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# DEVELOPING THE METHOD OF GENERATED OZONE AMOUNT REDUCTION IN DOMESTIC INDOOR AIR PURIFIERS

Air quality hugely affects human wellbeing, the fundamental wellsprings of contamination of which are strong suspended particles (of different sizes) and vaporous toxins (VOCs, NOx, SOx, scents). Many respiratory diseases are related to pollution of air, the heavy utilization of synthetic chemicals, the uncontrolled utilization of medications, different viral diseases, the development of new allergens and various different components. The use of indoor cleaning products and air fresheners can cause exposure to secondary air pollutants through inhalation of cleaning staff and building occupants. Because of Almaty air quality citizens often use devices for indoor air purification. Some of such devices remove VOCs with aid of catalytic organics decomposition under UV. Despite efficient organics decomposition, as side effect UV causes ozone formation which is harmful if exceeds certain concentration (ambient air standard).Ozone is usually present indoors due to external air intrusion. Thus, reduction of generated ozone concentration is an urgent task.

**Keywords:** air quality, ozone removal, catalytic decomposition, photocatalysis, airborne disease.

## Introduction.

Many respiratory diseases are linked to air pollution. Air quality analysis in Almaty showed high air pollution (Table 1). Therefore, citizens often use indoor air purification devices [1].

**Table 1 –** Air pollution in Almaty (maximum single concentration)

| Almaty districts | CO, mg/m$^3$ | Lead, mg/m$^3$ | NO$_2$, mg/m$^3$ | NO, mg/m$^3$ | O$_3$ mg/m$^3$ | SO$_2$, mg/m$^3$ |
|---|---|---|---|---|---|---|
| Almaly | 4.61 | 0.00015 | 0.08 | 0.27 | 0.52 | 0.123 |
| Zhetysu | 5.2 | 0.004 | 0.07 | 0.26 | 0.52 | 0.23 |
| Turksib | 3.8 | 0.0005 | 0.014 | 0.17 | 0.46 | 0.16 |

Problem of air pollution caused increase of popularity of air purifiers. The photocatalytic oxidetion (PCO) used in them is considered one of the economically feasible methods of purification from organic pollutants in comparison with other purifycation technologies, such as adsorption, biofiltration or thermocatalysis. FCO protects health in the long run by providing clean air that is almost completely free of pathogens and mold spores[2,3].

Since almost every existing air purifiers use UV-lamp as one of the many purification steps, problem of ozone generation is very important and needs to be taken into account.

Issue of air contamination caused increment of prominence of air purifiers. The photocatalytic oxidation (PCO) utilized in them is viewed as one of the financially attainable strategies for purging from natural poisons in examination with other cleansing advances, for example, adsorption, biofiltration or thermocatalysis [3]. PCO ensures wellbeing over the long haul by giving clean air that is totally liberated from pathogens and shape spores[4].

Notwithstanding, air purifiers dependent on UV-lights produce ozone (O3) during activity, either purposefully or as a side-effect of air ionization. This is a genuine concern, in light of the fact that O3 is a criteria air poison managed by wellbeing related government and state benchmarks [3,5,6]. Ozone-driven science is a wellspring of indoor auxiliary contaminations of potential wellbeing concern. This examination explores how measure of shaped ozone can be wiped out utilizing CuO impetus in type of work under direct UV-light [7].

Since pretty much every current air purifiers use UV-light as one of the numerous decontamination steps, issue of ozone age is significant and should be considered.

The use of indoor cleaning products and air fresheners can cause exposure to secondary air pollutants through inhalation of cleaning staff and building occupants.

Ozone is usually present indoors due to external air intrusion. There are also indoor sources of ozone for some office appliances and air purifiers. Indoor air purification has gained widespread popularity in recent years due to increasing air pollution issues in urban areas, with a broad variety of indoor air purifiers available to the public. Odorous volatile organic compounds (VOCs), dust, pollens, and airborne contaminants are the primary targets of indoor air purification, which are thought to intensify respiratory health problems[7]. There are three main types of air purifiers, from an operational point of view:

(1) air filtration, (2) air ionization, and (3) ozonolysis of air impurities.

