

IES

JOURNAL OF
ENVIRONMENTAL
SCIENCES

May 1, 2015 Volume 31
www.jesc.ac.cn

ISSN 1001-0742
CN 11-2629/X

Real-world diesel vehicle emission factors for China



Sponsored by
Research Center for Eco-Environmental Sciences
Chinese Academy of Sciences

Highlight articles

- 203 Mobility of toxic metals in sediments: Assessing methods and controlling factors
Yanbin Li and Yong Cai
- 206 Genotoxic effects of microcystins mediated by nitric oxide and mitochondria
Qingqing Liu and X. Chris Le

Review articles

- 61 Remediation effect of compost on soluble mercury transfer in a crop of *Phaseolus vulgaris*
Nora E. Restrepo-Sánchez, Liliana Acevedo-Betancourth, Beatriz Henao-Murillo and Carlos Peláez-Jaramillo
- 81 Phosphate removal from domestic wastewater using thermally modified steel slag
Jian Yu, Wenyan Liang, Li Wang, Feizhen Li, Yuanlong Zou and Haidong Wang
- 104 New generation Amberlite XAD resin for the removal of metal ions: A review
Akil Ahmad, Jamal Akhter Siddique, Mohammad Asaduddin Laskar, Rajeev Kumar, Siti Hamidah Mohd-Setapar, Asma Khatoon and Rayees Ahmad Shiekh

Regular articles

- 1 Mobility and sulfidization of heavy metals in sediments of a shallow eutrophic lake, Lake Taihu, China
Shouliang Huo, Jingtian Zhang, Kevin M. Yeager, Beidou Xi, Yanwen Qin, Zhuoshi He and Fengchang Wu
- 12 Predicting the aquatic risk of realistic pesticide mixtures to species assemblages in Portuguese river basins
Emília Silva, Michiel A. Daam and Maria José Cerejeira
- 21 Treatment and resource recovery from inorganic fluoride-containing waste produced by the pesticide industry
Yang Li, Hua Zhang, Zhiqi Zhang, Liming Shao and Pinjing He
- 30 Effects of water regime, crop residues, and application rates on control of *Fusarium oxysporum* f. sp. *cubense*
Teng Wen, Xinqi Huang, Jinbo Zhang, Tongbin Zhu, Lei Meng and Zucong Cai
- 38 *Microcystis aeruginosa*/*Pseudomonas pseudoalcaligenes* interaction effects on off-flavors in algae/bacteria co-culture system under different temperatures
Xi Yang, Ping Xie, Yunzhen Yu, Hong Shen, Xuwei Deng, Zhimei Ma, Peili Wang, Min Tao and Yuan Niu
- 44 Greenhouse gas emission and its potential mitigation process from the waste sector in a large-scale exhibition
Ziyang Lou, Bernd Bilitewski, Nanwen Zhu, Xiaoli Chai, Bing Li, Youcai Zhao and Peter Otieno
- 51 Role of secondary aerosols in haze formation in summer in the Megacity Beijing
Tingting Han, Xingang Liu, Yuanhang Zhang, Yu Qu, Limin Zeng, Min Hu and Tong Zhu
- 68 Enhanced U(VI) bioreduction by alginate-immobilized uranium-reducing bacteria in the presence of carbon nanotubes and anthraquinone-2,6-disulfonate
Weida Wang, Yali Feng, Xinhua Tang, Haoran Li, Zhuwei Du, Aifei Yi and Xu Zhang
- 74 NH₃-SCR denitration catalyst performance over vanadium-titanium with the addition of Ce and Sb
Chi Xu, Jian Liu, Zhen Zhao, Fei Yu, Kai Cheng, Yuechang Wei, Aijun Duan and Guiyuan Jiang

