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Original Article

Determination of Threshold Odor Limit of Formalin for Occupational Health in Laboratory

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Abstract

Formalin is water-based-solution of formaldehyde. It is used as preservative in anatomy,bio-monitoring and many other laboratories. The present study aimed to determine Threshold odor number (TON)for formalin. TON is the greatest dilution of sample with odor free water at which a definite perceptible odor is achieved.The test was conducted with a panel of 20 individuals which were subdivided into 2 panels; panel 1- lab workers and panel 2- non lab workers. These individuals were exposed to varied concentrations of formalin ranging from 0.01 to 0.1% with blanks inserted in series at regular intervals to avoid tiring the senses of testers. The observations were recorded by indicating whether odor is noted or not in each test bottle. The TON for lab workers was observed to be 1333 while for non-lab workers it was 2000.As per the findings of test, it can be concluded that increase in TON indicates more sensitivity towards formalin.The observed difference in TON value is due to some day to day exposure of the testers of panel 1 to formalin, thereby having olfactory adaptation to the odorant. As formalin is toxic even in very low concentration, therefore, use of mask while working with formalin in lab is recommended for occupational health of lab workers. This test has been standardised for formalin only but is equally applicable to determine TON for other chemicals used in laboratories and to check the quality of water bodies.

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Introduction

Formalin is generally used as preservative in many laboratories and its exposure to workers is a safety concern. It is considered a carcinogen by the International Agency for Research on Cancer (IARC). The Occupational Safety and Health Administration (OSHA) determined a set of regulations for formaldehyde industrial and laboratory use [1]. During the 1980s, there was a dispute between the US Environmental Protection Agency (EPA), OSHA, College of American Pathologists (CAP), Formaldehyde Institute, DuPont, and labor unions about formaldehyde's occupational exposure evaluation, which ultimately required the involvement of the US Court of Appeals for the District of Columbia in 1987 [2]. The National Industrial Chemicals Notification and Assessment Scheme (NICNAS) published a report on formaldehyde in 2006 stating that workers in formaldehyde-related laboratories are at risk of experiencing health effects from the chemical [3]. When formalin is present in air, some individuals may experience adverse effects such as watery eyes; burning sensation in eyes, nose and throat; coughing; wheezing; nausea; and skin irritation. The inhalation of formalin vapors causes cloudy swelling of the parenchyma of the kidney [4]. In bio-monitoring laboratory, formalin is used as preservative at concentration of 4% for macro-zoobenthos collected during sampling of water bodies.Keeping in view of occupational health and safety, the present study was conducted to determine Threshold Odor Number (TON) for formalin.

Material and Methods

To assure reliable threshold measurement, odor free glassware was used. Glassware was cleaned with soap and rinse with odor free water, dried in oven at 50±2°C and cooled down to room temperature before use.Wide mouth glass bottles (500 ml) with TFE lined closures were used during testing. For making different concentrations of formalin, graduated cylinder (200 ml) made up of glass and micropipette (100 µl) was used. Odor free water was prepared by passing tap water through activated carbon.

Different concentrations of formalin ranging from 0.01 to 0.1% were prepared with odor free water. Total volume of formalin and odor free water was 200 ml in each test bottle. Separate bottle containing only odor free water was used as reference for comparison. The testers were familiarized with the procedure before they participate in test. They were instructed to shake the bottle containing odor free water, open the lid and sniff vapors. Further, they were asked to smell each bottle in sequence, beginning with the least concentration of formalin i.e. 0.01% until the odor is detected with certainty. The blanks were inserted in the series at regular interval to avoid tiring the senses of testers. The observations were recorded by indicating whether odor is noted or not in each test bottle.To achieve sensory testing with good precision, as per APHA test no. 2150B threshold odor test [5], large sized panel of 20 individuals were selected. These were subdivided into 2 panels. Panel 1 comprising 10 individuals were selected from lab (Figure 1) while other 10 individuals of panel 2 were from outside lab (Figure 2).

Calculation

TON was calculated as per the formula:

$$TON = \frac{A+B}{A}$$

Where: A= ml formalin

B= ml odor free water

Results and Discussion

Threshold odor number is the dilution ratio at which odor is just detectable. In case of panel 1 (lab workers), the minimum concentration of formalin at which odor was noticeable by most individuals is 0.03% (Table 1). This corresponds to the TON 1333 (Table 3) while in case of panel 2 (non-lab workers), the perceptible odor is achieved at 0.02% formalin concentration (Table 2) by most individuals, corresponding to TON 2000 (Table 3). As per the findings of test, it can be concluded that increase in TON indicates more sensitivity towards formalin.The observed difference in TON value is due to some day to day exposure of the testers of panel 1 to formalin, thereby having olfactory adaptation to the odorant.

Table 1: Odor response from panel 1 (lab workers)

Sr. no.	Concentration of formalin (in %)												
	blank	0.01	0.02	blank	0.03	0.04	blank	0.05	0.06	blank	0.08	blank	0.1
Tester 1	-	-	-	-	+	+	-	+	-	-	+	-	+
Tester 2	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 3	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 4	-	-	-	-	+	+	-	+	-	-	+	-	+
Tester 5	-	-	-	-	+	+	-	+	+	-	+	-	+
Tester 6	-	-	-	-	+	-	-	+	-	-	+	-	+
Tester 7	-	-	-	-	+	+	-	+	+	-	+	-	+
Tester 8	-	+	-	-	-	+	-	+	+	-	+	-	+
Tester 9	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 10	-	+	+	-	+	+	-	+	+	-	+	-	+

Where +indicates odor is detected, -indicates odor is not detected

Table 2: Odor response from panel 2 (non lab workers)

Sr. no.	Concentration of formalin (in %)												
	blank	0.01	0.02	blank	0.03	0.04	blank	0.05	0.06	blank	0.08	blank	0.1
Tester 1	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 2	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 3	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 4	-	+	+	-	+	+	-	+	+	-	+	-	+
Tester 5	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 6	-	-	+	-	+	-	-	+	+	-	+	-	+
Tester 7	-	+	+	-	-	+	-	+	+	-	+	-	+
Tester 8	-	+	+	-	+	+	-	+	+	-	+	-	+
Tester 9	-	-	+	-	+	+	-	+	+	-	+	-	+
Tester 10	-	-	+	-	+	+	-	+	+	-	+	-	+

Where +indicates odor is detected, -indicates odor is not detected

Table 3: Threshold odor number corresponding to various concentrations

Sr. No.	Formalin Concentration (in %age)	Sample volume (ml) diluted to 200 ml	Threshold Odor No. (TON)
1.	0.01	0.05	4000
2.	0.02	0.10	2000
3.	0.03	0.15	1333
4.	0.04	0.20	1000
5.	0.05	0.25	800
6.	0.06	0.30	666.6
7.	0.08	0.40	500
8.	0.1	0.50	400

Fig. 1: Panel 1 (lab workers) (Reproduction size: at half page width)

Fig. 2: Panel 2 (non lab workers) (Reproduction size: at half page width)

Conclusion

As formalin is toxic even in very low concentration, therefore, use of mask while working with formalin in lab is recommended for occupational health of lab workers. Also ensure that a ventilation system is in place, eye bath and safety showers are available and ready to use. This test has been standardised for formalin only but is equally applicable to determine TON for other chemicals used in laboratories.

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