

Development of a new filter materials with effective VOCs adsorption and particulate filtration

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Introduction

Inhalation of excessive volatile organic compounds (VOCs) and particulate matter (PM_{2.5}) into body is associated with irritation, headache, endanger the central nervous system, cause dermatitis, and increase liver and kidney toxicity. The air pollution source consists of exhaust from locomotives and automobiles, thermal power plants, industrial exhaust, petroleum fuel combustion, and organic solvents in the central and southern petrochemical industrial areas such as Yunlin and Kaohsiung in Taiwan. To reduce inhaled pollutants, workers and residents in petrochemical industrial areas mostly choose to buy face masks. At present, there is CNS14774 (Medical face masks) in the domestic Standards for PM_{2.5} mask and more rigorous standard CNS15980 (The performance requirements and test method for PM_{2.5} mask). Currently, there is no suitable domestic standard for VOCs adsorption efficiency for activated carbon masks (only cyclohexane detection in CNS14756). Many VOCs adsorption masks (with activated carbon) have been sold in Taiwan, but none of the above products are certified by CNS14756, making the exact VOCs adsorption capacity unknown. Therefore, this study is aimed to develop and evaluate the effectiveness and protection of face masks (which can filter PM_{2.5} and absorb VOCs) for residents in petrochemical industrial areas.

Results

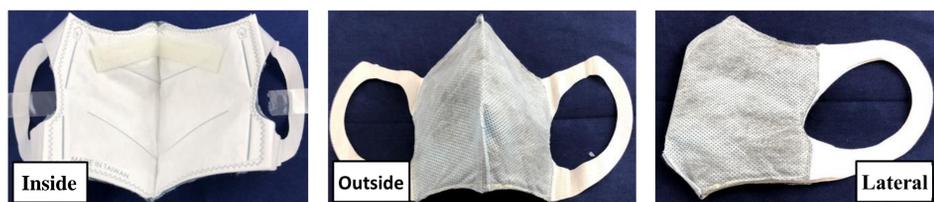


Figure 1. NHRI-PDAPCF-003 face mask. The first layer is made of Polypropylene (PP). The second layer is the newly developed filter (NHRI-PDAPCF-003). The third layer is high-density non-woven fabric made of meltblown. The inner layer is also made of non-woven polypropylene.

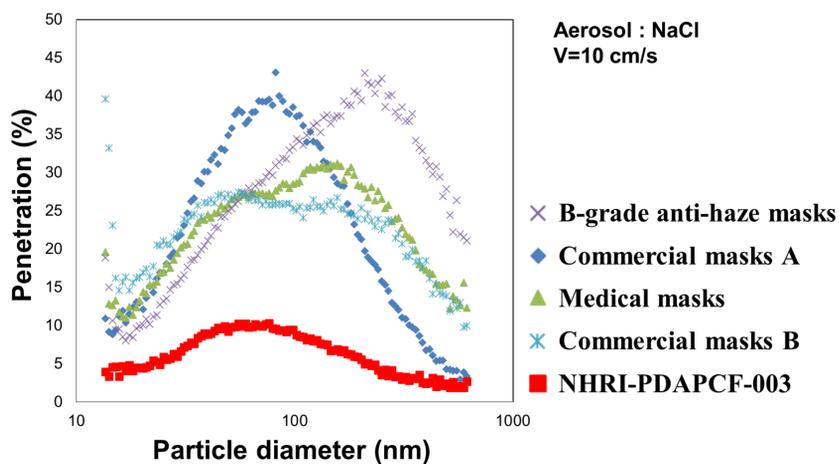


Figure 2. Particle penetration test. NHRI-PDAPCF-003 compares with 4 types of masks on the market: medical masks, B-grade anti-haze masks, and commercial masks (A and B). Only 10% of particles penetrated the filter in 10-1000 nm of NHRI-PDAPCF-003. Compared with other commercial face masks (25%-45%), it shows a good ability to block the penetration of particles.

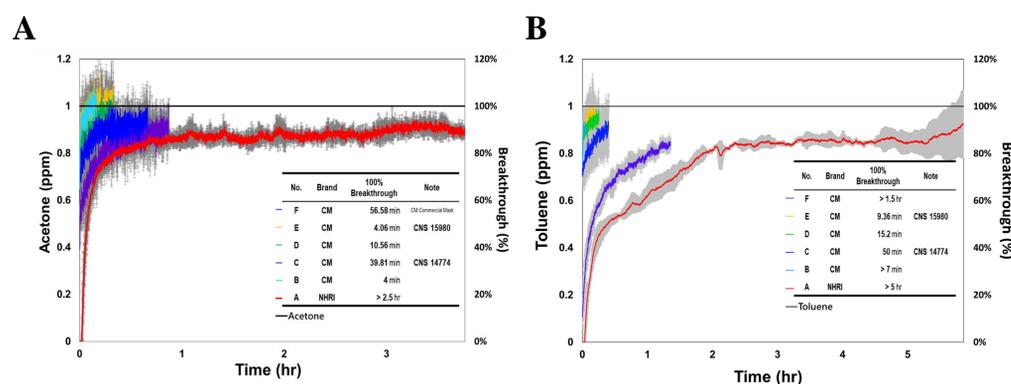


Figure 3. VOCs breakthrough test. (A) 1 ppm Acetone and (B) 1 ppm Toluene. In order to educate local people on how long the activated carbon mask needs to be replaced when they are exposed to the VOCs environment. As VOC emissions in industrial safety and environmental monitoring, BTEX is a good indicator of VOC emissions from various sources. NHRI-PDAPCF-003 compares with 5 types of activated carbon masks on the market (C&D followed CNS14774 or CNS15980). The NHRI-PDAPCF-003 can absorb at least 2.5 hr to 100% acetone breakthrough and even 5 hr to 100% toluene breakthrough.

