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Comparison of Oxidation Efficiency between Disposal of 2-Deoxyribose Using Ultrasound and Existing Method of Disposing Waste Water

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Introduction

Water is an indispensable element in human life. However, the current water purification system has failed to catch up the increment of waste water.

Since the purification process using chlorine was noticed by its toxic, the process using ozone or H_2O_2 has been widely used among a lot of countries. Although both have strong oxidizing power, they still have some problems with their high cost and small solubility to water. As ultrasound is known to encourage the progress of oxidation by hydroxyl radical from the ozone in water [1], it is expected to increase the efficiency of those purification processes.

The goal of this research is to compare the efficiency of oxidation between conventional techniques and methods enhanced by high intensity ultrasound. 2-deoxyribose has chosen as reactant of oxidation reactions.

Materials and methods

The setup was designed for several objectives; it should prevent temperature rise caused by the vibration of water molecules by ultrasound, water evaporation and water leakage.

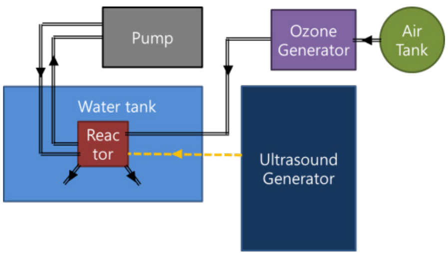

Fig 1. Simple diagram of setup

2-Deoxyribose	10 mM, 3 L
Ozone gas	0.5 L/min
Ultrasound	128 ± 5 kHz, 5.05 W
H_2O_2	0.6 mM
Treatment time	180 min
TBA	20 mM
Heat	80 °C, 75 min
Absorbance	532 ± 5 nm / 452 ±5 nm

Fig 2. Table of conditions

Fig 2 shows conditions maintained in experiments. Due to high energy from acoustic cavitation, generated by ultrasound, the ozone turns into hydroxyl radical in water [2]. When the hydroxyl radical is produced, it oxidizes 2-deoxyribose (Carbosynth, >99%) into malondialdehyde. After heating with adding 2-thiobarbituric acid (Sigma-Aldrich, >98%), a chromogen is produced [3]. It absorbs 532 nm light, which can be measured with UV spectroscope (GE Healthcare Ultrospec 2100 pro). For the H_2O_2 treating, H_2O_2 is added into the 3 L of 10 mM 2-deoxyribose solution so that the concentration of H_2O_2 becomes 0.6 mM.

$$\frac{1}{2}O_3 + \frac{1}{2}H_2O \xrightarrow{UT} \frac{1}{2}O_2 + OH\cdot$$

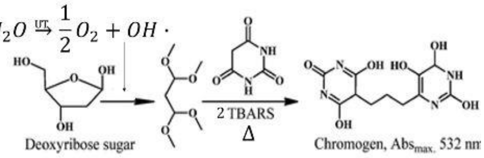

Fig 3. Oxidation process of 2-deoxyribose

Results and discussions

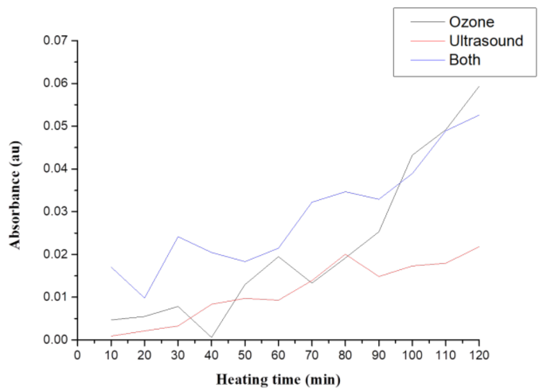

Fig 4. Absorbance at 532 nm by heating time. Both heating time and different treatments significantly affect the absorbance.

As shown in Fig 4, absorbance showed big differences among three treatments at 60 minutes of heated time. Moreover, the absorbance showed increasing trend as time passing by. This indicates that samples need to be heated enough to produce MDA, and 60 minutes is appropriate heating time for experiments. Regardless of heating time, the one treated by both of ozone gas and ultrasound showed the biggest absorbance at 532 nm during almost every heated time.

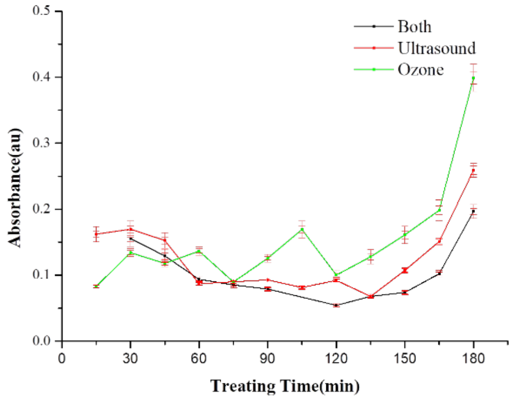

Fig 5. Absorbance at 532 nm by treatment time

During first 45 minutes, the absorbance of the solution that is treated with both ozone and ultrasound was higher than the absorbance of those that are treated only with either ozone or ultrasound. However, the ozone treated one showed sharp increase and finally after 3 hours, the both treated solution showed the lowest absorbance.

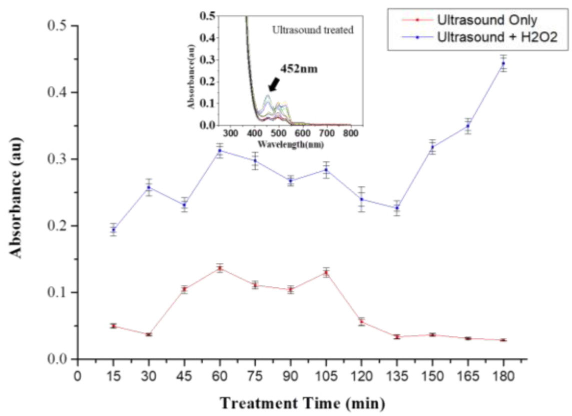

Fig 6. Absorbance at 452 nm

When the ultrasound was solely treated or applied to H_2O_2, the peak appears at 452 nm. TBA reaction of saturated aldehydes produced a yellow pigment with an absorption maximum at 452nm. This indicates that degraded 2-deoxyribose and TBA reacted and produced the pigment by OH radical.

Conclusions

Applying ultrasonic wave to 2-deoxyribose oxidizing process using ozone shows lower efficiency than the other processes. This indicates that exerting ultrasound in the process can be more contrary effect on efficiency than synergetic effect. However, applying ultrasonic wave to 2-deoxyriobse oxidizing process using H_2O_2 showed tendency to absorb more light at 452 nm than the process ultrasound solely treated. After 3 hours of the treatment, H_2O_2 process which ultrasound was applied, showed 15 times higher absorbance than the one that ultrasound was solely applied, which indicates more production of hydroxyl radical. The cause of this result can be inferred from a certain fact that the ozone has significantly low solubility, and the H_2O_2 was already an aqueous solution when it was treated. To prevent the outflow of the ozone gas, precisely enclosed reactor should be helpful.

Acknowledgment

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