

## Study the Impact of Sunlight and Temperature on Drink Ozonated Water

Abdul Malik Marwan Ahmed Al-Attas <sup>a</sup>, and Khalid Abdelazez Mohamed Ahmed <sup>\*,a,b</sup>

<sup>a</sup>Faculty of Science & Education (Alkhurma branch), Taif University, P.O. Box: 888 Postal Code: 5700 Saudi Arabia.

<sup>b</sup>Department of Chemistry, Faculty of Science and Technology, Al-Neelain University, P.O. Box 12702, Khartoum, Sudan.

Received: July 16 2013

Accepted: August 24 2013

### ABSTRACT

In this article, we investigate the influence of sun light and temperature on drinking water sterilization. Ozone is a superb way to get oxygen into drink water. However, the amount of ozone in ozonated water is applied to treat undesirable chemicals, biological contaminants, suspended solids and gases by hydroxyl radical generation process. Hydrogen peroxide is produced from drinks water when water bottle exposed to external factors such as light or temperatures. The concentration of H<sub>2</sub>O<sub>2</sub> in drinks water can be evaluated with the aid of decolorization of methyl orange (MO) by using Fenton reactions at  $\lambda_{\text{max}} \sim 507$  nm. The influence of sun light in generation of hydrogen peroxide has, therefore been performed in different reaction times. The result suggested that when drink water kept in sunlight for long time, caused a dramatically increase of the H<sub>2</sub>O<sub>2</sub> production.

**KEY WORDS:** Ozonation, Drink water, Fenton reagent, Hydrogen peroxide.

### INTRODUCTION

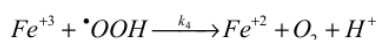
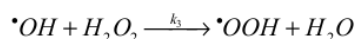
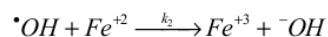
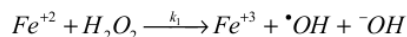
The last few years have witnessed an increasing awareness of the fragile state of most of the planets' drinking water resources. In order to cope with the growing pollution of our hydrosphere, educational and legislative programs are being implemented and two main strategies of water treatment begin to be applied <sup>1-3</sup>. The oxidation treatment of organic and inorganic compounds during ozonation can be occurred by ozone or OH radicals or a combination thereof. The oxidation pathway is determined by the ratio of ozone and OH radical concentrations and the corresponding kinetics <sup>4</sup>.

In order to produce high quality drinking water from any water resources, there are many different water treatment methods that can be used, each on its own, or in combination of physical and chemical with others to treat water for domestic use. To acquire good bacteriological quality in organically grown, chlorine is commonly used as a bleaching or oxidizing agent and can lead to many problems in the aquatic environments to the formation of potential toxic organochlorine compounds such as tetrachloroethene, trichloroethene and haloacetic ac. <sup>5, 6</sup> Most techniques are based on the formation of hydroxyl radicals which are the strongest oxidators that can be used in water treatment systems. Hydroxyl radicals can be generated in water through different combinations of oxidants, like ozone and hydrogen peroxide, or by combining a single oxidant with UV radiation. <sup>7</sup>

Many different attempts have already been made to describe ozone decomposition with or without the presence of organic compounds <sup>8</sup>. Two general accepted deterministic models for ozone decomposition in pure water, have been developed in the early 1980s, both based on the first model of Weiss <sup>9</sup>. Saving drink water needs to more research, especially for some factors such as light irradiation, temperatures and so on, can be produced of hydrogen peroxide.

Recently, there were numbers of routs were used to determine H<sub>2</sub>O<sub>2</sub> concentration, for examples spectrophotometric <sup>10,11</sup>, fluorometric <sup>12-14</sup>, chemiluminescent <sup>15,16</sup>, electro chemical <sup>17-19</sup>, iodide-starch colorimetric <sup>20</sup> and enzyme catalytic reaction. Due to their unusual sensitivity and rapid method, the oxidation decolorization of methyl orange (MO) by using Fenton reactions has been developed for hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) determination <sup>21</sup>.

