

高通量便携式荧光检测装置的研制与应用

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高通量便携式荧光检测装置的研制与应用

Development and Application of High-throughput and Portable
Fluorescence Device

刘佳佳

刘佳佳

指导教师姓名: 郭祥群 教授

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指导教师

郭祥群
教授

答辩委员会主席: _____

评 阅 人: _____

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By

LIU JIA-JIA

Supervisor: Prof. GUO XIANGQUN

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目 录

摘 要	I
Abstract	III
第一章 前 言	1
1.1 高通量的定义	1
1.2 高通量的载体	1
1.2.1 mm 级载体	1
1.2.1.1 微孔板.....	1
1.2.1.2 其他载体.....	2
1.2.2 μm 级载体	3
1.2.2.1 生物芯片.....	3
1.2.2.2 毛细管阵列.....	4
1.2.2.3 阵列微流控芯片.....	5
1.3 高通量的应用及意义	6
1.3.1 药物筛选.....	6
1.3.2 医疗诊断.....	6
1.3.3 高通量测序.....	7
1.3.4 生物作用研究.....	7
1.3.5 生态学.....	8
1.3.6 实际质检需要.....	8
1.4 高通量的检测方法	9
1.4.1 光学检测方法.....	9
1.4.1.1 荧光检测.....	9
1.4.1.2 紫外-可见吸收光谱检测	9
1.4.1.3 化学发光检测.....	9
1.4.2 电化学检测方法.....	10
1.5 高通量荧光检测系统进展	10
1.5.1 光路结构.....	10

1.5.2 单通道或多通道激发和检测.....	12
1.5.2.1 单通道激发和检测.....	12
1.5.2.2 多通道激发和检测.....	13
1.5.2.2.1 多通道检测.....	13
1.5.2.2.2 多通道激发.....	13
1.6 本论文设想	22
第二章 高通量便携式荧光检测装置的研制	24
2.1 引言	24
2.2 实验部分	24
2.2.1 仪器和试剂.....	24
2.2.2 高通量便携式荧光检测装置的设计.....	24
2.2.2.1 设计原则.....	24
2.2.2.2 激发光源的选择.....	25
2.2.2.2.1 氙灯.....	25
2.2.2.2.2 大功率发光二极管.....	26
2.2.2.2.3 激光器.....	27
2.2.2.2.4 激光二极管.....	28
2.2.2.2.5 激光模组.....	29
2.2.2.3 检测器的选择.....	30
2.2.2.3.1 光电倍增管.....	30
2.2.2.3.2 雪崩二极管.....	31
2.2.2.3.3 CCD 数码相机	32
2.2.2.4 光路结构的选择.....	35
2.2.3 基于一字线激光模组的荧光检测装置的设计与构建.....	35
2.2.3.1 激发光源.....	36
2.2.3.2 滤光片.....	37
2.2.3.3 CCD 数码相机	37
2.2.3.4 图像处理软件.....	37
2.2.3.5 排状微孔样品板.....	38
2.2.3.6 暗箱的建造.....	39
2.2.4 装置性能测试.....	40

2.3 结果与讨论	40
2.3.1 装置的特点.....	40
2.3.2 激光波长及滤光片的选择.....	41
2.3.3 装置性能评价.....	43
2.3.3.1 光源强度分布及光源校正.....	43
2.3.3.2 线性响应范围、检测限与重现性.....	47
2.4 小结	47
第三章 高通量便携式荧光检测装置在快速检测水溶液中 Hg²⁺的应	
用.....	48
3.1 引言	48
3.2 实验部分	49
3.2.1 仪器与试剂.....	49
3.2.1.1 主要仪器.....	49
3.2.1.2 主要试剂.....	49
3.2.2 实验方法.....	49
3.2.2.1 胶体金的制备.....	49
3.2.2.2 Hg ²⁺ 对 TSA@Au 光谱性质的影响.....	49
3.2.2.2.1 TSA@Au 吸收光谱对 Hg ²⁺ 浓度的响应.....	49
3.2.2.2.2 TSA@Au 散射光谱对 Hg ²⁺ 浓度的响应.....	50
3.2.2.3 条件优化.....	50
3.2.2.3.1 RB : TSA@Au 最优浓度比例	50
3.2.2.3.2 最优 pH.....	50
3.2.2.4 水溶液中 Hg ²⁺ 浓度的检测.....	50
3.2.2.5 自来水和湖水样品中 Hg ²⁺ 浓度的加标回收实验.....	50
3.3 结果与讨论	51
3.3.1 TSA@Au 的光谱特性.....	51
3.3.2 TSA@Au 的电镜表征.....	51
3.3.3 Hg ²⁺ 对 TSA@Au 光谱性质的影响.....	52
3.3.4 静电自组装 RB-TSA@Au 的 FRET 体系.....	54
3.3.5 基于 RB 与 TSA@Au 荧光共振能量转移的 Hg ²⁺ 检测	55

