locus-specific microemulsion catalysts for sulfur mustard (HD) chemical warfare agent decontamination [J]. Journal of American the Chemical Society, 2009, 131 (28): 9746-9755.
- [39] Collins T J. TAML oxidant activators: a new approach to the activation of hydrogen peroxide for environmentally significant problems[J]. Accounts of Chemical Research, 2002, 35(9): 782-790
- [40] Yang Y C, Baker J A, Ward J R. Decontamination of chemical warfare agents [J]. Chemical Reviews, 1992, 92 (8): 1729-1743.
- [41] 李增沛, 陈志升, 张兰波. 芥子气过氧化物消毒产物的气相 色谱-质谱测定[J]. 分析测试学报, 2007, **26**(6): 901-903.
- [42] Hoffman D M, McGuire R R. Oxidizer gels for detoxification of chemical and biological agents [P]. United States Patent: US6455751 B1, 2002-09-24.
- [43] Raber E, McGuire R R. Oxidative decontamination of chemical and biological warfare agents using L-Gel [J]. Journal of Hazardous Materials, 2002, 93(3): 339-352.
- [44] 张文福,魏秋华,苏裕心. 低腐蚀性过氧乙酸固体发生剂及 其制备方法与应用[P]. 中国专利: CN102415380A, 2012-4-

- 18.
- [45] Hignet G J. Magnesium salts of peroxycarboxylic acids, processes for their preparation and their use as bleaching agents in washing compositions, and processes [P]. European Patent: EP0027693B2, 1988-05-11.
- [46] Cronce D T. Chemical warfare agent decontamination foaming composition and method [P]. United States Patent: US6376436B1, 2002-04-23.
- [47] 朱大兰, 张文福. 过氧化氢泡沫消毒剂杀菌规律研究[J]. 中国消毒学杂志, 2006, **23**(6): 489-492.
- [48] Tadros M E. Formulations for neutralization of chemical and biological toxants [P]. United States Patent: US6566574B1, 2003-05-20
- [49] Menger F M, Rourk M J. Deactivation of mustard and nerve agent models via low-temperature microemulsions[J]. Langmuir, 1999, 15(2): 309-313.
- [50] Wagner G W, Procell L R, Yang Y C, et al. Molybdate/ peroxide oxidation of mustard in microemulsions [J]. Langmuir, 2001, 17(16): 4809-4811.
- [51] Mielnik T J, Krieger E W, Eddington D L, et al. Room decontamination with hydrogen peroxide vapor[P]. United States Patent: US7454551B2, 2008-05-08.
- [52] McVey I F, Selig V M, Schwartz L I, et al. Building decontamination with vaporous hydrogen peroxide [P]. United States Patent: US7361304B2, 2008-07-30.
- [53] Brickhouse M D, Turetsky A, MacIver B K, et al. Vaporous hydrogen peroxide (VHP) decontamination of a C-141B starlifter aircraft: validation of VHP and modified VHP (mVHP) fumigation decontamination process via VHP-sensor, biological indicator, and HD simulant in a large-scale environment [R]. Maryland: Edgewood Chemical Biological Center, U. S. Army Research, Development and Engineering Command, 2007. 1-53.
- [54] McAnoy A M, Sait M, Pantelidis S. Establishment of a vaporous hydrogen peroxide bio-decontamination capability [R]. Australia: Human Protection Performance Division, Defence Science and Technology Organization, 2007. 1-16.
- [55] Hou S, Kinlen P J, Viswanathan S, et al. Eletroactivated film with immobilized peroxide activating catalyst [P]. United States Patent: US 2009/10291844 A1, 2009-11-26.
- [56] Amitai G, Murata H, Andersen J D, et al. Decontamination of chemical and biological warfare agents with a single multifunctional material [J]. Biomaterials, 2010, 31 (15): 4417-4425.
- [57] Zhu S Q. Self-detoxifying devices with smart polymer coatings for chemical and biological warfare agents [EB/OL]. http:// physics. missouristate. edu/assets/physics/Dr_Siqiang_Zhu_04-29-2010. pdf. 2010-4-29.
- [58] Guidotti M, Rossodivita A, Ranghieri M C. Nano-structured solids and heterogeneous catalysts: powerful tools for the reduction of CBRN threats [A]. In: Vaseashta A, Braman E, Susmann P. NANO science for peace and security series A;

- Chemistry and Biology [C]. Dordrecht: Springer Netherlands, 2012. 89-97.
- [59] Ringenbach C R, Livingston S R, Kumar D, et al. Vanadium-doped acid-prepared mesoporous silica: synthesis, characterization, and catalytic studies on the oxidation of a mustard gas analogue [J]. Chemistry of Materials, 2005, 17 (22): 5580-5586.
- [60] Wagner G W, Procell L R, Yang Y C. Room Temperature Mineralization Of Chemical Warfare Agents Using Hydrogen
- Peroxide-Pd/C[R]. Maryland: Edgewood Chemical Biological Center, Aberdeen Proving Ground, 2002. 1-5.
- [61] Gao L Z, Zhuang J, Nie L, et al. Intrinsic peroxidase-like activity of ferromagnetic nanoparticles [J]. Nature Nanotechnology, 2007, 2(9): 577-583.
- [62] Love A H, Bailey C G, Hanna M L, et al. Efficacy of liquid and foam decontamination technologies for chemical warfare agents on indoor surfaces[J]. Journal of Hazardous Materials, 2011, 196 (1): 115-122.

欢迎订阅 2013 年《环境科学》

《环境科学》创刊于1976年,由中国科学院主管,中国科学院生态环境研究中心主办,是我国环境科学学科中最早创刊的学术性期刊.

《环境科学》自创刊以来,始终坚持"防治污染,改善生态,促进发展,造福人民"的宗旨,报道我国环境科学领域内具有创新性高水平,有重要意义的基础研究和应用研究成果,以及反映控制污染,清洁生产和生态环境建设等可持续发展的战略思想、理论和实用技术等.

《环境科学》在国内外公开发行,并在国内外科技界有较大影响,被国内外一些重要检索系统收录,如美国医学索引 MEDLINE;美国化学文摘 CA;俄罗斯文摘杂志 AJ;美国生物学文摘预评 BP;美国医学索引 IM;日本科学技术情报中心数据库 JICST;英国动物学记录 ZR;剑桥科学文摘(CSA):Environmental Sciences;剑桥科学文摘(CSA):Pollution Abstracts;剑桥科学文摘(CAS):Life Sciences Abstracts等;国内的检索系统有中国科技论文统计与引文数据库(CSTPCD);中文科技期刊数据库(维普);中国期刊全文数据库(CNKI);数字化期刊全文数据库(万方);中国科学引文数据库(CSCD);中国生物学文摘等.

全国各地邮局均可订阅,如有漏订的读者可直接与编辑部联系,办理补订手续.

《环境科学》2013年为大16开本,90元/册,全年12期.

国内统一刊号: CN11-1895/X 国际标准刊号: ISSN 0250-3301

国外发行代号: M 205 国内邮发代号: 2-821

编辑部地址:北京市海淀区双清路18号(2871信箱) 邮编:100085

电话:010-62941102;传真:010-62849343;E-mail:hjkx@rcees. ac. cn;网址:www. hjkx. ac. cn

Environmental Science (monthly)