Recently, Dmitry et al. <sup>22</sup> proposed a set of reactions to explain the MO degradation mechanism in aqueous solutions in the presence of Fenton reagent:



In this paper, the determination of hydroxide radical in ozonation drink water was observed by Fenton reaction system composed of H<sub>2</sub>O<sub>2</sub> and the decolorization extent of methyl orange solution. The stronger oxidized ability of Fenton reaction has driven to use for decolorizing of methyl orange and then leading to a sensitive as well as simple method for H<sub>2</sub>O<sub>2</sub> determination. The effect of sun light and temperature on generation of hydrogen peroxide was estimated.

**\*Corresponding Author:** Khalid Abdelazez Mohamed Ahmed, Department of Chemistry, Faculty of Science and Technology, Al-Neelain University, P.O. Box 12702, Khartoum, Sudan. Tel: (+966) 552-639-984 E-mail: khalidnadm@hotmail.com

## 2 MATERIALS AND METHODS

### 2.1 Materials

In our experiments, all the reagents were analytical grade and used without further purification. Drink water collected from different companies of Saudi Arabia. Methyl orange and iron sulfate hexahydrate (98%) were of analytical grade and purchased from India chemical reagent company.

### 2.1 Experimental procedure

In a typical procedure, 100 mg/L MO solution was prepared by dissolving of 1.0g MO in 100 mL of deionization water. 0.1 mol/L  $\text{FeSO}_4$  solution was prepared by dissolving 2.78g  $\text{FeSO}_4(\text{H}_2\text{O})_7$  in 100 mL of drink water. 1.0 M  $\text{H}_2\text{SO}_4$  were employed to adjust pH of 2.5. At travel time, 10 ml was taken from drink water after filtration. Decolorization of MO was measured by spectrophotometer model T80/T80+ UV/Vis at  $\lambda_{\text{max}} \sim 507$ .

## 3 RESULTS AND DISCUSSION

Fig. 1(a) shows the X-ray diffraction (XRD) patterns of catalytic powder before hydrogen peroxide determination by Fenton reaction. All the diffraction peaks can be exclusively indexed as the monoclinic  $\text{FeSO}_4(\text{H}_2\text{O})_7$  [space group: P2<sub>1</sub>/c (no. 14)], with lattice constants  $a=14.11$ ,  $b=6.51$  and  $c=11.02$  Å, compatible with the literature values of JCPDS no. 01-0255. When the catalytic reaction underwent, the  $\text{FeSO}_4(\text{H}_2\text{O})_7$  can be converted to  $\text{Fe}_2(\text{SO}_4)_2\text{O}(\text{H}_2\text{O})_7$ . As shown in Figure 3.1(b), the (XRD) patterns of catalytic powder after hydrogen peroxide performed by  $\text{FeSO}_4(\text{H}_2\text{O})_7$ . All diffraction peaks are indexed to a triclinic phase iron sulfate oxide hydrate, amaranthine type ( $\text{Fe}_2(\text{SO}_4)_2\text{O}(\text{H}_2\text{O})_7$ ) with lattice constants  $a=8.97600$ ,  $b=11.67800$  and  $c=6.69800$  Å which are in good agreement with the reported data JCPDS card no.76-0924. In our knowledge, this first time confirms the XRD analysis of Fenton powder after catalytic process.

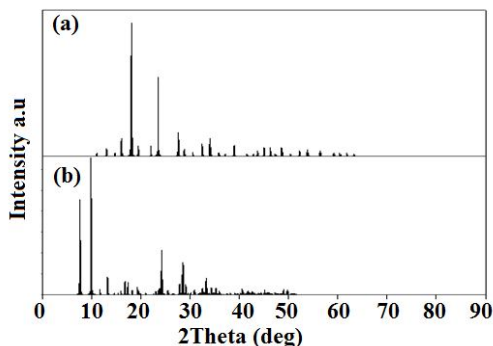


Fig. 1 XRD patterns of the Fenton catalyst powder (a) before catalytic performance and (b) after catalytic determination of  $\text{H}_2\text{O}_2$  in drink water.

Fig. 2 depicts a typical UV–visible absorption spectra recorded after the decolorization of MO in drink water. From figure, we can see the absorption density gradually decreases with times; means the Fenton reagent is highly effective for degradation of MO dye. The Fenton process involves the formation of  $\bullet\text{OH}$  radicals as the strongly oxidizing species.