CONTENTS

- 89 Acid-catalyzed heterogeneous reaction of 3-methyl-2-buten-1-ol with hydrogen peroxide
Qifan Liu, Weigang Wang and Maofa Ge
- 98 IKK inhibition prevents PM_{2.5}-exacerbated cardiac injury in mice with type 2 diabetes
Jinzhuo Zhao, Cuiqing Liu, Yuntao Bai, Tse-yao Wang, Haidong Kan and Qinghua Sun
- 124 Effects of aeration method and aeration rate on greenhouse gas emissions during composting of pig feces in pilot scale
Tao Jiang, Guoxue Li, Qiong Tang, Xuguang Ma, Gang Wang and Frank Schuchardt
- 133 Two-year measurements of surface ozone at Dangxiong, a remote highland site in the Tibetan Plateau
Weili Lin, Xiaobin Xu, Xiangdong Zheng, Jaxi Dawa, Ciren Baima and Jin Ma
- 146 Synergistic effects of particulate matter (PM₁₀) and SO₂ on human non-small cell lung cancer A549 *via* ROS-mediated NF- κ B activation
Yang Yun, Rui Gao, Huifeng Yue, Guangke Li, Na Zhu and Nan Sang
- 154 Adsorption and biodegradation of three selected endocrine disrupting chemicals in river-based artificial groundwater recharge with reclaimed municipal wastewater
Weifang Ma, Chao Nie, Bin Chen, Xiang Cheng, Xiaoxiu Lun and Fangang Zeng
- 164 Co-adsorption of gaseous benzene, toluene, ethylbenzene, m-xylene (BTEX) and SO₂ on recyclable Fe₃O₄ nanoparticles at 0-101% relative humidities
Connie Z. Ye and Parisa A. Ariya
- 175 Weak magnetic field accelerates chromate removal by zero-valent iron
Pian Feng, Xiaohong Guan, Yuankui Sun, Wonyong Choi, Hejie Qin, Jianmin Wang, Junlian Qiao and Lina Li
- 184 Trace metal concentrations in hairs of three bat species from an urbanized area in Germany
Lucie Flache, Sezin Czarnecki, Rolf-Alexander Düring, Uwe Kierdorf and Jorge A. Encarnação
- 194 Preparation and characterization of Pd/Fe bimetallic nanoparticles immobilized on Al₂O₃/PVDF membrane: Parameter optimization and dechlorination of dichloroacetic acid
Lijuan Zhang, Zhaohong Meng and Shuying Zang
- 209 Development of database of real-world diesel vehicle emission factors for China
Xianbao Shen, Zhiliang Yao, Qiang Zhang, David Vance Wagner, Hong Huo, Yingzhi Zhang, Bo Zheng and Kebin He
- 221 Anoxic degradation of nitrogenous heterocyclic compounds by activated sludge and their active sites
Peng Xu, Hongjun Han, Haifeng Zhuang, Baolin Hou, Shengyong Jia, Dexin Wang, Kun Li and Qian Zhao
- 226 Adsorption of three pharmaceuticals on two magnetic ion-exchange resins
Miao Jiang, Weiben Yang, Ziwei Zhang, Zhen Yang and Yuping Wang
- 235 Rapid and simple spectrophotometric determination of persulfate in water by microwave assisted decolorization of Methylene Blue
Lajuan Zhao, Shiyang Yang, Leilei Wang, Chao Shi, Meiqing Huo and Yan Li
- 240 Effect of water vapor on NH₃-NO/NO₂ SCR performance of fresh and aged MnO_x-NbO_x-CeO₂ catalysts
Lei Chen, Zhichun Si, Xiaodong Wu, Duan Weng and Zhenwei Wu

Available online at www.sciencedirect.com

ScienceDirect

www.journals.elsevier.com/journal-of-environmental-sciences

Rapid and simple spectrophotometric determination of persulfate in water by microwave assisted decolorization of Methylene Blue

Lajuan Zhao^{1,2}, Shiyang Yang^{1,2,*}, Leilei Wang³, Chao Shi², Meiqing Huo², Yan Li²

1. Key Laboratory of Marine Environment and Ecology, Ministry of Education, Qingdao 266100, China. E-mail: movinglj@sina.com

2. College of Environmental Science and Engineering, Ocean University of China, Qingdao 266100, China

3. Qingdao Shuiqingmuhua Environmental Engineering Co., Ltd., Qingdao 266100, China

ARTICLE INFO

Article history:

Received 21 July 2014

Revised 10 September 2014

Accepted 12 September 2014

Available online 20 February 2015

Keywords:

Decolorization

Methylene Blue

Microwave activation

Persulfate

Spectrophotometric determination

ABSTRACT

A rapid and simple method for determination of persulfate in aqueous solution was developed. The method is based on the rapid reaction of persulfate with Methylene Blue (MB) via domestic microwave activation, which can promote the activation of persulfate and decolorize MB quickly. The depletion of MB at 644 nm (the maximum absorption wavelength of MB) is in proportion to the increasing concentration of persulfate in aqueous solution. Linear calibration curve was obtained in the range 0–1.5 mmol/L, with a limit of detection of 0.0028 mmol/L. The reaction time is rapid (within 60 sec), which is much shorter than that used for conventional methods. Compared with existing analytical methods, it need not any additives, especially colorful Fe^{2+} , and need not any pretreatment for samples, such as pH adjustment.

© 2015 The Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences.

Published by Elsevier B.V.

Introduction

In recent years, persulfate has been attracted increasing attention as a stable and powerful oxidant. Persulfate is always applied for degradation of organic contaminants in ground-water and wastewater (Fang and Shang, 2012; Yuan et al., 2013; Ji et al., 2014). Though persulfate has a redox potential of $E^0 = 2.01 \text{ V}$ (Amin, 1981), activation is necessary for application because of its low reactivity (Yang et al., 2009). A more powerful sulfate radical ($\text{SO}_4^{\cdot-}$) with $E^0 = 2.6 \text{ V}$ can be produced by activation via thermal method (Huang et al., 2002), UV (Hori et al., 2005), metal ions (especially Fe^{2+}) (Liang et al., 2004) and activated carbon (Zhang et al., 2013). Microwave (MW) (Yang et al., 2009) is also an attractive thermal method to activate

persulfate. Yang et al. (2009) discovered that, with MW process, persulfate can oxidize azo dye Acid Orange 7, and the decolorization reached to 100% in 5 min, compared with a few hours without activation.