Vol. 34 No. 5 May 15, 2013

CONTENTS

Banna Health Sell-Continuental Carlos of Sel A. Companier's Sell-Recommendation (Carlos) Banna Health Sell-Continuental Carlos of Sel. A. Companier's Sell-Recommendation for Claims. Many, MAN Cargonage, H. Mangenous, et al. (1982) Organic New Teachment by Earthman Nemicosposing and Lare Generoscies (Price of Many) Bannier A. (1982) Carrol Stand of Staffor Wart Acidentics in Anthone Glaims. M. Gauger's, K.W. Benghes, L.O. Yao, et al. (1982) David Standard Characteristics of Biocheel Oxygen and In Alfording Factors in the Paul Bore Generoscient, Price of Many Carlos, and Carlos Characterists of Biocheel Oxygen and In Alfording Factors in the Paul Bore Essay During the Summer of the Esteemyl Dought Hydelegial Year 2011 Suplicated of Equilibrium Particioning Appears to Establish Schman Quality Clotes for Benry Netton in Bunguing Scote on Mangings (Gorer Willer, M. Warping, S.H. 2004). Applicated of Equilibrium Particioning Appears to Establish Schman Quality Clotes for Benry Netton in Bunguing Scote on Mangings (Gorer Willer, M. Warping, S.H. 2004). Applicated of Equilibrium Particioning Appears to Establish Schman Quality Clotes for Benry Netton in Bunguing Scote on Mangings (Gorer Willer, M. 2004). Applicated of Equilibrium Particioning Appears on Scote Scote Mangings (Gorer Willer, M. 2004). Applicated of Equilibrium Particioning Appears on Scote Mangings (Gorer Willer, M. 2004). Applicated of Equilibrium Particioning Appears on Scote Many Company (Gorer Willer, M. 2004). Applicated of Equilibrium Particioning Applicated Company (Gorer Willer, M. 2004). Applicated and Carlos of Many and Many Company (Gorer Willer, M. 2004). Applicated and Carlos of Many and Particioning Applicated and Carlos of Many and Particioning Application and Carlos of Many and Particioning Application and Carlos of Handward (Gorer William). Application of Many Carlos of Many o	Advances in Peroxide-Based Decontaminating Technologies	XI Hai-ling ZHAO San-ping ZHOU Wen (1645)
Hamm Behl Rick-Bood Envisormatic Cloric for Soil A. Companies Subs Determent Countries and Implication for China W. Mong, P. M. Mong, P. M. Mong, P. M. M. Stage, M.	Environmental Damage Assessment: International Regulations and Revelation to China	
Organic Water Tentimon De Enthoneur Vernicomposing and Larious Biotomerosine, Services and Perspective Strategies of Astination and Intalian Based on Energoism of Laises in Uniform All Camary, in Microbia, Hillmann (1970) Distribution Characteristics of Historical Northward Market Market All Camary, in Microbia, Hillmann (1970) Distribution Characteristics of Historical Olygons and he Allesing Fasters in the Paul Biotr Estuary Daving the Summer of the Esturmaly Daught Hydrological Yars 2011 **West Heavy Company of Paul Biotribus Persistation (Agencia Property of West Biotry **Part Paul Biotribus Persistation of Historical School Company of Paul Biotribus Persistation (Agencia) Strates in Negative Northward (1971) **Application of Paul Biotribus Persistation (Agencia Property of Paul Biotribus Persistation (Agencia) Strates in Negative Northward (1972) **Application of Paul Biotribus (Agencia) Strates in Negative Northward (1972) **Application of Paul Biotribus (Agencia) Strates in Negative Northward (1972) **Application of Paul Biotribus (1972) Agency (1972) **Application of Paul Biotribus (1972) Agency (19		
Statepies of Nurients Carel in Lake Based on Europies of Lake in China (Carel State of Sarty, KeW Lenghur, and Carel State of Sarty, KeW Lenghur, and Carel (1985) Impact Analysis of Vice to the Wine Caulty of Webs Efrec. (1986) Impact Analysis of Vice to the Wine Caulty of Webs Efrec. (1986) Impact Analysis of Vice to the Wine Caulty of Webs Efrec. (1986) Impact Analysis of Vice to the Wine Caulty of Webs Efrec. (1986) Impact Analysis of Vice to the Wine Caulty of Webs Efrec. (1986) Impact Analysis of Vice to the Wine Caulty of Ca		
Import Analysis of Xian to the Name Quality of White River. THE First, HAMA Starsens, ONLY THE ANALYSIS (INC.) In the Start Putting the Summer of the Extraody Dungth Hybridogical Year 2011. Philips In Analysis of Management and Starsens, Start Part of the Start Putting the Summer of the Extraody Dungth Hybridogical Year 2011. Application of Equilibrium Partitioning Approach to Establish Schimers Quality Criticis for Heavy Metab in Hunggang Section of Xiangiang River. HAMA Charson, QNN Yanawan, ZHEMG Himpola, et al. (1785). Assessing the Benthe Ecological Status in Yangue River Ensury Using AMBI and MAMBI. CAI Weet-point, MENN Weet, 1104 and CAI Criticis and Care Partition of Company (IN Yanawan, ZHEMG Himpola), et al. (1785). Philina Data and the First Flash Effect of Dilby, and O'Di tabul Rand of Wendows City. Hand Start Management Company (IN Yanawan, ZHEMG Himpola), et al. (1785). Philina Data and the First Flash Effect of Dilby, and O'Di tabul Rand of Wendows City. Hand Start Management Company (IN Yanawan, ZHEMG Himpola), et al. (1785). Philina Data and the First Flash Effect of Dilby, and O'Di River Management Company (IN Yanawan, ZHEMG River), and (IN Yanawan, ZHEMG River)	Strategies of Nutrients Control in Lakes Based on Ecoregions of Lakes in China	DIAO Xiao-jun, XI Bei-dou, HE Lian-sheng, et al. (1687)
Dischloric Characteristics of Biosobiol Oxygon and Its Affecting Entons in the Post River Entony Drought Rychological Year 2011 Application Land and the Particulum Particulum Approach to Exabilish Sediment Quality Crimin for Heavy Metals in Bruggung Section of Nanaging Roor HAN Chaosum, (WY Norwer, ZHENN, Bingshin, et al. (1785) Assessing the Benthic Evological Status in Yungzue River Estatuy Using AMBI and McAMBI CAU Wes-nigm, MENN, WEN, WE, LIU Leasm, et al. (1785) Bellusion Land and the First Palls Ellect of High Section (1985) and Old in the Bane Metal of Wendmin City WAND Jam, Bill Chaojan, CAU, 2007, and Mag Binnous. in Kings 1980 is Spice. WAND Jam, Bill Chaojan, CAU, 2007, and Mag Binnous in Kings 1980 is Spice. WAND Jam, SHIN Fang, ZHAW, Infecting (1785) Ellects of Ruddord Phartation Intensity on the Goods of Algo and Water Environment Managam, PARAW Z-Pening, Bings, et al. (1786) Catalysed Oxfortion of Cateched by the Hierosponous Ference-lake Recent on Shane Fe, QH.O., Spices. MED Je, YANG, Kao-Iran, ZHAW, Weisjan, et al. (1770) Catalysed Oxfortion of Cateched by the Hierosponous Ference-lake Recent on Shane Fe, QH.O., Spices. MED Jer, YANG, Kao-Iran, ZHAW, Weisjan, et al. (1771) Catalysed Oxfortion of Algorithm of Cateched by the Hierosponous Ference-lake Recent on Shane Fe, QH.O., Spices. MED Jerospon LIU Cooperain, William Cooperation of Shane Palls and Oxfortion Oxfortion of Ninebenness in Water by Arcifilderalise-science Red Mad Shane Managam, P.D. (1984), and the Cateched By the Hierosponous Ference Recent and Shane Managam, P.D. (1984), and the Cateched By the Hierosponous Ference Recent and Shane Managam, P.D. (1984), and the Cateched Recent of Technological Analysis and Oxfortion Oxfortion Oxfortion Cooperation of Ninebenness in Water Information Cooperation of Ninebenness in Water	Current Status of Surface Water Acidification in Northeast China	······ XU Guang-yi, KANG Rong-hua, LUO Yao, et al. (1695)
Age-institute of Equilibrium Partitoring Agrouch to Enablish Sedment Quality Citieria for Heavy Metals in Henganus Section of Xinegian (1970) Assessing the Berthie Ecological Status in Yangtae River Estatus Using AMBI and MAMBI CAL Wee-gain, MINN Company, GERN Einsplan, et al. (1785) Pultation Load and the Fire Floak Effect of EOQ, and COID in Uthon Bund of Weeshoo City WAND Jan., II Chao-jam., CHEN Ziene-ban, et al. (1785) Pultation Load and the Fire Floak Effect of EOQ, and COID in Uthon Bund of Weeshoo City WAND Jan., II Chao-jam., CHEN Ziene-ban, et al. (1785) Pultation Load and the Fire Floak Effect of Ecological Status in National Bus jan Spring. "UAN Assessing Minn Measuring Assessing Conference on Conference of Conference of Conference of Conference of Conference on Conference		
Agentiant of Engillenium Partitionium Approach to Establish Seediment (Muslips Criteria for Heavy Meths in Heav	Distribution Characteristics of Dissolved Oxygen and Its Affecting Factors in the Pearl River Estuary During the Summer of the	he Extremely Drought Hydrological Year 2011
HAN Clausem, (BY Tawes, EENNE Rigglin, et al. (175) Pollution to and and the First Place EFF Strate (1802), and (1910) in Urban Roard of Worshoo City WAND Jun, Bill Umerjane, CHEAN Zoer-loo, et al. (1785) Pollution total and the First Place EFF Strate (1802), and (1910) in Urban Roard of Worshoo City WAND Jun, Bill Umerjane, CHEAN Zoer-loo, et al. (1785) Pollutionship Review (201), and Maja Billioniss in Nangoi Bay in Spring WAND Jung, BILL Wang, BILL WAND Jung, BILL WAND Jung, BILL Wang, BILL WAND Jung, BILL Wang, BILL WAND Jung, BILL Wang, BILL WAND Jung, BILL WAND Jung, BILL Wang, BILL WAND Jung, BILL WAND Jung, BILL WAND Jung, BILL Wang, BILL WAND Jung, BILL Wang, BILL WAND Jung, BILL WAND Jung, BILL WAND Jung, BILL Wang, BILL WAND Jung, BILL WAND Jung, BILL Wang, BILL WAND Jung, BIL		YE Feng, HUANG Xiao-ping, SHI Zhen, et al. (1707)
Assessing the Benthic Ecological States in Yangton River Estang Using AMH and MA-MMB	Application of Equilibrium Partitioning Approach to Establish Sediment Quality Criteria for Heavy Metals in Hengyang Section	on of Xiangjiang River