3.3.6 体系条件优化.....	56
3.3.6.1 RB : TSA@Au 最优浓度比例	56
3.3.6.2 最优 pH.....	57
3.3.7 水溶液中 Hg ²⁺ 浓度的检测.....	59
3.3.7.1 装置检测结果.....	59
3.3.7.2 荧光仪检测结果对照.....	60
3.3.8 体系的离子选择性.....	61
3.3.9 自来水和湖水样品中 Hg ²⁺ 浓度的加标回收实验.....	62
3.4 小结	62
第四章 结论与展望	63
论文创新点	65
参考文献.....	66
攻读硕士学位期间发表的论文	76
致 谢.....	77

Content

Abstract in Chinese	I
Abstract in English	III
Chapter 1. Preface	1
1.1 Definition of high-throughput	1
1.2 Carrier of high-throughput	1
1.2.1 mm level carrier	1
1.2.1.1 Microplate	1
1.2.1.2 Other carrier	2
1.2.2 μm level carrier	3
1.2.2.1 Biochip	3
1.2.2.2 Array capillary	4
1.2.2.3 Microfluidic array	5
1.3 Applications of high-throughput	6
1.3.1 Pharmaceutical screening.....	6
1.3.2 Medical diagnosis	6
1.3.3 High-throughput sequencing.....	7
1.3.4 Study on biological action.....	7
1.3.5 Bionomics	8
1.3.6 Actual aquality testing.....	8
1.4 Detection techniques of high-throughput	9
1.4.1 Optics	9
1.4.1.1 Fluorescence	9
1.4.1.2 Ultraviolet-visible Spectrometry.....	9
1.4.1.3 Chemiluminescence	9
1.4.2 Electrochemistry	10
1.5 Progress in high-throughput fluorescence devices	10

1.5.1 Optics structures.....	10
1.5.2 Single-channel or multi-channel excitation and detection.....	12
1.5.2.1 Single-channel excitation and detection	12
1.5.2.2 Multi-channel excitation and detection.....	13
1.5.2.2.1 Multi-channel detection	13
1.5.2.2.2 Multi-channel excitation	13
1.6 Conceive of this dissertation	22
 Chapter 2. Development of High-throughput and Portable	
Fluorescence Device.	
2.1 Introduction.....	24
2.2 Experimentation.....	24
2.2.1 Apparatus and reagents	24
2.2.2 Design of high-throughput and portable fluorescence device	24
2.2.2.1 The principle of design	24
2.2.2.2 The selection of light source	25
2.2.2.2.1 Xenon lamp	25
2.2.2.2.2 High-power light emitted diode	26
2.2.2.2.3 Laser.....	27
2.2.2.2.4 Laser diode.....	28
2.2.2.2.5 Laser pointer	29
2.2.2.3 The selection of detector	30
2.2.2.3.1 Photomultiplier	30
2.2.2.3.2 Avalanche photo diode.....	31
2.2.2.3.3 CCD digital camera.....	32
2.2.2.4 The selection of optical structure	35
2.2.3 Development of the fluorescence device based on a line laser pointer	35
2.2.3.1 Light source	36
2.2.3.2 Filter.....	37
2.2.3.3 CCD digital camera.....	37
2.2.3.4 Chem-Image-Processor.....	37
2.2.3.5 Detachable microplate	38