Household use of some air ionization and air purifiers for ozonolysis has raised serious concerns, as they emit ozone (O3), an air pollutant standard, either as a result of air ionization or deliberately. Depending on the configuration, some ionic air purifiers will transmit O3 per hour at a rate of a couple of milligrams of O3, which is virtually similar to the O3 measurement transmitted during continuous operation by dry-process scanners. Ozonolysis air purifiers usually generate several hundred milligrams of O3 per hour indoor air with a target of oxidizing VOCs. O3 interacts with most saturated VOCs extremely slowly though. Half-lives of popular VOCs found indoors are days at 100 ppb of O3, or even years. O3 reacts much more easily with VOCs containing unsaturated carbon-carbon bonds found in cooking oils, air fresheners, cleaning items, and so on than with other polycyclic aromatic compounds contained in household materials (e.g., pigment coloring in carpets). However, these reactions, as stable products, produce carboxylic acids, epoxydes, organic peroxides, aldehydes, and ketones, some of which may have adverse health effects. This is why we had to decompose ozone to natural oxygen gas (dioxygen)[8].

Ozone decomposition to dioxygen is a thermodynamically preferred cycle with a reaction heat of somewhere = -138 kJ / mol and a free reaction energy of somewhere = -163 kJ / mol. However, ozone is thermally stable up to 523 K, so it requires catalysts to decompose at lower temperatures.

## Material and Methods

CuO is known to be catalyst for ozone decomposition under UV light (Figure 1). This property can be used to eliminate generated ozone. In order to increase contact surface and not to hinder air flow we used CuO immobilised on a mesh (Figure 2).

The determination of concentrations of ozone in air in the range of a few parts per million has become an increasingly important problem as a result of current toxicological and air pollution studies. Ozone was producing as a by product, which is obviously was bad because our household air purifier must clean air and not produce waste products. At the beginning we needed to calculate the amount of ozone our equipment generated, and then recheck the difference with the equipment with presence of CuO catalyst [9,10].

The chemical iodide methods tended to be among the most effective, and therefore were chosen for investigation. Thanks to its relatively weak, pH-independent RedOx potential, and iodine / iodide reversibility reaction. Iodometry can be used to assess both the amount of reducing agents (by direct iodine titration) and the amount of oxidizing agents (by thiosulfate titration)[11]. The same simple and accurate end point detection system, based on the blue starch complex, can be used in all cases (Table 1).

Many investigators have used iodometric methods for the determination of concentrations of ozone in the range of several percent by volume and higher. They have investigated the stoichiometry by comparison of the amounts of iodine liberated with the amounts of ozone determined by physical measurements of gas density or pressure change.