Pollutin role and the First Flow Effect of 100, and 1000 in them Remoff of Werelman City Hardmanning Enterior Measuring Memorphic Coefficient of Superpul Particular Matters. "VIX Xa-long, NER, 21MAN Libera, 21MA	A COLD INDIVIDUAL TO THE AND IN AND	HAN Chao-nan, QIN Yan-wen, ZHENG Bing-hui, et al. (1715)
Influencing Factors in Measuring Alsosptian Coefficient of Supering Particular Matters (1745) Relationship Revenue (70), and Alga Binomas in Nizagoi, Bing or Styring (1745) Effects of Turbulent Denotation theories on the Growth A Algae and Water Environment Similarous Recompt. of Algae and Bo Ostano Medable Environity Friendship Conference (1745) Catalyzed Oxidation of Carefuel by the Heterogenrous Fentuchide Reaction of Number 19 (1745) Catalyzed Oxidation of Carefuel by the Heterogenrous Fentuchide Reaction of Number 19 (1745) Catalyzed Oxidation of Vigoreses in Aqueous Systems by IV Virtualisties, Mechanics and Touciery of Photological Products May Despense in Aqueous Systems by IV Virtualisties, Mechanics and Touciery of Photological Products May Despense in Aqueous Systems by IV Virtualisties, Mechanics and Touciery of Photological Products May Despense in Aqueous Systems by IV Virtualisties, Mechanics and Touciery of Photological Products May Despense in Aqueous (1750) Catalyzed Oxidation of Nimelencores in Water by Acidification activated Red Musi Experimental Studies on Sudality of Pices from Cardinary Photological Daniel Mediations IV Was Despense in Aqueous, All Mechanics and Cardinary Company, All Mechanics and Recompany, All Mechanics and Cardinary Company, All Mechanics and Cardinary Company, All Mechanics and Cardinary Company, All Mechanics Co		
Relationship Retwern pOLy, and Algal Bismuns in Xianguei Bei in Spring Ellers of Tuttabeth Intentianis Intensity in the Goods of Algae and the Control of Mage and Algae and the Control of Mage Algae and Algae and the Control of Mage Algae and Algae and the Control of Mage Algae and	Pollution Load and the First Flush Effect of BUD ₅ and CUD in Urban Runoff of Wenzhou City	WANG Jun, BI Chun-juan, CHEN Zhen-lou, et al. (1/35)
Effects of Turbuleart Doctation Intensity on the Genoth of Algae and Work Parkinsmerch Smillanzoon Remond of Algae and the Ostoon Medablic Dismidel Frisidifies in Warte by Potassian Ferrate M. Xian-yan, M. Zhan, W. Xian-Gang, Zhi N. Wei-jan, et al. (1787) Catalyzed Oslution of Caterbol by the Heterogeneous Ferror-like Reaction of Nune-Fe ₂ O ₂ 1-LO ₂ System HE Je, Y. Xian Xian-Gang, Zhi N. Wei-jan, et al. (1782) Pathodeparation of Nune-fearer in Water by Archifesticas extracted Red Mul L. Xian Xi. Yacing, Li Hue ana, X. Bing, intensity, et al. (1782) Estalution of Nune-fearer in Water by Archifesticas extracted Red Mul L. Xian Xi. Yacing, Li Hue ana, X. Bing, intensity, et al. (1782) Estalution of Fee Strength Based on Morphological Analysis and Oytical Online Monitoring M. Yacing, P. Weiller, W. Xian, et al. (1787) Estalution of Fee Strength Based on Morphological Analysis and Oytical Online Monitoring M. Perputnion of Migae, v. Yacing, et al. (1782) Perputnion of Migae Quality Quality Categories with Studies of Medicine of Medicine Categories and Perputnion of Treatment of Municipal Waterated Essing and Studies of Medicine of Medicine Categories and Medicine Properties M. R. M. Xian, and S. W. R. Son-box, et al. (1882) Sudy on Sulfur-based Auttropolis Destinification with Different Electron Donos Yacing Remondal on A Oy Danission Characteristics Dring the Shortest Sundainance National Properties M. R. M. Xian, and a Categories and Archifestical Destination of Treatment of Municipal Waterateristics in Categories and Properties and Pertainfication Process Yacing Destination of Solid-Phase Extraction for Enrichment of Toxic Organic Compounds in Water Sumples T. W. A. Weiller, and an A. (1883) Health Effect of Valatic Adelected Compounds in Potaccatalytic Oxigation of Anomalies Compounds in Potaccatalytic Oxigation of Anomalies Compounds in Potaccatalytic Oxigation of Anomalies Compounds in Potaccatalytic Oxigation of Nune-ferring and Coxigation of Nune-ferring and Compounds in Potaccatalytic Oxigatio	Influencing Factors in Measuring Absorption Coefficient of Suspended Particulate Matters Polytically Polytical Polytical Polytical Polytics in Vicingia Pay in Spring	
Smallamous Remond of Algae and Its Odornous Metabolic Binefield Trissfifts in Water by Rassissin Ferante MA Navy-m. AlfANG Ze-lam, WANG Hosper, et al. (1782) Reachaged Catalogue of Metabolic and Carbool by the Hosper, 2014, 20, System BE, E., VANG Metabolic, et al. (1782) Procedegulation of Nagrone in Ageons Systems by U Trealanton, Mechanism and Tanking of Planchysis Products MA Da-jam, III Gas-gaung, I. Wen-ying, et al. (1782) Experimental Studies on Stability of Planc from Calmium Pollation Energypery Featment III Wang-roug, G10 (1902 eer, YANG Reschie), et al. (1787) Becknistion of Planching Planch of Mechanism of Reschied the Metabolic Planch Mechanism of Planching Planch of Mechanism of Reschied to Planch Studies on Stability of Planch Studies and Stability of Planch Studies and Stability of Planch Mechanism of Planching Planching of Reschied and Mechanism of Reschied Planching Planching of Reschied and Mechanism Polytechnism of Studies Planching Planching of Reschied Planching Planching of Reschied Planching Planching of Reschied and Stability of Reschied Planching Planching		
Catalyse Ordation of Carboth by the Heterogenous Fortne-like Reaction of Nano-Fe ₂ O ₂ -H ₂ O ₃ System — HE, Le, YANO, Nanofang, ZHANO, Wei-jun, et. al. (1782) Catalyte Ornation of Nitebennese in Water by Actification activated Red Mul. Experimental Studies on Stability of Foss from Californian Dilution Energypts Prestment Ill Wangangong, G10 Qing-wei, YANG Read-in, et. al. (1787) Evaluation of The Strongth Excel on Marphological Analysis and Optical Online Monitoring IN Pregalant, 1785, Congaina, R.W. St. Soolan, et. (1787) Pregalant, 1785, Congaina, R.W. St. Soolan, et. al. (1882) Mechanis of Reductive Deschioration of Triederophrends with Different Electron Discose WAM Jan-juan, HI Minequée, MA vangemen, et. al. (1882) Menhame Fooling by Secondary Ellisted of Urban Secongs and the Membrane Properties MERON Congae, HIR, Will Carlot, et. al. (1882) Menhame Fooling by Secondary Ellisted of Urban Secongs and the Membrane Properties MERON Kano-pan, HIM Stage, A.W. Stading, et. al. (1882) Study on Sulfar-Based Antotrophic Destification with Different Electron Discose YUAN Yang, 2HOU Wei, St. WAN, Chin, et. al. (1883) Study on Sulfar-Based Antotrophic Destification with Different Electron Discose YUAN Yang, 2HOU Wei, St. WAN, Chin, et. al. (1883) Study on Sulfar-Based Antotrophic Destification with Different Electron Discose YUAN Yang, 2HOU Wei, St. WAN, Chin, et. al. (1883) Study on Sulfar-Base Electron for Discose and Destification of Sulfar-Base Electron Discose YUAN Yang, 2HOU Wei, St. WAN, Chin, et. al. (1883) Polycyclic Masks Exposure Affects Gene Expression of Specific Proteins in Earthware Electron feitod Health Effect of Volalife Addelyde Compounds in Photocentilytic Oxidation of Aromatics Compounds in March Sulfary St. (1887) Health Effect of Volalife Addelyde Compounds in Photocentilytic Oxidation of Aromatics Compounds (Wang Californese), 2HOU Wei, St. WAN, Chin, et. al. (1887) Berlin Ellis Ellis Andrea, 2HOU Wei, St. WAN, Chin, et. al. (1887) Berlin Ellis Andrea, 2HOU Wei, St. W		
Photodegradation of Napenous in Appeous Systems by Ut Trailations, Mechanisms and Toxicity of Photopies Products All De-jams, III Gos-gaug, II. Wereving, et al. (1982) Experimental Sudies on Salahip of Dees from Calmina Publishes Energency Transeus III. Wang-cong, Cl.O (1965-es), 13MR Construction of Original Constructions of Treiderspheral with Different Electron Dones Wan Toxing and Wang-cong, Cl.O (1965-es), 13MR Construction of Treiderspheral with Different Electron Dones Wan Toxing and III. Wang-cong, Cl.O (1965-es), 13MR Construction of Treiderspheral with Different Electron Dones Wan Toxing and III. Wang-cong, Cl.O (1965-es), 13MR Construction of Treiderspheral with Different Electron Dones Wan Toxing and III. Wang-cong, Cl.O (1965-es), 13MR Construction of Treiderspheral with Different Electron Dones Wan Toxing and III. Wang-cong, 13MR Construction, 13MR Construction of Magnetic Quadrater Using the Confidence of Memoritan Properties MEMO Kase-cong, 14MR Construction, 13MR Construction of Memoritan Properties MEMO Kase-cong, 14MR Construction, 13MR Construction of Memoritan Properties MEMO Kase-cong, 14MR Construction, 13MR Construction of Memoritan Properties MIAN Vision, 13MR Construction, 13MR Construction of Memoritan Properties MIAN Vision, 13MR Construction of Memoritan Properties MIAN Vision, 13MR Construction, 13MR Construction of Memoritan Properties MIAN Vision, 13MR Construction, 13MR Construction of Memoritan Properties MIAN Vision, 13MR Construction, 13MR Construction of Memoritan Properties MIAN Vision, 13MR Construction, 13MR		