To investigate the impact of sunlight irradiation on catalytic determination of  $\text{H}_2\text{O}_2$  by Fenton reaction process, the experiment is performed in presence or absent sunlight As for Fig. 3, the value of  $\text{H}_2\text{O}_2$  is little increase with the increase of reaction time when followed reaction in the absence of sunlight irradiation (curves II). However, in curve I, the amount of  $\text{H}_2\text{O}_2$  increases observably with the increase of reaction time and, in these cases, MO as reducing agent was degraded into small species according to following the reaction in excess hydroxyl radicals and the rate of radical production increase with MO decolorization.

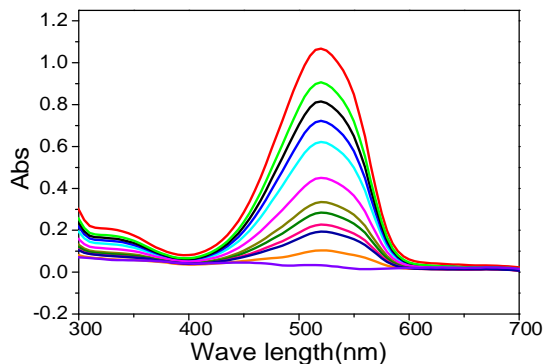


Fig. 2 UV–visible absorption spectra recorded after the decolorization of MO by Fenton reactions in different times.

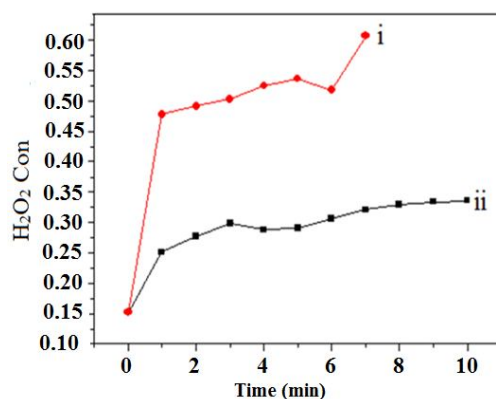


Fig. 3 The catalytic determination of H<sub>2</sub>O<sub>2</sub> by Fenton reaction process, (I) within sunlight and (II) without sunlight irradiation.

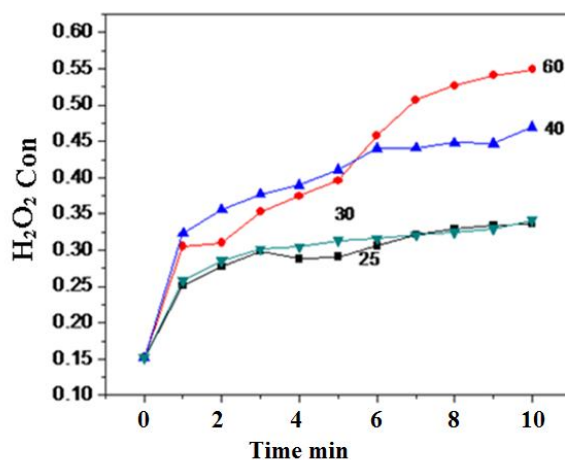


Fig. 4 The effect of temperature on drink water.

Evaluation of the impact of temperature on drink water is also investigated. As shown in Fig. 4, the concentrations of H<sub>2</sub>O<sub>2</sub> at different temperatures. If a reaction does occur during at low temperatures, the small values increase of H<sub>2</sub>O<sub>2</sub>. With increase the temperatures, the amount of peroxides is gradually increments.