Despite that persulfate has a versatile application in many aspects, there are only several methods for determination of it. Wahba et al. (1959) studied the stoichiometric relationship between the redox reaction, then reported the reductometric titration method. Amin (1981) proposed the polarography method which was based on the various changes in current polarography with different concentrations of persulfate. Until lately, Liang et al. (2008) investigated the relationship between the concentrations of persulfate and the absorbance changes of the solution, and developed the

* Corresponding author. E-mail: shiningpup@hotmail.com (Shiyang Yang).

spectrophotometric method. Among these methods, the most common ones were based on Eq. (1).



The traditional titration method, which was simple and accurate, involved a back-titration by thiosulfate. Together with the slow rate between persulfate and iodide, the reaction time was lasting over 40 min (Huang et al., 2002). Liang et al. (2008) created the rapid spectrophotometric method and reduced the reaction time to 15 min via Fe^{2+} activation. But the process needs pretreatment of sample, such as adjustment of the pH in solution, and needs adding colorful Fe^{2+} into the system, which may disturb the spectrophotometric determination. On the other hand, these determination methods of persulfate always focus on the concentration larger than 1 mmol/L (Wahba et al., 1959; Liang et al., 2008). Considering the numerous applications of persulfate, it is very necessary to develop a sensitive method for determining the lower concentration of persulfate in aqueous solution.

Dyes, which can be decolorized by strong oxidants, were used as indicators (Jurado et al., 2006; Dhaouadi et al., 2006). Zou et al. (2014) reported a spectrophotometric method of peroxymonosulfate by measuring the decolorization extent of Methylene Orange via $\text{SO}_4^{\cdot -}$ (Eq. (2)), which was produced by Co^{2+} -activated peroxymonosulfate. Ding et al. (2011) proposed a new method which was used to determine the concentration of persulfate by means of decolorization extent of four dyes. In case of the slow reaction rate of persulfate, Ding et al. (2011) combined normal heating with Fe^{2+} activation methods for acceleration. As a result, it can be completed in a few minutes. However, it may lead some obstructions to the scale application. First, as the traditional method, it needs to adjust the pH of sample. What's more, both thermal activation and metal iron activation were used, which made the system complicated and tedious.



In this article, we developed a new method to determine persulfate in aqueous solution by measuring the decolorization extent of Methylene Blue (MB) via microwave (MW) process. It was found that a method with more rapid, convenient, and simple procedures was achieved. Under the optimized conditions, a good linear correlation was shown between the decolorization extent and the persulfate concentration. To check the feasibility and accuracy of the proposed method, we also make a comparison between our proposed method and the classic iodometric spectrophotometric methods.

1. Materials and methods

1.1. Reagents and solutions

All the used chemicals were of analytical reagent grade. Sodium persulfate, potassium iodide, sodium hydroxide and hydrochloric acid were purchased from Shanghai Chemical Reagent Company, China. MB was purchased from Tianjin Kermel Chemical Reagent Company, China. Solutions of 1.0 mol/L H_2SO_4 and 1.0 mol/L NaOH were used to adjust pH. All experiments were carried out using double distilled water.

1.2. Apparatus and measurement procedure

The decolorization experiments were conducted in a series of polypropylene ethylene plastic pipes (10.0 mL) with a total reaction solution volume of 5.0 mL. Sample solutions of persulfate (1.0 mL) and MB (4.0 mL) were mixed. The mixture solution was placed in an oven for a specific time as required. Unless otherwise specified, the initial concentration of MB was 10 mg/L, and the reaction time was 60 sec. MW radiation was provided by a domestic MW oven (900 W). After this process, the pipes were quickly transferred into a water bath for cooling down to room temperature ($20 \pm 1^\circ\text{C}$). It was worth to mention that, during such a short period of time, the loss of the solution caused by volatilization was negligible. The UV-vis absorbance of samples was analyzed with a Shimadzu UV1206 spectrophotometer (Shimadzu Corporation, Kyoto, Japan). The degradation of MB was monitored by measuring the maximum absorbance at $\lambda = 664 \text{ nm}$. The decolorization extent was characterized by ΔA , $\Delta A = A_0 - A_t$, where A_0 and A_t were the absorbance of the dye solutions before reaction and after MW process of time t . The changes in pH of the mixed solution of persulfate and MB during the MW process were also investigated. ΔpH was the difference in pH before and after MW process. To ensure the accuracy and replicability of the collected data, the experiments were operated at least three times under identical conditions.