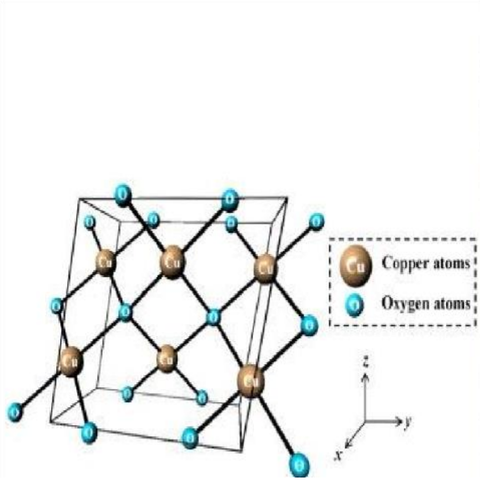


**Figure 1.** structure of CuO crystal

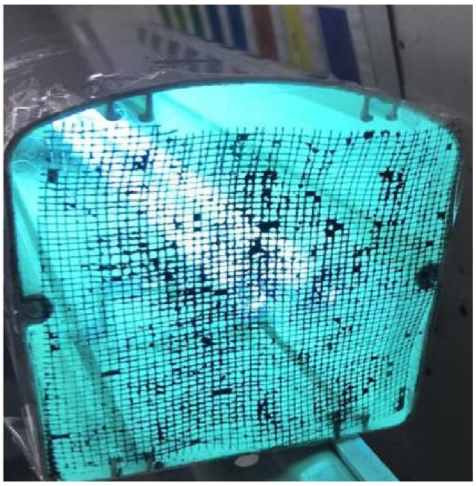


**Figure 2.** B) CuO mesh used as a catalyst for ozone neutralisation

**Table 1.** Ozone Procedures Reagents [11]

| |
|---|
| 1.Potassium iodide solution. Dissolve 10.0 grams KI into 100 mLs demineralized water. C = N/V= 10/(39+ 127)/0,1=0,6024 mole/l |
| 2.the (65%) concentrated sulfuric acid reagent<br>3.Starch indicator. |
| 4.Sodium thiosulfate solution (0.1N). |
| 5.Sodium pyrophosphate (decahydrate), 5% solution. |

Apparatus

| |
|---|
| 1.Analytical balance (+/- 0.1 mg/L) |
| 2.Small weighing bottle (< 5 mLs) |
| 3.250 mL Erlenmeyer flask |
| 4.50 mL buret |
| 5.Conical flask for titration per 100 ml - 2 pcs. |
| 6.Rubber pear or pipettor - 1 pc |
| 7. 250-mL Beaker. |
| 8.250-mL Graduated cylinder. |
| 9.10 ml aliquot pipette - 1 pc. |
| 10.Small funnel for a burette - 1 pc. |
| 11.A glass under a burette of 50 - 100 ml - 1 pc. |

### *MEASUREMENTS*

Iodine liberated by the ozone was measured titrimetrically. Distilled water was used in the reference tube. Titrations were made with 0.1 N sodium thiosulfate in a semi-micro buret and using a visual endpoint with starch indicator.

### *PROCEDURE AND STANDARDIZATION*

For the use with the alkaline reagent was prepared as follows: The strong stock solution of potassium iodate (0.2973 gram per liter) was diluted: with distilled water to give a dilute standard of which 1 ml was equivalent to 105.8 micrograms

$I_2$. Aliquots of 0.1 to 0.5 ml of this dilute standard were diluted to 10 ml , acidified via HCl.

*STOICHIOMETRY*

It thus seems evident that the actual reaction between the ozone and the iodide must have a different stoichiometry in alkaline solution.

The reactions :

$$(1)\ 0_3+2H^++2I^-\rightarrow 40_2+H_2O+I_2$$

In weak alkali, the equivalent reactions for the same stoichiometry are commonly given as:

$$(2)\ 30_3 + I^- \rightarrow 30_2 + I_2+ 0_3$$

followed upon acidification by:

$$(3)\ 0_3 + 6H^+ + 6I^- \rightarrow 3I_2+ 3H_20$$

**Results and Discussion**

We found experimental evidence to indicate that in strong alkali this pattern is not followed. When portions of samples in reagent $I_2$ were acidified to pH 6.2 with solid boric acid, the iodine released was approximately 50 % of that resulting from the usual acidification to pH 2. No iodine mas obtained from the reagent $I_2$ with added iodate, upon acidification with boric acid.