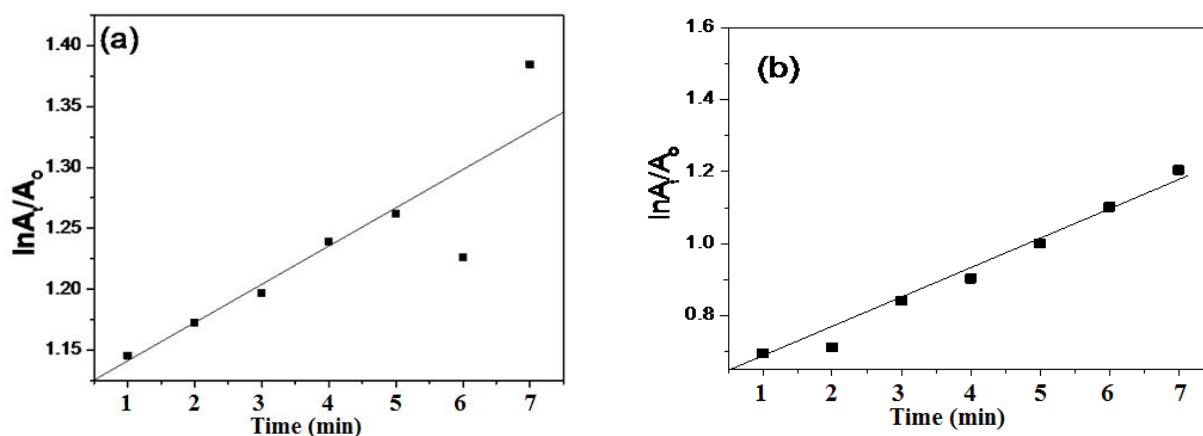


Fig. 5 The Kinetic reaction of hydrogen peroxide evaluation with times catalyzed by Fenton reaction process (a) sunlight and (b) without sunlight.

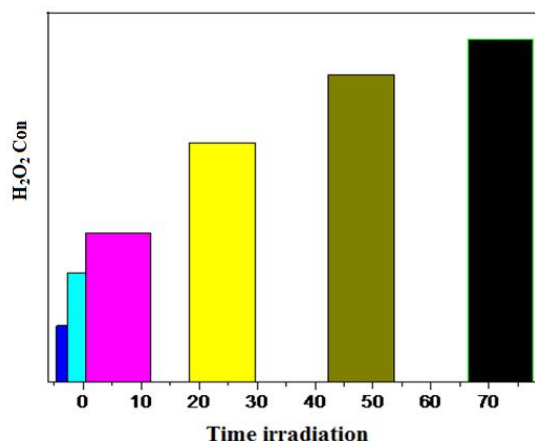
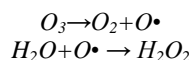


Fig 6 Degradation percentages of MO with Fenton reaction system.

The Kinetic reaction of hydrogen peroxide evaluated by using Fenton reaction process under sunlight and absent sunlight can be considered in Figure 5. A plot of  $[ln (A_0/A_t)]$  versus times, and the slope give good linear correlation also suggesting the reaction follows a first-order reaction ( $R^2_{RhB} \sim 0.9-0.972$ ). From the plots, the rate constant of reaction in sunlight is about  $0.3097 \text{ min}^{-1}$  (Fig.5(a)), and it about  $0.227 \text{ min}^{-1}$  in an absent sunlight (Fig.5(b)). This result suggested that the photocatalytic activity of Fenton reaction process in sunlight irradiation has higher rate than the absent of light.

On the other hand, the impact of sun light on drink water is shown in Fig. 6. The concentrations of hydrogen peroxide are raised within increases of irradiation times. The less amount of peroxide is produced, when forward the in short time. Water therapy exhibitions with light for longtime, the hydrogen peroxide is more produced from drinks water. This result postulated that the sunlight has markedly been influence on production of hydrogen peroxide. There is however, a new dimension emerging in the use of ozone in water treatment. In several laboratory and pilot scale studies, ozone is now being combined with hydrogen peroxide and ultraviolet radiation to produce to result which have not possible with ozone lone. The literature is replete with example of  $O_3/UV$  and  $O_3/H_2O_2$  studies in which inorganic and oxidized much more effectively than one can accomplish with ozone or any other common oxidant.<sup>23</sup> We shall refer to system process as advance oxidation process and include in this category other processes which the radical, namely ozone at high temperature and sunlight. The reaction mechanism of producing hydrogen peroxide from ozone can be described by two steps. The ozone is proceed free oxygen radical when exhibit with sun in low step, then oxygen radical rapidly react with water to form hydrogen peroxide.