Latabytic Dozutine of Nindecenze in Water by Arifification-activated Red Mad Experimental Studies on Studied of these from Cadminn Pollution Engrapers, Frantmert LIU Wang-cong, 100, 1900, and, 240 Kershon, et al. (1790) Evaluation of Floc Strength Based on Mephological Analysis and Optical Online Menincing JIN Peng-kang, F.NK Yang-sing, WANG Bas-hos, et al. (1802) Menhane Fooling by Secondary Claimson Stal and Its Molespite on Method Tomper from Water ZHANG Cade, In IIU Xins-sin, 2114 Mag-sile, MA Yong-sere, et al. (1802) Menhane Fooling by Secondary Efflored of Urban Sewage and the Membrane Properties MENN Xins-song, ZHANG Enis-Jone, WANG Lie, et al. (1822) Teachment of Municipal Waterstater Using the Conditioned Reversed 4/O-JUBR Process LIANG, Tins-Jone, 2114 MC Linchen, WANG Lie, et al. (1822) Study on Solfier-Isseed Autorophic Destriction and in Different Electron Dances WAN Jing, 21140 Wei-li, WANG His, et al. (1835) Nitrogen Remoral and Vp. Danission Connecteristics Dance in Sector Simulatoneon Ninfication and Destriction of Solid-Plases Extraction for Enrichment of Toxic Organic Compounds in Water Samples — JIANG Xing-Jone, 11 Fing, W. Uh. Fina, et al. (1851) Hoghly Riche Made September Sector Simulatoneon Ninfication and Destriction of Solid-Plases Extraction for Enrichment of Toxic Organic Compounds in Water Samples — JIANG Xing-Jone, 11 Fing, W. Uh. Fina, et al. (1851) Hoghly Riche Made September Sector Simulatoneon Ninfication and Destriction of Solid-Plases Extraction for Enrichment of Toxic Organic Compounds in Water Samples — JIANG Xing-Jone, 11 Fina, W. Uh. Fina, et al. (1851) Hoghly Riche Made Sector Simulation of Solid-Plases Extraction for Enrichment of Toxic Organic Compounds in Water Samples — JIANG Xing-Jone, 21 Fina, W. Uh. Samples, et al. (1851) Hoghly Richeston Analysis of Solid-Plases Extraction of Suiface Compounds in Photocrathylic Oxidation of Anomatics Compounds in Photocrathylic Oxidation of Anomatics Compounds in Photocrathylic Oxidation of Solid Revent Section of Solid		
Experimental Studies on Stability of Ploes from Cardination Pollation for Exceptage Raced to Marchaged Analysis and Optical Olime Workshoring Jik Pong-kang Faxo Yeng-ming WAM Stab-obs. et al. (1872) Heckanism of Reductive Derblorination of Trichboropherod with Different Electron Donos WAN Jin-quan, HU Meng-die, MA Yong-wen, et al. (1885) Perpention of Magnetic Quantemy Chitosan Stal and Its Atherption of Meleph Orange from Water ZHAMO Cong In, HU Xin-min, 17NG Shiriya, et al. (1852) Treatment of Manicipal Wastewater Using the Combined Recented A*70-MBR Process MEMON Xino-ming, 2011 Gos-bong, YAMO Shading, et al. (1882) Study on Sulfish-Sead adutospiciph Envirations with Different Electron Boxons YLAM Ying, 2011 Wei-Fig WAM, This; et al. (1883) Niteogen Removal and Ny, O Ensisted Characteristics During the Shortout Simultaneous Nitrification and Denitrification Process YLAM Ying, 2011 Wei-Fig WAM, This; et al. (1883) Niteogen Removal and Ny, O Ensisted Characteristics During the Shortout Simultaneous Nitrification and Denitrification Process YLAM Ying, 2011 Wei-Fig WAM, This; et al. (1883) Niteogen Removal and Ny, O Ensisted Characteristics During the Shortout Simultaneous Nitrification and Denitrification Process YLAM Ying, 2011 Wei-Fig WAM, This; et al. (1883) Niteogen Removal and Ny, O Ensisted Characteristics of Open Shortout Shortout Characteristics of Open Shortout Characteristics of Specific Proteins in Eurobsom Eisenia feide CHEN Cham, UIU Xino-weir, ZHENG Shum-un, et al. (1887) Health Rick Assessment and Onnor Formation Potentials of Volatile Organic Compounds in Plotted Characteristics of Polyboursimonian Dipherpet Elberis in Second Women from Schama Province YLA Ying, WAM Che-ming, LIAO Quis-wen, YAMG Ta-min, et al. (1887) Destribution Characteristics of Heavy Metal Concentration of Surface Sul in Helvin Industrial Park in Industria	Catalytic Ozonation of Nitrobenzene in Water by Acidification-activated Red Mud	KANG Ya-ning, LI Hua-nan, XU Bing-bing, et al. (1790)
Realmand of Doc Strength Based on Morphological Analysis and Optical Olime Monitoring Mechanism of Relaterite Declanization of Tichichophoral study Bioferat Delateron Decours WAN Inc., Managerite, Waspersin, 24 (1882) Preparation of Magnetic Quaternary Chitosan Salt and Its Adsorption of Meelyl Orange from Water ZHANG Cong-lu, HU Xiao-min, YING Shi-ying, et al. (1882) Membrane Fouling by Secondary Effected of Urban Seages and the Membrane Properties MENG Xiao-mag., ZHANG India-den, WANG Li-j. et al. (1822) Tearnament of Managerial Wasterwater Using the Cambridge Reversed A'O-MBR Process MENG Xiao-mag., ZHANG India-den, WANG Li-j. et al. (1823) Study on Sulur-based Austrotypic Dentification with Different Electron Domos Without Study Study Study Study Study on Sulur-based Austrotypic Delaterity Study	Experimental Studies on Stability of Flocs from Cadmium Pollution Emergency Treatment	LIU Wang-rong, GUO Oing-wei, YANG Ren-bin, et al. (1797)
Mechanis of Relactive Deckloriation of Trieldrophered with Different Electron Donos		
Membrane Fouling by Scoodary Effluent of Urban Scaage and the Membrane Properties Teatment of Mannicipal Wasterated Using the Combined Reversed A ² /O-MBR Process THANG Jian-jum, ZOU Gao-Jong, YANG Shafang, et al. (1823) Study on Sulfire-based Austorquite Desiration with Different Electron Boxors Nitogen Remoral and Ny. O Emission Characteristics During the Shorton Simultaneous Nittification and Dentification Process "UANN Ying, ZHOU Wei-1, WANG Hin, et al. (1835) Optimization of Solid-Place Extraction for Enrichment of Tools organic Compounds in Waster Sumples "ZHANG Manu, II Pengeim, WI, Univary, et al. (1845) Polycyclic Musks Exposure Affects Gene Expression of Specific Proteins in Earthwom Essain, Feidd "CHEN Clum, UU Xiao-wei, ZHENG Shuw-an, et al. (1857) Health Risk Assessment and Otone Formation Obsertations of Voletic Organic Compounds from Pharmaceutical Industry in Zhejiang Province "XU Zhi-rong, WANG Zhe-ming, XU Ming-rhu, et al. (1884) Health Effect of Volatile Aldebryde Compounds in Photocachytic Oxidation of Anomatics Compounds XU Zhi-rong, WANG Zhe-ming, XU Ming-rhu, et al. (1887) Genty CSPR for Predicting the Toxicity of Insidualdoulum Indies Liquids Spatial and Temporal Characteristics of Polybronization of Surfaces Soil in Hebin Industrial Park in Shimishan Northwest China FAN Xin-pang, MI Wen-Ison, MA Zhen-raing, et al. (1887) Obstribation Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shimishan Northwest China FAN Xin-pang, MI Wen-Ison, MA Zhen-raing, et al. (1887) Obstribation Characteristics of Desiro Andrews China FAN Xin-pang, MI Wen-Ison, MA Zhen-raing, et al. (1887) Obstribation Characteristics of Desiro Andrews China FAN Xin-pang, MI Wen-Ison, MA Zhen-raing, et al. (1991) Obstribation Characteristics of Desiro Andrews China FAN Xin-pang, MI Wen-Ison, MA Zhen-raing, et al. (1992) Obstribation of Chemical Composition at Major Citics in Fujian Province ZHEN Chan, YANG Bing-ping, MI Wen-Ison, MA Zhen-raing, et al. (1993) Obstribatio		
Treatment of Municipal Wasteneart Lising the Combined Reversed A'O-MiRR Process Study on Sulfur-based Autotoophic Dentification with Different Electron Donos Study on Sulfur-based Autotoophic Dentification with Different Electron Donos Nitrification and Dentification Process ILANG Xine-Jing, LI Fing, WU Jin-ban, et al. (1885) Optimization of Solid-Phase Extraction for Enrichment of Toxic Organic Compounds in Water Sangles ZHANG Ming-quan, II Feng-min, WU Quarysun, et al. (1887) Optimization of Solid-Phase Extraction for Enrichment of Toxic Organic Compounds in Water Sangles ZHANG Ming-quan, II Feng-min, WU Quarysun, et al. (1887) Health Risk Assessment and Ozone Formation Potentials of Volatile Organic Compounds from Pharmaceutical Industry in Zb-jung Province Will Zharung, WANG Zhe-ming, XU Ming-dun, et al. (1884) Health Effect of Volatile Ablebyde Compounds in Photocatalytic Oxidation of Anomatics Compounds ZHAO Wei-roong, LIAO Qiu-wen, YANG Ya-man, et al. (1887) Compositions and Distribution Characteristics of Polyhominatal Diphespy Elhers in Secume of Women from Schuan Province SHAO Wei-roong, LIAO Qiu-wen, YANG Ya-man, et al. (1887) Compositions and Distribution Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shinaishan Northwest Claim CRANC/PRIS for Predecting the Toxicity of Indusbasium Intenticipals FAN Xin-gang, MI Wen-bao, MA Zhen-eing, et al. (1887) Distribution Characteristics and Current Situation of Soil Rare Earth Contamination in the Bayan Oko Mining Area and Bastoo Tailing Reservoir in Inner Mangalia CHO Wei, FUR Rui-jing, ZHAO Ren-sin, et al. (1895) Road Dast Lording and Chemical Composition at Major Cities in Fujian Province ZHENG An, YANG Bing-yin, W. WANG Ya-ping, et al. (1901) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Ya-Rui, Rui-Jin,	Preparation of Magnetic Quaternary Chitosan Salt and Its Adsorption of Methyl Orange from Water	ZHANG Cong-lu, HU Xiao-min, YING Shi-ying, et al. (1815)
Sudy on Saline-based Austrosphic Pentirification with Different Electron Donors TYLAN Ying, ZHOU Wei-li, WANG Hai, et al. (1855) Optimization of Solid-Phase Estraction for Enrichment of Toxic Organic Compounds in Water Samples ZHAG Ming-quan, LI Forga-min, WU Qian-yuan, et al. (1851) Polycycle Missle Exposure Affects Gene Expression of Specific Proteins in Earthworn Econic fetals Health Risk Assessment and Onore Formation Potentials of Volatile Organic Compounds from Pharmaceutical Industry in Zhejung Province XU Zhi-mag, WANG Zhe-ming, XU Ming-dua, et al. (1864) Health Eick Assessment and Conore Formation Potentials of Volatile Organic Compounds from Pharmaceutical Industry in Zhejung Province XU Zhi-mag, WANG Zhe-ming, XU Ming-dua, et al. (1864) Health Eick Assessment and Conore Formation Potentials of Volatile Organic Compounds ZHAO Wei-mong, LHAO Qiu-wen, YANG Ya-man, et al. (1871) Compositions and Obstribution Characteristics of Polyhominiated Diphenyl Elbers in Secund Women from Sichuan Province SHAO Min, CHEN Yong-beng, LI Maise-yu (1877) QSAR (QSR for Predeficing the Toxicity of Imulatoxian Industry of Industry of State State of Polyhominiated Diphenyl Elbers in Secund Women from Sichuan Province SHAO Min, CHEN Yong-beng, LI Maise-yu (1872) QSAR (QSR for Predeficing the Toxicity of Imulatoxian Industry of Industr	Membrane Fouling by Secondary Effluent of Urban Sewage and the Membrane Properties	MENG Xiao-rong, ZHANG Hai-zhen, WANG Lei, et al. (1822)