2.2.3.6 Black box	39
2.2.4 Performance of the device.....	40
2.3 Results and discussion	40
2.3.1 Characteristics of the device	40
2.3.2 The selection of excitation wavelength and light-filter.....	41
2.3.3 Performance of the device.....	43
2.3.3.1 Distribution of light intensity and light correction	43
2.3.3.2 Linear range, limit of detection and repeatability	47
2.4 Conclusion.....	47
 Chapter 3. Application of High-throughput and Portable	
Fluorescence Device in quick detection of Hg²⁺ in aqueous solution .48	
3.1 Introduction.....	48
3.2 Experimentation.....	49
3.2.1 Apparatus and Apparatus	49
3.2.1.1 Main Apparatus	49
3.2.1.2 Main Apparatus	49
3.2.2 Experimental methods	49
3.2.2.1 Synthesis of TSA@Au	49
3.2.2.2 Effects of Hg ²⁺ on the optical characteristics of TSA@Au	49
3.2.2.2.1 Absorption spectrum of TSA@Au in the presence of Hg ²⁺ at various concentrations	49
3.2.2.2.2 Resonance Light Scattering spectrum of TSA@Au in the presence of Hg ²⁺ at various concentrations.....	50
3.2.2.3 Condition optimization	50
3.2.2.3.1 Optimal concentration ratio of RB : TSA@Au.....	50
3.2.2.3.2 Optimal pH.....	50
3.2.2.4 Detection of Hg ²⁺ in aqueous solution.....	50
3.2.2.5 Recovery of standard addition of Hg ²⁺ in tap water and pond water samples.....	50
3.3 Results and discussion	51
3.3.1 Optical characteristics of of TSA@Au	51
3.3.2 TEM images of TSA@Au	51

3.3.3 Effects of Hg ²⁺ on the optical characteristics of TSA@Au	52
3.3.4 FRET electrostatic assembly of RB and TSA@Au	54
3.3.5 Hg ²⁺ detection based on FRET between RB and TSA@Au	55
3.3.6 Condition optimization	56
3.3.6.1 Optimal concentration ratio of RB : TSA@Au	56
3.3.6.2 Optimal pH.....	57
3.3.7 Detection of Hg ²⁺ in aqueous solution.....	59
3.3.7.1 Result by the as-constructed device.....	59
3.3.7.2 Comparison of this method with the fluorospectrophotometer	60
3.3.8 Ion Selectivity	61
3.3.9 Recovery of standard addition of Hg ²⁺ in tap water and pond water samples	62
3.4 Conclusion	62
Chapter 4. Conclusions and Perspectives.....	63
Innovations of the dissertation researches	65
References	66
Published articles	76
Acknowledgements	77

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摘要

多通道高通量荧光检测系统因能将批量分析速度提高数倍至数十倍,在药物筛选、医疗诊断、高通量测序、生物作用研究、生态学、实际质检等领域具有重要的实践意义。近年来,具有多通道特点的高通量荧光检测装置的研究取得了重要进展,但是这些装置并没有同时实现小巧轻便、结构简单、灵敏度高、成本低廉、并适用于不同波长物质的检测。因此,本论文设计并构建了一种基于一字线激光模组的高通量便携式荧光检测装置,介绍了该装置的设计、结构、性能以及实用检测效果。论文共分为四章,包括前言、高通量便携式荧光检测装置的研制、高通量便携式荧光检测装置在快速检测水溶液中 Hg^{2+} 中的应用及结论与展望。

第一章,前言,通过文献调研,对高通量检测的应用及意义进行了归纳和总结;介绍了近年来高通量检测的分析方法;综述了高通量荧光检测装置的研究现状,并在此基础上提出了论文的研究思路。