## CONCLUSION

In conclusions, the hydrogen peroxide in drink water was determined by using Fenton reaction process. M.O was used to detector the hydroxide radical. Uv-vis spectrophotometer was employed to evaluate the absorption intensity. Moreover, XRD spectrum was used to study the stability of Fenton reaction before and after catalyst reaction process. The influences of sunlight and temperature on the Fenton reaction process were investigated. The result showed that the drink water kept in sunlight for long time, caused a dramatically increase of the  $H_2O_2$  production.

**Acknowledgments.** The authors gratefully acknowledge the *Faculty of Science and Education-Alkhurma branch- Taif University* for the technical assistance on characterization.

## REFERENCES

- 1) Li, Y.; Fu, Z.-Y.; Su, B.-L. *Adv. Funct. Mater.* 2012, 22, 4634.
- 2) Pavitra, E.; Yu, J.S. *Mater. Lett.* 2013, 90, 134.
- 3) Ge, J.; Lei, J.; Zare, R.N. *Nature Nanotech.* 2012, 7, 428.
- 4) Li, Y.B.; Bando, Y.; Golberg, D. *Appl. Phys. Lett.* 2003, 82, 1962.
- 5) Rook, J.J. *J. Water Treat. Exam.* 1974, 23, 234.
- 6) Audenaert, W.T.M.; Callewaert, M.; Nopens, I.; Cromphou, J.; Vanhoucke, R.; Dumoulin, A.; Dejjans, P.; Van Hulle, S. W.H. *Chem. Eng. J.* 2010, 157, 551.

- 7) Wang, W.Z.; Xu, C.K.; Wang, G.H.; Liu, Y.K.; Zheng, C.L. *Adv. Mater.* 2002, 14, 837.
- 8) Weixin, Z.; Cheng, W.; Xiaoming, Z.; Yi, X.; Yitai, Q. *Solid State Ionics* 1999, 117, 331.
- 9) Ching, S.; Petrovay, D.J.; Jorgensen, M.L. *Inorg. Chem.* 1997, 36, 883.
- 10) Julien, C.; Massot, M.; Hadjean, B. R.; Franger, S.; Bach, S. *Solid State Ionics* 2003, 159, 345.
- 11) Ahmed, K.A.M.; Huang, K.; *Mater. Chem. Phys.* 2012, 133, 605.
- 12) Kim, S.H.; Kim, S.J.; Oh, A.M. *Chem. Mater.* 1999, 11, 557.
- 13) Gaillot, A.C.; Drits, V.A.; Plancon, A.; Lanson, B. *Chem. Mater.* 2004, 16, 1890.
- 14) Gaillot, A.C.; Lanson, B.; Drits, V.A.; *Chem. Mater.* 2005, 17, 2959.
- 15) Ogata, A.; Komaba, S.; Kumagai, N. *J. Electrochem. Soc.* 2006, 74, 28.
- 16) Komaba, S.; Kumagai, N.; Chiba, S. *Electrochimica Acta* 2001, 46, 31.
- 17) Lee, H.Y.; Manivannan, V.; Goodenough, J.B. *C.R. Acad. Sci. Series IIC Chem.* 1999, 2, 565.
- 18) Tsuda, M.; Arai, H.; Sakurai, Y. *J. Power Sources* 2002, 110, 52.
- 19) Giovannelli, F.; Chartier, T.; Lambert, A.C.; Delorme, F.; Zaghrioui, M. Seron, A. *J. Solid State Chem.* 2009, 182, 1021.
- 20) Franger, S.; Bach, S.; Farcy, J.; Pereira-Ramos, J.P.; Baffier, N. *J. Power Sources*, 2002, 109, 262.
- 21) Dai, Y.; Wang, K.; Xie, J. *Appl. Phys. Lett.* 2007, 90, 104102.
- 22) Nakayama, M.; Kanaya, T.; Lee, J.W.; Popov, B.N. *J. Power Sources*, 2008, 179, 361.
- 23) William. H.G; Kang, J.W.; Chapin. D.H. *Ozone Sci. Eng.* 1987, 9, 335.