2. Results and discussion

2.1. Effect of reaction time

MB, one of the basic dyes, was used as the indicator for the determination of persulfate. MW activation, rather than Fe^{2+} activation, was used to promote the reaction. The influence of MW reaction time on the decolorization extent of MB was investigated and the results are shown in Fig. 1. It shows that for various concentrations of persulfate, all the reactions took

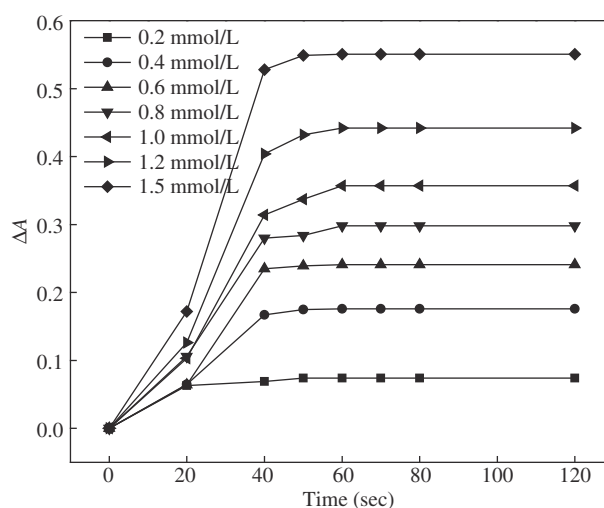


Fig. 1 – Effect of reaction time on the decolorization of Methylene Blue (MB) by persulfate with various concentrations under microwave (MW) process.

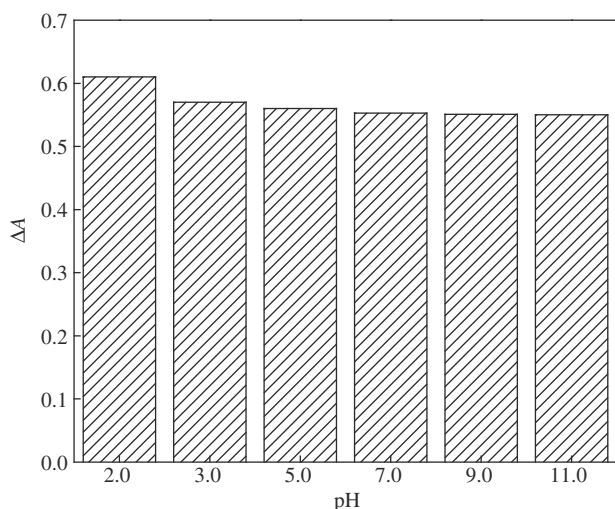


Fig. 2 – Effect of initial pH value on the decolorization of Methylene Blue (MB) by persulfate under microwave (MW) process.

place rapidly particularly in the first 40 sec and reached to the end over 60 sec. The appearance of the plateau was due to the total consumption of added persulfate. This proposed method was more rapid compared with the process of non-activation (40 min) (Huang et al., 2002), the process with Fe^{2+} activation

(15 min) (Liang et al., 2008), and the process with normal thermal and Fe^{2+} activation (2–7 min) (Ding et al., 2011).

2.2. Effect of initial pH

As all Fenton-like reactions, pH value is a key parameter for persulfate to react with target substance. In most cases (Do et al., 2013; Jo et al., 2014), it is strict for pH condition in a specific reaction, which makes process complicated and the added acid or alkali may introduce errors. Fig. 2 shows different ΔA against various initial pH values of samples. ΔA was measured as a variable of decolorization between 1.5 mmol/L persulfate sample solution and the control sample without persulfate.

It was obvious that there was no significant change with different initial pH values. In other words, the initial pH had little influence on the decolorization extent. In the previous studies (Liang et al., 2008; Ding et al., 2011), Fe^{2+} was added into the system in order to achieve end points in a shorter time. As a significant feature of Fenton's reaction, pH is a critical parameter of the system. It is very exciting to find that, in our present experiment, the determination process needs no pH adjustment.

2.3. Effect of initial MB concentration

Fig. 3 shows a series of UV–vis absorption spectra corresponding to various initial MB concentrations. It can be clearly seen