Nitogen Removal and N., O Emission Characteristics During the Shortest Smulthaneous Nirification and Denitrification Poecess	Treatment of Municipal Wastewater Using the Combined Reversed A ² /O-MBR Process	······· ZHANG Jian-jun, ZOU Gao-long, YANG Shu-fang, et al. (1828)
Optimization of Solid-Phase Extraction for Enrichment of Toxic Organic Compounds in Water Samples	Study on Sulfur-based Autotrophic Denitrification with Different Electron Donors	······ YUAN Ying ,ZHOU Wei-li , WANG Hui , et al. (1835)
Polycycle Masks Exposure and Ozone Formation Potentials of Volatile Ozganic Compounds Four Pharmaceutical Industry in Zhejiump Province XU Zhi-mong, WANG Zhe-ming, XU Ming-dhu, et al. (1857) Health Risk Assessment and Ozone Formation Potentials of Volatile Ozganic Compounds from Pharmaceutical Industry in Zhejiump Province XU Zhi-mong, WANG Zhe-ming, XU Ming-dhu, et al. (1864) Health Effect of Volatile Aldehyde Compounds in Photocatalytic Oxidation of Aromatics Compounds ZHAO Wei-mong, LIAO (lin-wen, YANG Ya-man, et al. (1871) Oxford Oxfor		
Health Risk Assessment and Ozone Formation Potentials of Volatile Organic Compounds from Pharmaceutical Industry in Zhejiang Province XU Zhi-rong, WANG Zhe-ming, XU Ming-zhu, et al. (1864) Health Effect of Volatile Aldelryde Compounds in Photocatalytic Oxidation of Aromatics Compounds ZHAO Wei-rong, LIAO Qiu-wen, YANG Ya-tun, et al. (1871) Compositions and Distribution Characteristics of Polybrominated Diphenyl Ethers in Serum of Women from Sichuan Province SHAO Min, CHER Yong-heng, II Xiao-yu (1877) SQSAR/QSPR for Predicting the Toxicity of Induanoium Ionic Liquids ZHAO II-hong, ZHAO Yong-sheng, ZHAOR Hong-abong, et al. (1882) Spatial and Temporal Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shizuishan Northwest China FAN Xin-gang, MI Wen-hon, MA Zhen-ning, et al. (1887) Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Obo Mining Area and Baoton Tailing Reservoir in Inner Mongolia CUO Wei, FU Rui-ying, ZHAO Ren-xin, et al. (1895) Road Dust Loading and Chemical Composition at Major Cities in Fujian Province MINES And You Yeng, And Chang-xin, WANG San-yen, et al. (1985) Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Sophean Grown in Rare Earth Mine Tailings CUO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jun, HUANG Flong-hui, qi Di Zhan-hui, et al. (1922) Isolation, Identification and Oxidizing Characterization of an Iron-Sulfur Oxidizing Bacterium IVOI from Acid Mine Drainage LIU Vu-jiao, YANG Xin-ping, WANG Shi-mei, et al. (1932) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jun, HUANG Flong-hui, et al. (1932) Isolation of an Effective Berzo [a] pyrene Degrading Strain and Boggadation Characteristics CAI Han, YIN Hua, YE, Jin-shao, et al. (1932) Arerobic		
XU Zhi-rong, WANG Zhe-ming, XU Ming-zhu, et al. (1864) Health Effect of Volatile Aldehyde Compounds in Photocatalytic Oxidation of Aromatics Compounds ZHAO Wei-rong, LIAO Qiu-wen, YANG Ya-nan, et al. (1871) Compositions and Distribution Characteristics of Polybrominated Diploenyl Ethers in Serum of Women from Sichuan Province ZHAO Ji-hong, ZHAO Yong-sheng, LI Xiao-yu (1877) QSAR/QSPR for Predicting the Toxicity of Imidazolium Ionic Liquids Spatial and Temporal Characteristics of Heavy Metal Concentration of Surface Sul in Hebin Industrial Park in Shiznishan Northwest China FAN Xin-gang, MI Wen-bao, MA Zhen-ring, et al. (1882) Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Obo Mining Area and Bostou Tailing Reservoir in Inner Mongolia Circl Wei, F. (Rui-ying, ZHAO Rem-xin, et al. (1895) Road Dast Loading and Chemical Composition at Major Cities in Fujian Province CIO Wei, F. (Rui-ying, ZHAO Rem-xin, et al. (1895) Road Dast Loading and Chemical Composition of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1901) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1908) Effects of Arbascular Mycoorrhizal Fugion of the Growth and Rare Earth Lements Update of Sophean Grown in Rare Earth Mine Tailang, NAI Chang-xin, WANG Yan-wen, et al. (1908) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABS Area, Southern China Effects of Arbascular Mycoorrhizal Fugion of the Growth and Rare Earth Lements Updated Temporation of the Contamental Polymery Lements of Sophean Cown in Rare Earth Mine Tailang Survey and Parket Mine Dainage LIU Vu-jiao, YANG Xin-jing, WANG Shi-mei, et al. (1932) Isolation, Identification and Oxidazing Chanacterisation of an Effective Renoal alpyrene Degrading Strain and Its Degradation Characteristics CAI Han, YIN Hua, YE Jin-abao, et al. (1932) Is		
Health Effect of Volatile Aldelyde Compounds in Photocatalytic Oxidation of Aromatics Compounds SHAO Min, CHEN Yong-beng, LI Xiao-yu (1877) Compositions and Distribution Characteristics of Polybrominated Diphemyl Ethers in Seram of Women from Sichuan Province SHAO Min, CHEN Yong-beng, LI Xiao-yu (1877) Compositions and Distribution Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shizuishan Northwest China FAN Xin-gang, MI Wen-bao, MA Zhen-ning, et al. (1882) Spatial and Temporal Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shizuishan Northwest China FAN Xin-gang, MI Wen-bao, MA Zhen-ning, et al. (1887) Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Oho Mining Area and Baotou Tailing Reservoir in Innere Mongolia GLO Wei, FU Rui-ying, ZHAO Ren-xin, et al. (1895) Road Dust Loading and Chemical Composition at Major Cities in Fujian Province ZHENG An, YANG Bing-yu, WU Shui-ping, et al. (1901) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1908) Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Sophean Grown in Rare Earth Mine Tailings GLO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jun, HUANG Hong-hui, QI Zhan-hui, et al. (1922) Isolation, Identification and Oxidizing Characterization of an Iron-Sulfur Oxidizing Bacterium LYOI from Acid Mine Drainage GLO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1993) Aerobic Microbial Degradation of 2, 2', 4, 4'-Tetrahrominated Diphenyl Ether ZHANG Shn, Franco Giulio, IJ Xiao-bao, et al. (1993) Aerobic Microbial Degradation of 2, 2', 4, 4'-Tetrahrominated Diphenyl Ether ZHANG Shn, Franco Giulio, IJ Xiao-bao, et al. (1993) Aerobic Microbial Degradation of Aerosol Prometal Algoric	Health Risk Assessment and Ozone Formation Potentials of Volatile Organic Compounds from Pharmaceutical Industry in Zhe	ejiang Province
Compositions and Distribution Characteristics of Polybrominated Diphenyl Ethers in Serum of Women from Sichuan Province ZHAO Jin-bong, ZHAO Gong-sheng, ZHANG Hong-thong, et al. (1882) Spatial and Temporal Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shizuishan Northwest Clina FAN Xin-gang, MI Won-bao, MA Zhen-ning, et al. (1887) Distribution Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shizuishan Northwest Clina FAN Xin-gang, MI Won-bao, MA Zhen-ning, et al. (1887) Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Obo Mining Area and Baotou Tailing Reservoir in Innere Mongolia GUO Wei, P. URui-ying, ZHAO Ren-xin, et al. (1895) Road Dast Loading and Chemical Composition at Major Cities in Fujian Province ZHENG An, YANG Bing-yu, WU Shui-ping, et al. (1901) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1908) Effects of Arbusecular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mine Tailings GUO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jun, HUANG Hong-hui, Qi Zhan-thui, et al. (1923) Isolation of an Effective Benzo[a] pyrene Degrading Strain and Its Degradation Characteristics CAI Han, YIN Hua, YE Jin-shao, et al. (1937) Aerobic Microbial Degradation of 2,2',4,4'-Tetrahominated Diphenyl Ether ZHANG Shu, France Giulio, Il Xino-bao, et al. (1945) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 CHEN Yuan-yuan, TIAN He-zhong, YANG Dong-yan, et al. (1958) Characteristics of Precipitation pH and Conductivity at Mt. Huang CHEN Yuan-yuan, TIAN Ha, Zhong, Ala Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autuum in Guangzhou CHE	TILDS CHILD III I COLL COLL COLL COLL	XU Zhi-rong, WANG Zhe-ming, XU Ming-zhu, et al. (1864)
QSMR/QSPR for Predicting the Toxicity of Imidazolium Ionic Liquids Spatial and Temporal Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shizaishan Northwest China RAN Xin-gang, MI Wern-bao, MA Zhen-ning, et al. (1887) Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Oho Mining Area and Baotou Tailing Reservoir in Inner Mongolia CUO Wei, IF Rui-ying, ZHAO Ren-xin, et al. (1895) Road Dust Loading and Chemical Composition at Major Cities in Fujian Province CUO Wei, PER Man, YANG Bing-yu, WU Shui-ping, et al. (1901) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1908) Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mine Tailings CUO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jun, HUANG Hong-hui, qt al. (1922) Isolation, Identification and Oxidizing Chanacterization of an Iron-Sulfur Oxidizing Bacterium IXOI from Acid Mine Drainage LIU Yu-jiao, YANG Xin-ping, WANG Shi-mei, et al. (1930) Isolation of an Effective Benzo[a] pyrene Degrading Strain and Its Degradation Characteristics CAI Han, YIN Hua, YE Jin-shao, et al. (1957) Piggery Wastewater Cultivating Bioflocculant-Producing Flora B-737 and the Fermentation Characteristics CAI Han, YIN Hua, YE Jin-shao, et al. (1951) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 Characteristics of Precipitation pf and Conductivity at M. Huang SHI Chune, DEXC Xus-leing, WU Bi-sew, et al. (1958) Characterization of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangehou TAN Ji-hua, ZHAO Jineping, DUAN Yus-en, et al. (1982) Characterization of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangeh		
