

Indigenous vs. Factory-Made Activated Carbon Fabric Masks to Reduce Lead Absorption-A Pilot Study

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Abstract

An attempt was made to determine the usefulness of Activated Carbon Fabric (ACF) masks to reduce lead absorption. Indigenous and factory made ACF masks were given to factory workers. The blood levels 6 months before giving the mask, on the day of giving the masks and one month after using the mask, were determined. The usefulness of indigenous versus factory made ACF mask was thus obtained. This was a pilot study and apparently both the indigenous and the factory made mask seemed useful in reducing the blood lead level.

Keywords: Activated carbon fabric; Blood lead level; Battery workers

Introduction

Activated Carbon Fabric (ACF) is a new and fibrous adsorbent, which has been obtained from an appropriate fibrous precursor by an adequate carbonization and activation process. Among various combinations of precursors it is desirable to obtain ACF with a high mechanical durability as well. Currently, ACFs are manufactured from regenerated cellulose (viscose rayon), phenolic resin (kynol), polyacrylonitrile (PAN) and coal tar/petroleum pitch-based fibers. ACF can be used in the form of cloth or felt for absorption. Filament yarn cloth is treated with 5% phosphoric acid at 88°C for about 30 minutes and dried at 100°C. This material is subjected to controlled carbonization in an inert gas atmosphere for about 4 hours. The resulting ACF is cooled to room temperature and activated for specific applications.

Activated carbon fabric is mechanically weak but highly porous in nature. Due to this, it possesses unique characteristics as compared to conventional activated carbon, which is commonly used in granular, pelletized, powdered and moulded form. Due to the thin fibrous shape in activated carbon fabric, fast intraparticle adsorption kinetics take place in gas and liquid phase adsorption. Molecules/atoms of pollutants have an affinity towards the activated carbon fabric surface by physical adsorption at low temperatures. Activated Carbon Fabric is a flexible form of activated carbon. The precursor is carbonized in inert atmosphere after due chemical treatment. Activation is carried out under closely controlled process parameters to get optimum properties. Finally, the product is adequately cooled before it is exposed to the atmosphere. ACF is made up of filament yarn, due to which ACF is electrically conductive and hence it can be regenerated by passing a low voltage current across the ACF surface, or by heating of ACF at 100°C for 15 to 30 min. The distribution of pore size is in the narrow range of <10 nm. Molecules of pollutants bouncing across the activated carbon fabric surface gradually lose their energy and finally come to rest on it. Due to weak bonds in the physical adsorption, molecules can be removed from the activated carbon fabric surface by providing heat energy [1].

According to tests conducted by the division of Toxicology, Central Drug Research Institute, Lucknow, India, the ACF developed

by HEG Ltd, Mandideep, Near Bhopal, India, is very effective in trapping pungent fumes, foul odors and smell of fresh or decaying organic matter of animal origin. Tests conducted at the department of Chemical Engineering, Indian Institute of Science, Bangalore, India found that the 40% lead metal ions are adsorbed by ACF. The Microbiology division of the Bombay Textile Research Association, Mumbai, India, has shown that ACF has good antibacterial activity [2].

Materials and Methods

Since ACF is known for its adsorbent characteristics, an attempt was made to prepare masks in which ACF material is fixed, and the effectiveness of these masks in bringing down the blood lead levels of battery workers was attempted. Such a study has not been reported anywhere in the available literature.

Factories manufacturing storage batteries use large amounts of lead. During these processes, lead fumes are liberated. The fastest means of absorption of lead into the body is through inhalation. Masks are usually worn by workers in such factories to prevent absorption by ingestion and inhalation of these fumes. These masks are usually made of ordinary cloth.