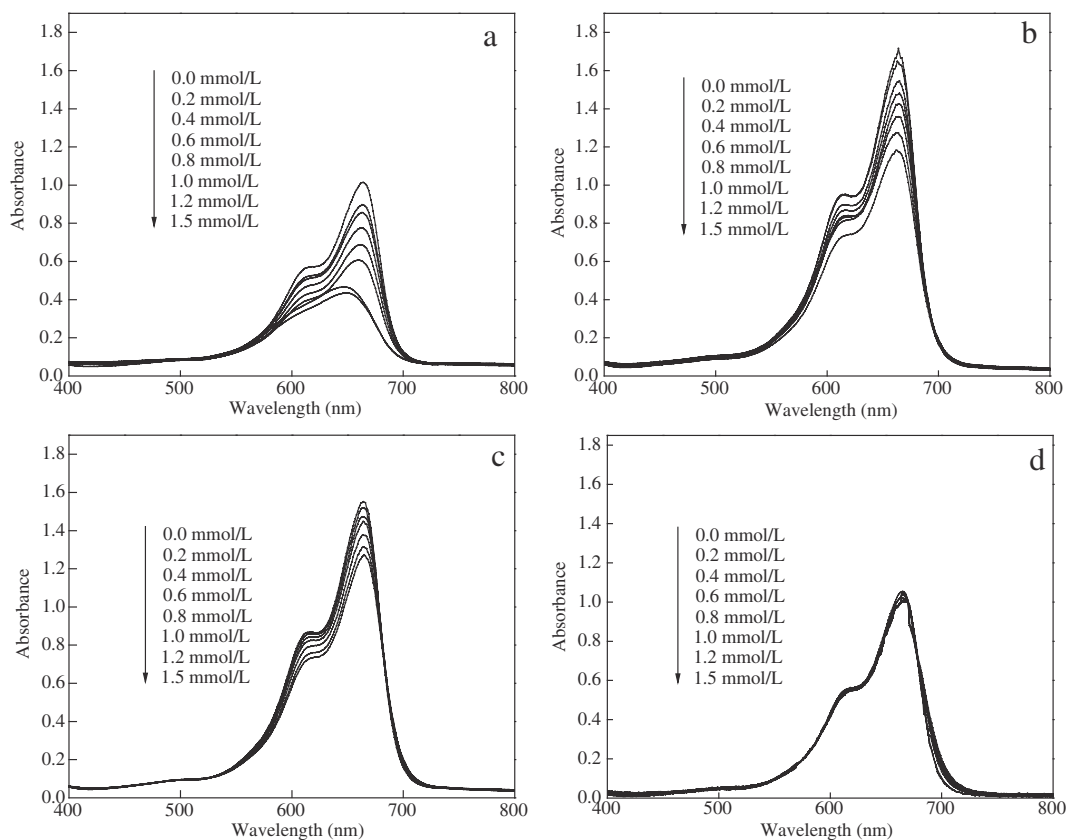


Fig. 3 – UV visible absorption spectra recorded after the decolorization of MB by persulfate at various concentrations, (a) and (b) not diluted, (c) diluted four times, (d) diluted ten times. The initial concentration of MB was (a) 5 mg/L, (b) 10 mg/L, (c) 25 mg/L, and (d) 50 mg/L.

Table 1 – Decreases in pH values and peak shifts with various concentrations of Methylene Blue (MB).

Concentration of MB (mg/L)	Δ pH	Blue shift of the peak (nm)
5	4.5	16
10	4.1	Negligible
25	4.1	Negligible
50	4.0	Negligible

that with increasing initial MB concentration, gaps between adjacent curves became smaller. When the initial concentration reached up to 25 mg/L, the gaps were too small to be recognized. Moreover, there was no certain relationship between gaps and the various concentrations of persulfate. As the initial concentration increased to 50 mg/L, the curves overlapped a lot and became difficult to be identified. However, the initial MB concentration did not seem the lower the better. When the initial MB concentration was 5 mg/L, the maximum absorbance appeared a blue shift. The data from Table 1 showed the decreases in pH value after reaction with various MB concentrations. The pH variation may be caused by the hydrolysis of SO_4^- (Eq. (3)) (Waldemer et al., 2007) and the generated intermediate carboxylic acid (such as formic or oxalic) (Hisaindee et al., 2013). And in strong acid condition, when the concentration of MB was below 5 mg/L, the peak of the maximum absorbance may emerge a blue shift. In addition, with the degradation process of MB, part of the structure may be interrupted. As shown in Fig. 3a, the character peaks of MB generated blue shifts and even disappeared. Therefore, the optimal initial concentration of MB was 10 mg/L.



2.4. Validation of method

The linearity of the proposed method was investigated by recording the ΔA responses to standard persulfate solutions in

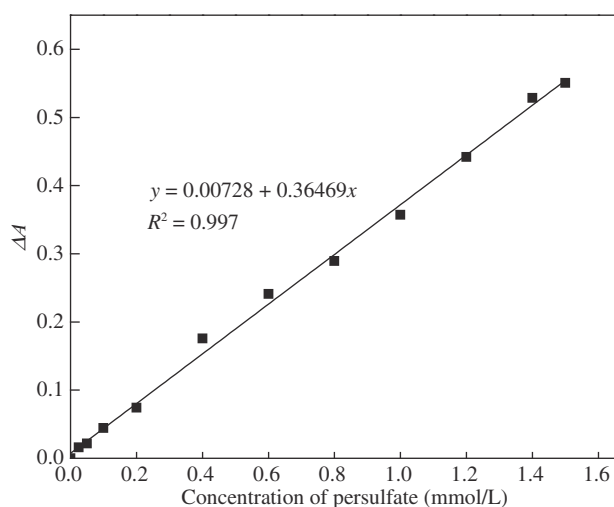


Fig. 4 – Calibration curve for the determination of persulfate with the MB-MW based spectrophotometric method under optimized reaction conditions.

Table 2 – Recovery of persulfate determined by analyzing three sets of standard samples.