Reversible iodine/iodide reaction mentioned above is

$$2I_- \leftrightarrow I2 + 2e_-$$

and obviously whether it should be treated as oxidation with iodine or reduction with iodides depends on the other redox system involved.Second important reaction used in the iodometry is reduction of iodine with thiosulfate:

$$S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

In the case of both reactions it is better to avoid low pH. Thiosulfate is unstable in the presence of acids, and iodides in low pH can be oxidized by air oxygen to iodine. Both processes can be source of titration errors. Iodine is very weakly soluble in the water, and can be easily lost from the solution due to its volatility. However, in the presence of excess iodides iodine creates $I_{3-}$ ions. This lowers free iodine concentration and such solutions are stable enough to be used in lab practice. Still, we should remember that their shelf life is relatively short (they should be kept tightly closed in dark brown bottles, and standardized every few weeks). Iodine solutions are prepared dissolving elemental iodine directly in the iodides solution. Elemental iodine can be prepared very pure through sublimation, but because of its high volatility it is difficult to weight. Thus use of iodine as a standard substance, although possible, is not easy nor recommended. Iodine solutions can be easily normalized against arsenic (III) oxide ($As_2O_3$) or sodium thiosulfate solution.

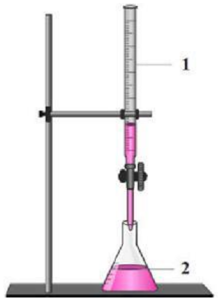
It is also possible to prepare iodine solutions mixing potassium iodide with potassium iodate in the presence of strong acid:

$$5I^- + IO_3^- + 6H+ \rightarrow 3I_2 + H_2O$$

**Experimental Section**

This section summarizes key features of the experimental methods (Figures 3,4)..

Experimental Procedure.



1. $Na_2S_2O_3$ 0,1M

2. mixture of titrant with generated $I_2$

**Figure 3.** Experimental Procedure

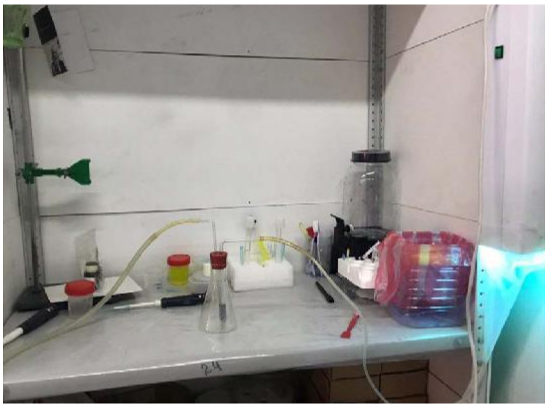


**Figure 4.** Design of experiment

Design of experiment:

$$O_2 + O \rightarrow O_3 \text{ (under direct UV-LIGHT)}$$

$$O_3\ (g) + 2KI\ (aq) + H_2SO_4\ (aq) \rightarrow I_2\ (s) + K_2SO_4\ (s) + O_2\ (g) + H_2O\ (l)$$

$$3.\ I_2 + 2Na_2S_2O_3\text{->}\ 2NaI + Na_2S_4O_6$$

**Figure 5.** Titration of a solution to determine the concentration of trapped ozone.

Equivalent weight of $Na_2S_2O_3$= 158/2=79 equivalent g/mole

$C_1V_1=C_2V_2$ (Figure 5).

Titration without CuO catalyst

| |
|---|
| v1= 4,60 ml |
| v2=4,,62 ml |
| v3=4,61 ml |
| v average=4,61 ml |

Titration in the presence of CuO catalyst

| |
|---|
| v1=4,12 ml |
| v2=4,13 ml |
| v3=4,125ml |
| v average=4,125 ml |

We calculated the mass of generated $O_3$ without the use of catalyst mesh

$m(O_3)=V(Na_2S_2O_3)*\ C(Na_2S_2O_3)*Meq(O_3)*$ V volumetric flask/ V aliquot * 1000 = 0,1* 4,61 *24*100/1000*10=0,11 g in 1 $dm_3$
= 0,11 mg per 1 $m_3$

This amount is higher than maximum permissible concentration. Whereas, the maximum permissible concentration of ozone in the air of the working area is - 0.1 mg / m3.

However, when we used our CuO mesh catalyst, mass of generated $O_3$ significantly decreased

$m(O_3)=V(Na_2S_2O_3)*\ C(Na_2S_2O_3)*Meq(O_3)*$ V volumetric flask/ V aliquot * 1000= 0,1*4,125*24*100/1000*10=0,099g in 1 $dm_3$
= 0,099 mg per 1 $m_3$

Our result fits the standards.