Spatial and Temporal Characteristics of Heavy Metal Concentration of Surface Soil in Hebin Industrial Park in Shizuishan Northwest China FAN Xin-gang, MI Wen-bao, MA Zhen-ning, et al. (1887) Bistribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Obo Mining Area and Baoton Tailing Reservoir in Inner Mongolia CIO Wei, FU Rui-ying, ZHAO Ren-xin, et al. (1895) Road Dust Loading and Chemical Composition at Major Cities in Fujian Province ZHENG An, YANG Bing-yu, WU Shii-ying, et al. (1991) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1908) Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mine Tailings CIO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1993) Agicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jim, HUANG Hong-hui, of Zhan-hui, et al. (1922) Isolation of an Effective Berazo' a) pyrene Degrading Strain and Its Degradation Characteristics CAI Han, YIN Hua, Y E Jin-shao, et al. (1937) Aerobic Microbial Degradation of 2,2′, 4, 4′-Tetrabominated Diphenyl Ether ZHANG Shu, Franco Guilloi, II Xiao-bao, et al. (1945) Piggery Wastewater Cultivating Bioflocculant-Producing Flora B-73′ and the Fermentation Characteristics CHEN Yuan-yuan, TAN He-zhong, YANG Dong-yan, et al. (1988) Characteristics of Precipitation pH and Conductivity at Mt. Huang Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer WEB Bin, YIN Yan, QING Yan-shuo, et al. (1982) Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou TAN Ji-hua, ZHAO Jin-ghing, WU Bi-wen, et al. (1982) Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou TAN Ji-hua, ZHAO Jin-ghing, WU Bi-wen, et al.	OSAR/OSDR for Predicting the Tevicity of Invidencient Logic Liquids	THAO Is bong THAO Vong shong THANC Hong ghong et al. (1882)
Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Obo Mining Area and Baotou Tailing Reservoir in Inner Mongolia "GUO Wei, PU Rula-ying, ZHAO Ren-xin, et al. (1895) Road Dust Loading and Chemical Composition at Major Cities in Fujian Province "CUO Wei, PU Rula-ying, ZHAO Ren-xin, et al. (1901) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites "WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1908) Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mine Tailings "CUO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China "GUO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1922) Isolation, Identification and Oxidizing Ing Train and Its Degradation Characteristics "CAI Han, YIN Hau, Y Elin-shao, et al. (1937) Aerobic Microbial Degradation of 2, 2', 4, 4'-Tetrahrominated Diphenyl Ether "ZHANG Shu, Franco Giulio, I I Xiao-bao, et al. (1937) Aerobic Microbial Degradation of 2, 2', 4, 4'-Tetrahrominated Diphenyl Ether "ZHANG Shu, Franco Giulio, I I Xiao-bao, et al. (1951) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 CHEN Yuan-yuan, TIAN He-zhong, YANG Dong-yan, et al. (1958) Characteristics of Precipitation pH and Conductivity at Mt. Huang SHI Chun-e, DENG Xue-linag, WU Bi-wen, et al. (1964) Chemical Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou CHEN Yan-ling, CHEN Jin-sheng, HU Gong-ren, et al. (1982) Characteristics of Organic Acids in Atmospheric Particles Luring Haze Periods in Autumn in Guangzhou CHEN Yan-ling, CHEN Jin-sheng, HU Gong-ren, et al. (1982) Characteristics of Organic Acids in Atmospheric Particulates in Shanghai During		
Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Obo Mining Area and Baotou Tailing Reservoir in Inner Mongolia GUO Wei, FU Rui-ying, ZHAO Ren-xin, et al. (1895) Road Dust Loading and Chemical Composition at Major Cities in Fujian Province ZHENG An, YANG Bing-yu, Wil Shui-ping, et al. (1901) Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xin, WANG Yan-wen, et al. (1908) Elfects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mine Tailings GUO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jun, HUANG Hong-hui, Qi Zhan-hui, et al. (1922) Isolation, Identification and Oxidzing Characterization of an Iron-Sulfur Oxidizing Bacterium LYOI from Acid Mine Drainage LIU Yu-jiao, YANG Xin-ping, WANG Shi-mei, et al. (1937) Aerobic Microbial Degradation of 2, 2°, 4, 4°-Tetrabrominated Diphenyl Ether ZHANG Shu, Franco Giulio, I U Xiao-bao, et al. (1945) Figgery Wastewater Cultivating Bioflocculant-Producing Flora B-737 and the Fermentation Characteristics PEI Rui-lin, XIN Xin, ZHANG Xue-qiao, et al. (1954) Characteristics of Precipitation pH and Conductivity at Mt. Huang SHI Chun-c, DENG Xue-liang, Wu Bi-wen, et al. (1964) Characteristics of Precipitation pH and Conductivity at Mt. Huang SHI Chun-c, DENG Xue-liang, Wu Bi-wen, et al. (1964) Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangplou TAN Ji-hua, ZHAO Jing-ping, DUAN Jing-chun, et al. (1982) Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangplou TAN Ji-hua, ZHAO Jing-ping, DUAN Jing-chun, et al. (1982) Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangplou TAN Ji-hua, ZHAO Jing-ping, DUAN Jing-chun,	Spatial and Temporal chalacteristics of freaty inclar concentration of Surface confirm freshir industrial Faix in Surzaisman Fo	FAN Xin-gang, MI Wen-bao, MA Zhen-ning, et al. (1887)
Road Dust Loading and Chemical Composition at Major Cities in Fujian Province	Distribution Characteristic and Current Situation of Soil Rare Earth Contamination in the Bayan Obo Mining Area and Baotor	u Tailing Reservoir in Inner Mongolia
Numerical Simulation and Application of Electrical Resistivity Survey in Heavy Metal Contaminated Sites WANG Yu-ling, NAI Chang-xim, WANG Yan-wen, et al. (1908) Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mine Tailings GUO Wei, ZHAO Ren-xim, ZHAO Wen-jing, et al. (1915) Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jum, HUANG Hong-hui, QI Zhan-hui, et al. (1922) Isolation, Identification and Oxidizing Characterization of an Iron-Sulfur Oxidizing Bacterium LY01 from Acid Mine Drainage LIU Yu-jiao, YANG Xin-ping, WANG Shi-mei, et al. (1930) Isolation of an Effective Benzo [a] pyrene Degrading Strain and Its Degradation Characteristics — CAI Han, YIN Hua, YE Jin-shao, et al. (1931) Aerobic Microbial Degradation of 2, 2', 4, 4'-Tetrabrominated Diphenyl Ether — ZHANG Shu, Franco Giulio, LI Xiao-bao, et al. (1945) Piggery Wastewater Cultivating Bioflocculant-Producing Flora B-737 and the Fermentation Characteristics — PEI Rui-lin, XIN Xin, ZHANG Nuc-quao, et al. (1951) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 — CHEN Yuan-yuan, TIAN He-zhong, YANG Dong-yan, et al. (1958) Characteristics of Precipitation pH and Conductivity at Mt. Huang — SHI Chun-e, DENG Xue-liang, WU Bi-wen, et al. (1964) Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer — WEN Bin, YIN Yan, QING Yan-shuo, et al. (1973) Pollution Characteristics of Organic Carbon (OC) and Elemental Carbon (EC) in PM2, 5 During the Winter in Three Major Cities in Fujian Province, China — CHEN Yan-ling, CHEN Jin-sheng, HU Gong-ren, et al. (1982) Characteristics and Sources of Atmospheric Particulates in Shanghai, China — YUAN Ning, LIU Wei, ZHAO Xiu-liang, et al. (1995) Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Downtown of Pudong		GUO Wei, FU Rui-ying, ZHAO Ren-xin, et al. (1895)
Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mine Tailings — GUO Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) — Guo Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) — Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Menitoring Data in the Downtown of Pudong, Shanghai — GUO Ya-riago Ouyan, Edizor, and Sirian in Altumn at Suburban Xiamen, China — Guo Wei, ZHAO Ren-xin, ZHAO Wen-jing, et al. (1915) — Study on Quantification and Oxidizing Characterization of an Iron-Sulfur Oxidizing Bacterium LYOI from Acid Mine Drainage — LIU Yu-jiao, YANG Xin-ping, WANG Shi-mei, et al. (1930) Isolation of an Effective Benzo[a] pyrene Degrading Strain and Its Degradation Characteristics — CAI Han, YIN Hua, YE Jin-shao, et al. (1937) Aerobic Microbial Degradation of 2, 2', 4, 4'-Tetrabrominated Diphenyl Ether — ZHANG Shu, Franco Guildo, II Xiao-bao, et al. (1945) Piggery Wastewater Calibrating Bioloculant-Producing Flora B-737 and the Fermentation Characteristics — PEI Ruii-lin, XIN Xin, ZHANG Xue-qiao, et al. (1951) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 — CHEN Yuan-yuan, TIAN He-zhong, YANG Dong-yan, et al. (1958) Characteristics of Precipitation pH and Conductivity at Mt. Huang — SHI Chun-e, DENG Xue-liang, WU Bi-wen, et al. (1964) Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer — WEN Bin, YIN Yan, QING Yan-shuo, et al. (1973) Pollution Characteristics of Organic Carbon (OC) and Elemental Carbon (EC) in PM _{2,5} During the Winter in Three Major Cities in Fujian Province, China — CHEN Yan-ling, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmospheric Particulates by Using Air Quality Monitoring Data in the Downtown of Pudong, Shanghai — CHEN Yan-ling, CHEN Jin-sheng, HU Gong-ren, et al. (2003) Geochemical Characteristics and Sources of Atm		
Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jun, HUANG Hong-hui, QI Zhan-hui, et al. (1920) Isolation, Identification and Oxidizing Characterization of an Iron-Sulfur Oxidizing Bacterium LYO1 from Acid Mine Drainage		
Algicidal Activity Against Red-tide Algaes by Marine Bacterial Strain N3 Isolated from a HABs Area, Southern China SHI Rong-jum, HUANG Hong-hui, QI Zhan-hui, et al. (1922) Isolation, Identification and Oxidizing Characterization of an Iron-Sulfur Oxidizing Bacterium LYOI from Acid Mine Drainage LIU Yu-jiao, YANG Xin-ping, WANG Shi-mei, et al. (1930) Isolation of an Effective Benzo[a] pyrene Degrading Strain and Its Degradation Characteristics CAI Han, YIN Hua, YE Jin-shao, et al. (1943) Aerobic Microbial Degradation of 2, 2′, 4, 4′-Tetrabrominated Diphenyl Ether ZHANG Shu, Franco Giulio, LI Xiao-bao, et al. (1945) Piggery Wastewater Cultivating Bioflocculant-Producing Flora B-737 and the Fermentation Characteristics PEI Rui-lin, XIN Xin, ZHANG Xue-qiao, et al. (1951) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 CHEN Yuan-yuan, TIAN He-zhong, YANG Dong-yan, et al. (1958) Characteristics of Precipitation pH and Conductivity at Mt. Huang SHI Chun-e, DENG Xue-liang, WU Bi-wen, et al. (1964) Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer WEN Bin, XIN Yan, QING Yan-shuo, et al. (1973) Pollution Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou TAN Ji-hua, ZHAO Jing-ping, DUAN Jing-chun, et al. (1982) Characterization of Organic Carbon (OC) and Elemental Carbon (EC) in PM2, 5 During the Winter in Three Major Cities in Fujian Province, China CHEN Yan-ting, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China CHEN Yan-ting, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai During Dust in the Downtown of Pudong, Shanghai CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG	Effects of Arbuscular Mycorrhizal Fungi on the Growth and Rare Earth Elements Uptake of Soybean Grown in Rare Earth Mi	ine Tailings
Isolation, Identification and Oxidizing Characterization of an Iron-Sulfur Oxidizing Bacterium LY01 from Acid Mine Drainage		
Isolation of an Effective Benzo[a] pyrene Degrading Strain and Its Degradation Characteristics		9
Aerobic Microbial Degradation of 2,2',4,4'-Tetrabrominated Diphenyl Ether ZHANG Shu, Franco Giulio, LI Xiao-bao, et al. (1945) Piggery Wastewater Cultivating Bioflocculant-Producing Flora B-737 and the Fermentation Characteristics PEI Rui-lin, XIN Xin, ZHANG Xue-qiao, et al. (1951) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 CHEN Yuan-yuan, TIAN He-zhong, YANG Dong-yan, et al. (1958) Characteristics of Precipitation pH and Conductivity at Mt. Huang SHI Chun-e, DENG Xue-liang, WU Bi-wen, et al. (1964) Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer WEN Bin, YIN Yan, QING Yan-shuo, et al. (1973) Pollution Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou TAN Ji-hua, ZHAO Jing-ping, DUAN Jing-chun, et al. (1982) Characterization of Organic Carbon (OC) and Elemental Carbon (EC) in PM _{2,5} During the Winter in Three Major Cities in Fujian Province, China CHEN Yan-ting, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China YUAN Ning, LIU Wei, ZHAO Xiu-liang, et al. (1995) Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Downtown of Pudong, Shanghai CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHEKO Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2025) Sudy on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant UIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2034) Superposition Impact Character of Air P	,	1 0,
Piggery Wastewater Cultivating Bioflocculant-Producing Flora B-737 and the Fermentation Characteristics PEI Rui-lin, XIN Xin, ZHANG Xue-qiao, et al. (1951) Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011 CHEN Yuan-yuan, TIAN He-zhong, YANG Dong-yan, et al. (1958) Characteristics of Precipitation pH and Conductivity at Mt. Huang SHI Chun-e, DENG Xue-liang, WU Bi-wen, et al. (1964) Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer WEN Bin, YIN Yan, QING Yan-shuo, et al. (1973) Pollution Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou TAN Ji-hua, ZHAO Jing-ping, DUAN Jing-chun, et al. (1982) Characterization of Organic Carbon (OC) and Elemental Carbon (EC) in PM _{2.5} During the Winter in Three Major Cities in Fujian Province, China CHEN Yan-ting, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China YUAN Ning, LIU Wei, ZHAO Xiu-liang, et al. (1995) Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Downtown of Pudong, Shanghai CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China Li Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air		
Correlation Between Acidic Materials and Acid Deposition in Beijing During 1997-2011		
Characteristics of Precipitation pH and Conductivity at Mt. Huang SHI Chun-e, DENG Xue-liang, WU Bi-wen, et al. (1964) Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer WEN Bin, YIN Yan, QING Yan-shuo, et al. (1973) Pollution Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou TAN Ji-hua, ZHAO Jing-ping, DUAN Jing-chun, et al. (1982) Characterization of Organic Carbon (OC) and Elemental Carbon (EC) in PM2. 5 During the Winter in Three Major Cities in Fujian Province, China CHEN Yan-ting, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China Steed Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai China CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QLAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO2 Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal		
Chemical Characteristics of Water-Soluble Components of Aerosol Particles at Different Altitudes of the Mount Huang in the Summer		
Pollution Characteristics of Organic Acids in Atmospheric Particles During Haze Periods in Autumn in Guangzhou		
Characterization of Organic Carbon (OC) and Elemental Carbon (EC) in PM _{2.5} During the Winter in Three Major Cities in Fujian Province, China CHEN Yan-ting, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China YUAN Ning, LIU Wei, ZHAO Xiu-liang, et al. (1995) Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Downtown of Pudong, Shanghai CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal		
CHEN Yan-ting, CHEN Jin-sheng, HU Gong-ren, et al. (1988) Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China YUAN Ning, LIU Wei, ZHAO Xiu-liang, et al. (1995) Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Downtown of Pudong, Shanghai CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal		
Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China YUAN Ning, LIU Wei, ZHAO Xiu-liang, et al. (1995) Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Downtown of Pudong, Shanghai CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal	characterization of organic canoni (vo) and incinental canoni (10) in 1312.5 butting the winter in times study cates in	
Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Downtown of Pudong, Shanghai CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal	Size Distribution of Carbonaceous Particulate Matter in Atmosphere of Shanghai, China	···············YUAN Ning LIU Wei ZHAO Xiu-liang et al. (1995)
CUI Hu-xiong, WU Ya-ming, DUAN Yu-sen, et al. (2003) Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal	Secondary Aerosol Formation Through Photochemical Reactions Estimated by Using Air Quality Monitoring Data in the Down	ntown of Pudong, Shanghai
Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010) Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal	, , , , , , , , , , , , , , , , , , , ,	
Near Surface Atmospheric CO ₂ Variations in Autumn at Suburban Xiamen, China LI Yan-li, MU Chao, DENG Jun-jun, et al. (2018) In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025) Airborne Fungal Community Composition in Indoor Environments in Beijing FANG Zhi-guo, OUYANG Zhi-yun, LIU Peng, et al. (2031) Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant GUO Wei, WANG Bo-guang, TANG Xiao-dong, et al. (2038) Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal	Geochemical Characteristics and Sources of Atmospheric Particulates in Shanghai During Dust Storm Event	······ QIAN Peng, ZHENG Xiang-min, ZHOU Li-min (2010)
In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method		
Study on Quantification Assessment and Odor Fingerprint of Volatile Aromatic Hydrocarbons from Sewage Treatment Plant	In-situ Measurement of Background Atmospheric HCFC-142b Using GC-MS and GC-ECD Method	GUO Li-feng, YAO Bo, ZHOU Ling-xi, et al. (2025)
Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044) Thermal Stability and Transformation Behaviors of Pb in Yima Coal LIU Rui-qing, WANG Jun-wei (2051)		
Thermal Stability and Transformation Behaviors of Pb in Yima Coal		
	Superposition Impact Character of Air Pollution from Decentralization Docks in a Freshwater Port	LIU Jian-chang, LI Xing-hua, XU Hong-lei, et al. (2044)
Synergistic Emission Reduction of Chief Air Pollutants and Greenhouse Gases Based on Scenario Simulations of Energy Consumptions in Beijing		
	Synergistic Emission Reduction of Chief Air Pollutants and Greenhouse Gases Based on Scenario Simulations of Energy Cons	sumptions in Beijing XIE Yuan-bo, LI Wei (2057)