Concentration of sample (mmol/L)	Measured concentration ^a (mmol/L)	Recovery (%)
0.1	0.093 ± 0.002	93.26
0.3	0.270 ± 0.04	89.75
0.7	0.719 ± 0.03	103.04
1.0	0.967 ± 0.012	96.70
1.2	1.161 ± 0.03	95.92
1.3	1.291 ± 0.012	99.31
1.5	1.488 ± 0.001	99.27

^a Data are presented as mean ± standard deviation.

the range of 0–1.5 mmol/L. A calibration curve was obtained by adding 1.0 mL persulfate sample into 4.0 mL 10 mg/L MB, then experiencing 60 sec MW process for the mixture system. As shown in Fig. 4, the correlation was linear between ΔA and concentration of persulfate. The remaining MB and the persulfate value also presented a good linear relationship. What's more, correlation coefficient between remaining MB and concentration of persulfate was 0.997, same as that of the calibration curve. It is noticed that the concentration of persulfate shown in Fig. 4 was the original concentration of persulfate sample, not the concentration in the mixed solution.

Since spectrophotometer sensitivity can be accurate to 0.001, the limit of detection (LOD) of the proposed method obtained was 0.0028 mmol/L. Recoveries were measured through determining three sets of standard samples within a range of 0–1.5 mmol/L (Table 2). Good recovery values from 89.75% to 103.04%, a low method detection limit (MDL) of 0.0016 mmol/L, and a relative standard deviation (RSD) of 3.71% based on seven determinations were obtained.

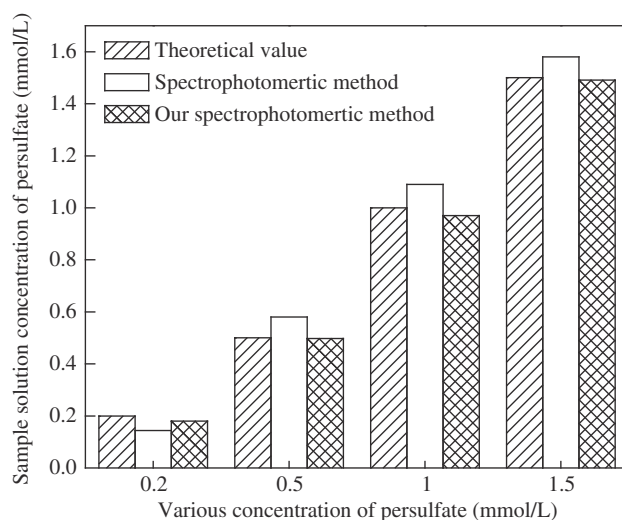


Fig. 5 – Comparisons of persulfate concentrations in the measured sample solutions for the theoretical value, the spectrophotometric method and MB-MW based spectrophotometric method.

2.5. Monitoring aqueous samples using the proposed method

To check the feasibility of the proposed method in practical analysis, the developed method was used to monitor the samples, which were simulated by various known concentrations of persulfate. We made a comparison among the theoretical value, the spectrophotometric method based on iodometric method (Liang et al., 2008) and our method. The results shown in Fig. 5 confirmed that the persulfate concentrations of the proposed method were closer to the theoretical values than those of the iodometric based spectrophotometric method. The average error of the proposed method was 3.43%, while the average error of the spectrophotometric method was 14.58%.

3. Conclusions

The proposed MB-MW based spectrophotometric method for determination of persulfate in water is very rapid, simple and convenient in comparison with other methods. This method process demands no pretreatment of sample, no strict conditions and no valuable instruments. The analytical results reveal its potential use for the detection of low persulfate concentration.

Acknowledgments

This work was supported by the National Natural Science Foundation of China (No. 21107101).