## Conclusion

Everyone are at risk from air pollution indoors. Air pollution issue has caused increased use of air purifiers. In activity, however, air purifiers based on UV-lamps emit ozone (O3), either deliberately or as an air ionization byproduct. This is a serious concern, because O3 is an air pollutant already governed by federal and state health-related regulations. Ozone-driven chemistry is a source of possible health concern in indoor secondary contaminants. This study investigated how to remove the amount of ozone produced using the CuO catalyst in the form of mesh under direct UV-light.

An overview of the patent literature discusses the structure, preparation methods, and efficiency of current ozone decomposition catalysts. Catalysts are found to consist of noble metals or metal oxides backed by a large supporting surface layer. We chose CuO as a catalyst, because it is considered to be a catalyst under UV light for ozone decomposition. This property is used to remove the ozone that is produced.

Without the use of CuO catalyst our household air purifier based on UV- light generated excess amount of ozone which exceeded the maximum permissible concentration standards. After performing experiments with CuO mesh we obtained permissible results.

Since practically every present air purifiers use UV-light as one of the various purification steps, issue of ozone is noteworthy and ought to be considered.

## References

1. The characteristics of pollution in the big industrial cities of Kazakhstan by the example of Almaty (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6148231/)
2. Human Health Cost of Air Pollution in Kazakhstan Ussen Kenessariyev1, Alexander Golub2, Michael Brody2, Askhat Dosmukhametov1,Meiram Amrin1, Aya Erzhanova1, Dinara Kenessary1 2013, 4, 869-876 http://dx.doi.org/10.4236/jep.2013.48101 Published Online August 2013 (http://www.scirp.org/journal/jep)
3. J. O. Anderson, J. G. Thundiyil and A. Stolbach, “Clearing the Air Review of the Effects of Particulate Matter Air Pollution on Human Health,” Journal of Medical Toxicology, Vol. 8, No. 2, 2012, pp. 166-175
4. Reactivity of Inorganic Substances. Handbook. Revised and Augmented Edition. By R. A. Lidin, V. A. Molochko, and L. L. Andreeva. Begell House Inc., New York. 1996. 938 pp. $165.00. ISBN 1-56700-050-9
5. Ozone Solubility In Water G.V. Egorova, V.A. Voblikova, L.V. Sabitova, I.S. Tkachenko, S.N. Tkachenko, V.V. Lunin Moscow University Chemistry Bulletin volume 70, pages207–210 (2015)
6. Hygiene standards and rules for working with ozone/ Moscow/Russian Federation. GOST 12.1.007-76 (http://www.melp.ru/ozon.html)
7. Harris Quantitative Chemical Analysis 8th edition. Daniel C. Harris.p117
8. Gas phase ozone decomposition catalysts B. Dhandapani, S.T. Oyama https://doi.org/10.1016/S0926-3373(96)00044-6
9. Structure and growth mechanism of CuO plates obtained by microwave-hydrothermal without surfactants A.P. Moura a , L.S. Cavalcante b,*, J.C. Sczancoski a , D.G. Stroppa c , E.C. Paris a , A.J. Ramirez c , J.A. Varela b , E. Longo.Advanced Powder Technology 21 (2010) 197–202
10. Carbon monoxide oxidation over CuO/CeO2 catalysts Xiaolan Tang, Baocai Zhang, Yong Li, Yide Xu, Qin Xin, Wenjie Shen∗
11. Full-Service Wastewater Treatment Programs for Municipal, Industrial and Refinery

Applications(http://www.h2o2.com/technicallibrary/analyticalmethods/default.aspx?pid=70&amp;name=Iodometric-Titration) C. T. Kingzett, Chem. News, 41:76 (1880); 43:161 (1881)I. M. Kolthoff, Chem Weekblad, 17:197 (1920)