第二章,高通量便携式荧光检测装置的研制。本章设计并构建了一种基于一字线激光模组的高通量便携式荧光检测装置,通过选用小型化而灵敏的光源、检测器和光路结构,同时实现装置的小巧轻便、结构简单、灵敏度高、成本低廉、并适用于不同波长物质的多通道检测。结合自行研制的图像处理软件,对 96 孔微孔板样品的检测与数据处理可在 10 min 内完成,实现了溶液的高通量定量检测。检测罗丹明 B 的灵敏度为 $2.80 \pm 0.15 \text{ nmol/L}$ 。

第三章,高通量便携式荧光检测装置在快速检测水溶液中 Hg^{2+} 的应用。基于罗丹明 B 与纳米金荧光共振能量转移 (FRET) 的 Hg^{2+} 检测方法,应用本装置检测水溶液中 Hg^{2+} 浓度,检测限为 7.72 ppb;检测自来水样品中 Hg^{2+} 的加标回收率为 99.9 ~ 102.4 %, RSD 为 1.54 ~ 2.57 %;检测湖水样品中 Hg^{2+} 的加标回收率为 96.2 ~ 98.9 %, RSD 为 1.60 ~ 2.45 %。本装置有望用于大批量样品的现场快速检测。荧光仪检测该体系的检测限比本装置低 1 个数量级,但本装置检测具有简单、快速、费用低等特点。

第四章,对研究工作做出总结,指出其不足之处,并对该课题的研究前景进行了展望。

关键词：高通量；便携式；荧光检测装置；一字线激光模组

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Abstract

Multi-channel and high-throughput fluorescence measuring systems provide a great advantage in speeding up the batch analysis from several-fold to hundred-fold, and would be practically significant in application areas such as pharmaceutical screening, medical diagnosis, high-throughput sequencing, study on biological action, bionomics, actual aquality testing, etc. Recently, the research on the multi-channel and high-throughput fluorescence devices has made great progress. However, they haven't realize portability, simpleness, high-sensitivity, low-cost and application in the detection of matters with different excitation wavelength simultaneously. Herein we report the design and fabrication of a novel high-throughput and portable fluorescence device using a line laser pointer as the light source. The principle, structure, performance and application of the as-constructed device is introduced.

This thesis consists of four chapters.

Chapter 1, Introduction. A brief introduction of the application and significance of high-throughput detection were given. A basic principle of high-throughput detection methodology were introduced. A review discussing the present stage of single-channel and multi-channel high-throughput fluorescence devices was outlined. Based on the update development in these areas, the research plan for the thesis was put forward.

Chapter 2, Development of High-throughput and Portable Fluorescence Device. The design and fabrication of a novel high-throughput and portable fluorescence device using a line laser pointer as the light source was reported. The as-constructed device realizes portability, simpleness, high-sensitivity, low-cost and application in the detection of matters with different excitation wavelength simultaneously by choosing small and sensitive optical assembly and structure. It takes less than 10 min to collect and process data for a 96 microplate-batch analysis of solution samples, by combining use of lab-made software, Chem-Image-Processor (CIP). Its sensitivity

was evaluated with rhodamine B (RB) and the limit of detection (LOD) was 2.80 ± 0.15 nmol/L.

Chapter 3, Application of High-throughput and Portable Fluorescence Device in quick detection of Hg^{2+} in aqueous solution. The new system has been further validated by the detection of Hg^{2+} in aqueous solution based on the modulation effect of Hg^{2+} on the FRET efficiency between RB and TSA@Au, and a LOD of 7.72 ppb was obtained. The standard addition recovery of Hg^{2+} in tap water samples was 99.9 ~ 102.4 % and the RSD was 1.54 ~ 2.57 %. The standard addition recovery of Hg^{2+} in pond water samples was 96.2 ~ 98.9 % and the RSD was 1.60 ~ 2.45 %. It has shown great promise in volume-detection on the spot. The LOD obtained by the as-constructed device was an order of magnitude higher than that obtained by the fluorospectrophotometer, but the detection with the device was simple, quick and low-cost.

Chapter 4, Conclusions and Perspectives. The research work was summarized and the prospect of the research field was given.

Key words: High-throughput; Portable; Fluorescence device; Line laser pointer

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