REFERENCES

- Amin, D., 1981. Indirect amplification method for determining peroxydisulphate by alternating-current polarography. *Analyst* 106 (1268), 1217–1221.
- Dhaouadi, A., Monser, L., Sadok, S., Adhoum, N., 2006. Flow-injection methylene blue-based spectrophotometric method for the determination of peroxide values in edible oils. *Anal. Chim. Acta* 576 (2), 270–274.
- Ding, Y., Zhu, L., Yan, J., Xiang, Q., Tang, H., 2011. Spectrophotometric determination of persulfate by oxidative decolorization of azo dyes for wastewater treatment. *J. Environ. Monit.* 13 (11), 3057–3063.
- Do, S.H., Kwon, Y.J., Bang, S.J., Kong, S.H., 2013. Persulfate reactivity enhanced by $\text{Fe}_2\text{O}_3\text{-MnO}$ and $\text{CaO-Fe}_2\text{O}_3\text{-MnO}$ composite: identification of composite and degradation of CCl_4 at various levels of pH. *Chem. Eng. J.* 221, 72–80.
- Fang, J.Y., Shang, C., 2012. Bromate formation from bromide oxidation by the UV/persulfate process. *Environ. Sci. Technol.* 46 (16), 8976–8983.
- Hisaindee, S., Meetani, M.A., Rauf, M.A., 2013. Application of LC-MS to the analysis of advanced oxidation process (AOP) degradation of dye products and reaction mechanisms. *TrAC, Trends Anal. Chem.* 49, 31–44.
- Hori, H., Yamamoto, A., Hayakawa, E., Taniyasu, S., Yamashita, N., Kutsuna, S., et al., 2005. Efficient decomposition of environmentally persistent perfluorocarboxylic acids by use of persulfate as a photochemical oxidant. *Environ. Sci. Technol.* 39 (7), 2383–2388.
- Huang, K.C., Couttenye, R.A., Hoag, G.E., 2002. Kinetics of heat-assisted persulfate oxidation of methyl tert-butyl ether (MTBE). *Chemosphere* 49 (4), 413–420.
- Ji, Y.F., Ferronato, C., Salvador, A., Yang, X., Chovelon, J.M., 2014. Degradation of ciprofloxacin and sulfamethoxazole by ferrous-activated persulfate: implications for remediation of groundwater contaminated by antibiotics. *Sci. Total Environ.* 472, 800–808.
- Jo, Y.H., Do, S.H., Kong, S.H., 2014. Persulfate activation by iron oxide-immobilized MnO_2 composite: identification of iron oxide and the optimum pH for degradations. *Chemosphere* 95, 550–555.
- Jurado, E., Fernandez-Serrano, M., Nunez-Olea, J., Luzon, G., Lechuga, M., 2006. Simplified spectrophotometric method using methylene blue for determining anionic surfactants: applications to the study of primary biodegradation in aerobic screening tests. *Chemosphere* 65 (2), 278–285.
- Liang, C., Bruell, C.J., Marley, M.C., Sperry, K.L., 2004. Persulfate oxidation for in situ remediation of TCE. II. Activated by chelated ferrous ion. *Chemosphere* 55 (9), 1225–1233.
- Liang, C., Huang, C.F., Mohanty, N., Kurakalva, R.M., 2008. A rapid spectrophotometric determination of persulfate anion in ISCO. *Chemosphere* 73 (9), 1540–1543.
- Wahba, N., El Asmar, M.F., El Sadr, M.M., 1959. Iodometric method for determination of persulfates. *Anal. Chem.* 31 (11), 1870–1871.
- Waldemer, R.H., Tratnyek, P.G., Johnson, R.L., Nurmi, J.T., 2007. Oxidation of chlorinated ethenes by heat-activated persulfate: kinetics and products. *Environ. Sci. Technol.* 41 (3), 1010–1015.
- Yang, S.Y., Wang, P., Yang, X., Wei, G., Zhang, W.Y., Shan, L., 2009. A novel advanced oxidation process to degrade organic pollutants in wastewater: microwave-activated persulfate oxidation. *J. Environ. Sci.* 21 (9), 1175–1180.
- Yuan, S., Liao, P., Alshawabkeh, A.N., 2013. Electrolytic manipulation of persulfate reactivity by iron electrodes for trichloroethylene degradation in groundwater. *Environ. Sci. Technol.* 48 (1), 656–663.
- Zhang, J., Shao, X., Shi, C., Yang, S., 2013. Decolorization of Acid Orange 7 with peroxymonosulfate oxidation catalyzed by granular activated carbon. *Chem. Eng. J.* 232, 259–265.
- Zou, J., Ma, J., Zhang, X., Xie, P.C., 2014. Rapid spectrophotometric determination of peroxymonosulfate in water with cobalt-mediated oxidation decolorization of methyl orange. *Chem. Eng. J.* 253, 34–39.



Editorial Board of Journal of Environmental Sciences

Editor-in-Chief

X. Chris Le University of Alberta, Canada

Associate Editors-in-Chief

Jiuhui Qu Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Shu Tao Peking University, China
Nigel Bell Imperial College London, UK
Po-Keung Wong The Chinese University of Hong Kong, Hong Kong, China

Editorial Board

Aquatic environment

Baoyu Gao Shandong University, China
Maohong Fan University of Wyoming, USA
Chihpin Huang National Chiao Tung University, Taiwan, China
Ng Wun Jern Nanyang Environment & Water Research Institute, Singapore
Clark C. K. Liu University of Hawaii at Manoa, USA
Hokyong Shon University of Technology, Sydney, Australia
Zijian Wang Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Zhiwu Wang The Ohio State University, USA
Yuxiang Wang Queen's University, Canada
Min Yang Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Zhifeng Yang Beijing Normal University, China
Han-Qing Yu University of Science & Technology of China, China

Terrestrial environment

Christopher Anderson Massey University, New Zealand
Zucong Cai Nanjing Normal University, China
Xinbin Feng Institute of Geochemistry, Chinese Academy of Sciences, China
Hongqing Hu Huazhong Agricultural University, China
Kin-Che Lam The Chinese University of Hong Kong, Hong Kong, China
Erwin Klumpp Research Centre Juelich, Agrosphere Institute, Germany