8 workers involved in the manufacture of batteries were initially chosen for this study. ACF material was obtained from Hindustan Electro Graphites Ltd. (HEG Ltd.). This material was cut into small pieces and stitched on the inside of operation theatre masks, with a white linen coating. The ACF was sandwiched between the OT mask and white linen, so that the worker did not come directly in contact with the ACF. This was done to prevent any irritation that could be caused through direct contact with ACF. OT masks were used, because

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Received October 20, 2012; Published December 28, 2012

Citation: Kuruville A, Pillay VV, Adhikari P, Venkatesh T, Chakrapani M, et al. (2013) Indigenous vs. Factory-Made Activated Carbon Fabric Masks to Reduce Lead Absorption-A Pilot Study. 2:606 doi:[10.4172/scientificreports.606](https://doi.org/10.4172/scientificreports.606)

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they are made up of cotton material, and snugly cover the mouth and nose, thereby providing comfort and effectiveness.

6 months before providing the masks, the blood lead level was determined for these workers from the National Referral Centre for Lead Poisoning in India (NRCLPI), Bangalore. This indigenous mask (referred as M1 in this study) was given to these workers and their blood was sent to NRCLPI, Bangalore, in heparinized vacutainers. The workers continued to work in the same place while using the masks. They were instructed to clean this mask, by immersing this mask (M1) in boiling water for 15 minutes. Among this group of workers, there were 3 workers who were on chelation treatment for high blood lead level. It was decided to check the blood lead level of the workers after a month of using the mask.

Six months later, 7 ready to use respiratory masks were provided by HEG Ltd. These masks are marketed by Environ Care Products, New Delhi. In general these masks are expected to absorb obnoxious gases in the environment and capture the fine dust and soft particles. The potential uses include passive subjects such as lay public and active subjects such as traffic police, farmers who spray insecticides and pesticides, painters, cement and stone industry workers etc. 5 of them were mesh masks (referred as M2 in this study) and 2 were breath-o-pollution masks (referred as M3 in this study). Both these types of masks are fitted with exhalation valves. They are soft, non toxic, foldable and can slip into the pocket. They use ACF as a filter. In the case of the breath-o-pollution masks (M3), the filter is detachable and it can be removed for regeneration or replacement, and the external surface is made of plastic. The mesh mask (M2) does not have a filter cartridge and the exterior is made of mesh. It can be degenerated by immersing the mask in boiling water for about 30 minutes. These masks were given to 7 workers, who was already using the previous mask (M1) which had worn out by then. They were asked to use these masks (M2 and M3) for one month, after which their blood lead was drawn in heparinized vacutainers and sent to NRCLPI, Bangalore.

The workers were instructed to clean the masks (M2 and M3) every week by immersing the mask or the cartridge (in case of M3), in hot water for 30 minutes and then dry them. This instruction was given by the authorities of HEG Ltd. as a unique property of an ACF fabric is the possibility to “reactivate” the fabric when it has become saturated, so that it can be used again.

Results

Table 1 shows that there was a reduction in blood lead levels in the

Serial No	Blood Lead level taken six months before giving masks "A"	Blood lead level on the day ACF mask was given "B"	Difference of blood lead before using mask "B-A"	Blood lead level one month after ACF mask was given "C"	Whether on treatment	Difference in Blood lead level after using mask "B-C"
1	68.6	77.9	+9.3	67.1	No	-10.8
2	69.3	77.6	+8.3	74.1	No	-3.5
3	75.6	82.9	+7.3	80.3	No	-2.6
4	59.7	65	+5.3	65.1	No	+0.1
5	66.6	80.3	+13.7	91.8	No	+11.5
6	116.6	91.5	-25.1	76.5	Yes	-15
7	109.1	100.9	-8.2	74	Yes	-26.9
8	101.6	78.3	-23.3	80.1	Yes	+1.8

Table 1: Effect of ACF mask (M1) on blood lead level on battery workers.

Mask	Average Blood Lead before giving mask	Average Blood Lead after giving mask	Difference (%)
M 1	75.26 µg/dl	70.83 µg/dl	-5.9
M 2	82.95 µg/dl	74.1 µg/dl	-10.7
M 3	67.25 µg/dl	71.05 µg/dl	+5.7

Table 2: Effect of ACF masks (M1, M2, M3) on average blood lead levels.

first 3 workers after using the indigenous ACF mask (M1). The blood lead level of the 4th worker did not rise much after using this mask. The 5th worker however, showed an increase in blood lead level, before and after the use of this mask. The last three workers were under treatment for high blood lead levels. There was a substantial decrease in blood lead before using the mask and also after using the same in the case of the 6th and the 7th workers. In the case of the 8th worker, blood lead levels have increased slightly after using the ACF (M1) mask.