《环境科学》第6届编辑委员会

主 编:欧阳自远

副主编:赵景柱 郝吉明 田 刚

编 委: (按姓氏笔画排序)

万国江 王华聪 王凯军 王绪绪 田 刚 田 静 史培军

朱永官 刘志培 汤鸿霄 陈吉宁 孟 伟 周宗灿 林金明

欧阳自远 赵景柱 姜 林 郝郑平 郝吉明 聂永丰 黄 霞

黄耀 鲍强潘纲潘涛魏复盛

环维种草

(HUANJING KEXUE)

(月刊 1976年8月创刊) 2013年5月15日 34卷 第5期

ENVIRONMENTAL SCIENCE

(Monthly Started in 1976)

Vol. 34 No. 5 May 15, 2013

主	管	中国科学院	Superintended	by	Chinese Academy of Sciences
	办		Sponsored	by	Research Center for Eco-Environmental Sciences, Chinese
主	• • •	中国科学院生态环境研究中心	Sponsoreu	Бу	· · · · · · · · · · · · · · · · · · ·
协	办	(以参加先后为序)			Academy of Sciences
		北京市环境保护科学研究院	Co-Sponsored	by	Beijing Municipal Research Institute of Environmental
		清 华 大 学 环 境 学 院			Protection
主	编	欧阳自远			School of Environment, Tsinghua University
编	辑	《环境科学》编辑委员会	Editor-in -Chief		OUYANG Zi-yuan
>m)	7-7	北京市 2871 信箱(海淀区双清路	Edited	by	The Editorial Board of Environmental Science (HUANJING
		18号,邮政编码:100085)			KEXUE)
					P. O. Box 2871, Beijing 100085, China
		电话:010-62941102,010-62849343			Tel: 010-62941102, 010-62849343; Fax: 010-62849343
		传真:010-62849343			E-mail:hjkx@rcees.ac.cn
		E-mail; hjkx@ rcees. ac. cn			http://www. hjkx. ac. en
		http://www. hjkx. ac. cn	Published	bv	Science Press
出	版	斜学出版社	1 dolished	Dy	16 Donghuangchenggen North Street,
		北京东黄城根北街 16 号			,
		邮政编码:100717	D 1 4 1	,	Beijing 100717, China
印刷装	も订	北京北林印刷厂	Printed	by	Beijing Bei Lin Printing House
发	行	斜学出版社	Distributed	by	Science Press
		电话:010-64017032			Tel:010-64017032
		E-mail:journal@mail.sciencep.com			E-mail: journal@ mail. sciencep. com
订 购	处	全国各地邮电局	Domestic		All Local Post Offices in China
国外总统	发行	中国国际图书贸易总公司	Foreign		China International Book Trading Corporation (Guoji
		(北京 399 信箱)	-		Shudian), P. O. Box 399, Beijing 100044, China

中国标准刊号: ISSN 0250-3301 CN 11-1895/X

国内邮发代号: 2-821

国内定价:90.00元

国外发行代号: M 205

国内外公开发行