Peijun Li

Institute of Applied Ecology, Chinese Academy of Sciences, China
Michael Schlöter German Research Center for Environmental Health, Germany
Xuejun Wang Peking University, China
Lizhong Zhu Zhejiang University, China

Atmospheric environment

Jianmin Chen Fudan University, China
Abdelwahid Mellouki Centre National de la Recherche Scientifique, France
Yujing Mu Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Min Shao Peking University, China
James Jay Schauer University of Wisconsin-Madison, USA
Yuesi Wang Institute of Atmospheric Physics, Chinese Academy of Sciences, China
Xin Yang University of Cambridge, UK

Environmental biology

Yong Cai Florida International University, USA
Henner Hollert RWTH Aachen University, Germany
Jae-Seong Lee Sungkyunkwan University, South Korea
Christopher Rensing University of Copenhagen, Denmark
Bojan Sedmak National Institute of Biology, Slovenia
Lirong Song Institute of Hydrobiology, Chinese Academy of Sciences, China
Chunxia Wang National Natural Science Foundation of China
Gehong Wei Northwest A & F University, China

Daqiang Yin

Tongji University, China
Zhongtang Yu The Ohio State University, USA

Environmental toxicology and health

Jingwen Chen Dalian University of Technology, China
Jianying Hu Peking University, China
Guibin Jiang Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Sijin Liu Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Tsuyoshi Nakanishi Gifu Pharmaceutical University, Japan

Willie Peijnenburg University of Leiden, The Netherlands
Bingsheng Zhou Institute of Hydrobiology, Chinese Academy of Sciences, China

Environmental catalysis and materials

Hong He Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Junhua Li Tsinghua University, China
Wenfeng Shangguan Shanghai Jiao Tong University, China
Ralph T. Yang University of Michigan, USA

Environmental analysis and method

Zongwei Cai Hong Kong Baptist University, Hong Kong, China
Jiping Chen Dalian Institute of Chemical Physics, Chinese Academy of Sciences, China
Minghui Zheng Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, China
Municipal solid waste and green chemistry
Pinjing He Tongji University, China

Editorial office staff

Managing editor Qingcai Feng
Editors Zixuan Wang Suqin Liu Kuo Liu Zhengang Mao
English editor Catherine Rice (USA)

JOURNAL OF ENVIRONMENTAL SCIENCES

环境科学学报(英文版)

www.jesc.ac.cn

Aims and scope

Journal of Environmental Sciences is an international academic journal supervised by Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences. The journal publishes original, peer-reviewed innovative research and valuable findings in environmental sciences. The types of articles published are research article, critical review, rapid communications, and special issues.

The scope of the journal embraces the treatment processes for natural groundwater, municipal, agricultural and industrial water and wastewaters; physical and chemical methods for limitation of pollutants emission into the atmospheric environment; chemical and biological and phytoremediation of contaminated soil; fate and transport of pollutants in environments; toxicological effects of terrorist chemical release on the natural environment and human health; development of environmental catalysts and materials.

For subscription to electronic edition

Elsevier is responsible for subscription of the journal. Please subscribe to the journal via <http://www.elsevier.com/locate/jes>.

For subscription to print edition

China: Please contact the customer service, Science Press, 16 Donghuangchenggen North Street, Beijing 100717, China. Tel: +86-10-64017032; E-mail: journal@mail.sciencep.com, or the local post office throughout China (domestic postcode: 2-580).

Outside China: Please order the journal from the Elsevier Customer Service Department at the Regional Sales Office nearest you.

Submission declaration

Submission of the work described has not been published previously (except in the form of an abstract or as part of a published lecture or academic thesis), that it is not under consideration for publication elsewhere. The publication should be approved by all authors and tacitly or explicitly by the responsible authorities where the work was carried out. If the manuscript accepted, it will not be published elsewhere in the same form, in English or in any other language, including electronically without the written consent of the copyright-holder.

Editorial

Authors should submit manuscript online at <http://www.jesc.ac.cn>. In case of queries, please contact editorial office, Tel: +86-10-62920553, E-mail: jesc@rcees.ac.cn. Instruction to authors is available at <http://www.jesc.ac.cn>.

Journal of Environmental Sciences (Established in 1989) Volume 31 2015

Supervised by	Chinese Academy of Sciences	Published by	Science Press, Beijing, China
Sponsored by	Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences		Elsevier Limited, The Netherlands
Edited by	Editorial Office of Journal of Environmental Sciences P. O. Box 2871, Beijing 100085, China Tel: 86-10-62920553; http://www.jesc.ac.cn E-mail: jesc@rcees.ac.cn	Distributed by	
		Domestic	Science Press, 16 Donghuangchenggen North Street, Beijing 100717, China Local Post Offices through China
		Foreign	Elsevier Limited http://www.elsevier.com/locate/jes
Editor-in-chief	X. Chris Le	Printed by	Beijing Beilin Printing House, 100083, China

CN 11-2629/X Domestic postcode: 2-580

Domestic price per issue RMB ¥ 110.00

ISSN 1001-0742