While comparing the efficacy of the 3 types of ACF masks used (Table 2), both M1 and M2 have helped in reducing the average blood lead levels. However, M3 has actually increased the average blood lead level.

Discussion

Activated Carbon Fabric is a new generation material with potential for a wide range of novel applications. Capability of Activated Carbon Fabric to adsorb gaseous pollutants to a large extent makes it suitable for personal protection masks, particularly in areas where various gases, fumes, smoke, vapors and odors are present. The HEG Ltd. have shown that chromium, copper, nickel, cadmium, cobalt, lead, zinc, iron, manganese, acids, alkalis and anions such as chlorides, fluorides are easily adsorbed by ACF.

With reference to Table 1, in the case of the first 5 workers, there is an increase in the blood lead levels before using the ACF (M1) mask. In the case of the remaining 3 workers, who were on chelation, there is a decrease in blood lead even before giving the ACF (M1) masks. Since the difference between the first five and the last three is that the latter was on chelation, the reduction in blood lead levels here can be attributed to chelation.

After using the M1 mask, there was a reduction in the blood lead levels in the first 3 workers implying the role of ACF for the same. As regards the 4th worker whose blood lead has remained constant after using the mask, this mask has proved to be useful as a preventive measure. In the case of the 5th worker, there is an unpredictable rise in blood lead even after wearing the masks. His blood lead was on the rise even before using this mask. This rise in blood lead even with and without the mask could be due to some other reason. The possibility that he had not used his mask regularly cannot be ruled out.

Chelation has been a known form of treatment for lead poisoning since many years [3]. Since the blood lead has decreased before and after using the mask in the case of those workers under chelation

(except in the case of the 8th worker who showed a slight increase after using the mask), the ACF mask used here, seems to act like a preventive measure for checking lead poisoning.

According to a study on the effect of chelation on children, the lead which is once deposited in the brain is eliminated very slowly because of its half-life of 2 years in the brain. Moreover, once in the brain, lead cannot be removed by chemical chelating agents. Thus, it is clear that the only way to prevent lead poisoning is to prevent lead from getting into the bodies of the workers. Since the ACF masks have shown to be effective in bringing down the blood lead level, these masks could be introduced among workers who are dealing with lead.

While comparing the three types of ACF masks (M1, M2, M3) used here (Table 2), it was observed that after using the first mask (M1) there was a fall of blood lead level from 75.26 micro gram/deciliter (average) to 70.83 microgram/deciliter (average) (5.9% reduction).

The mesh mask M2 was effective in bringing the blood lead level down by 10.7% (Average blood lead of 82.95 microgram/deciliter to an average of 74.1%).

The breath O mask, M3 however increased the value by 5.7% (from an average of 67.25 microgram/deciliter to an average of 71.05 microgram/deciliter.)

In the first group, there was a modest reduction of 5.9% in the blood lead. This suggests the usefulness of ACF in preventing further exposure, as these workers have been working in the same factory.

The mesh mask (M2) which is also incorporated with ACF is seen to reduce the level of blood level considerably (10.7%).

The breath o mask (M3) however gave a negative result. This increase in blood lead level by 5.7% is an indication that this mask was not effective in preventing the absorption of lead. This may be due to improper fitting, as one of the workers complained of the same.

The indigenous ACF mask (M1) had the advantage of snugly covering the mouth and the nostrils and also not producing any irritation.

Activated Carbon Fabric masks were used for the first time on battery workers to determine their usefulness, and they were found to be useful in preventing further lead exposure.

Acknowledgement

We are grateful to Hindustan Electro Graphics Ltd., Delhi, India, for providing ACF material to make indigenous masks and to Environ Care Products, India for the factory made masks. This work could not have been completed without the consent and support of the battery workers and their employers. We remain obliged to them.

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