Reference

- Chen, C. C., & Willeke, K. (1992). Aerosol penetration through surgical masks. *American journal of infection control*, 20(4), 177-184.
- Huang, S. H., Chen, C. W., Kuo, Y. M., Lai, C. Y., McKay, R., & Chen, C. C. (2013). Factors affecting filter penetration and quality factor of particulate respirators. *Aerosol and Air Quality Research*, 13(1), 162-171.

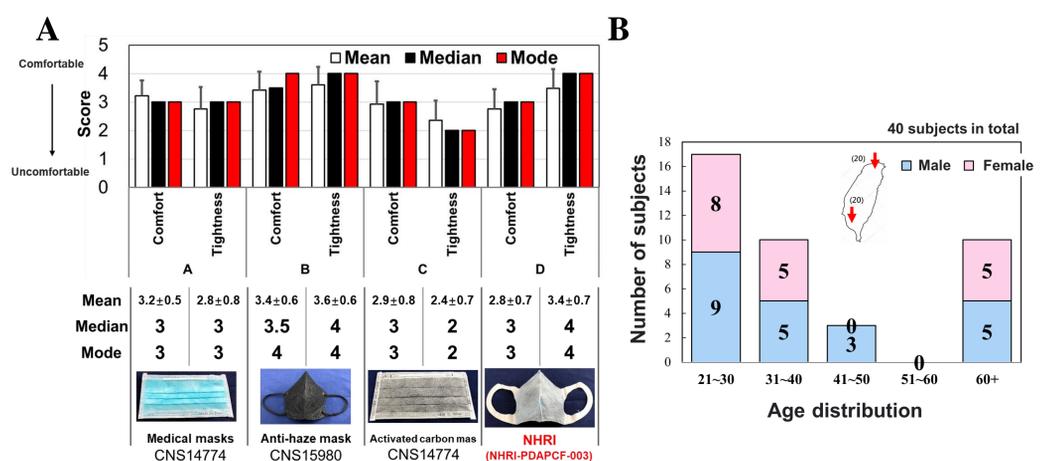


Figure 4. (A) Mask comfort interviews; (B) The age and gender distribution of the IRB Clinical Trials. In order to understand the comfort and tightness of the actual feeling of the NHRI-PDAPCF-003, this study also combined with the IRB Clinical Trials. A total of 40 subjects from Taipei and Kaohsiung was invited to blindly test the wearing of masks and compared the commercial face masks with NHRI-PDAPCF-003. Participants are asked to wear different masks to discuss comfort and tightness through interviews. Record personal comfort and fit with a questionnaire of 4 points. 1 is very uncomfortable or not fit; 4 is very comfortable or fit well. There are four masks are provided, including A. CNS14774 general medical masks, B. CNS15980 anti-haze three-dimensional masks, C. CNS14774 activated carbon masks, D. NHRI-PDAPCF-003 developed by this study. The results show that in terms of the degree of tightness, the median and mode of the B and D (NHRI-PDAPCF-003) both have 4 points, while the activated carbon mask has a minimum of 2 points. In terms of comfort, the median and mode of each mask have 3 points, while B masks have higher comfort levels of 3.5 and 4 points, as shown in Figure 4A. The age and gender distribution of the subjects are shown in Figure 4B.

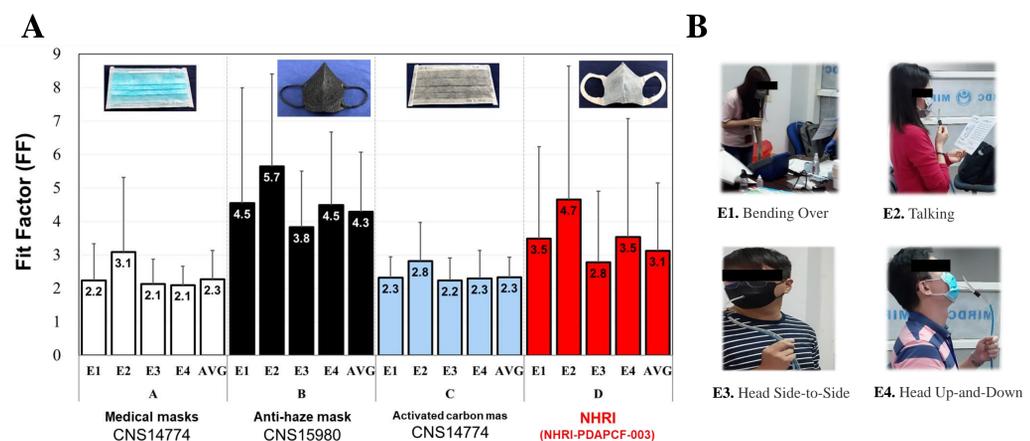


Figure 5. NHRI-PDAPCF-003 face mask

Using ProtaCount to detect the fit factor values of subjects wearing different masks. After the subjects are required to wear masks, they will perform 4 consecutive actions (5B) according to the OSHA fit test in the United States, and monitor the fit factor (FF, Fit Factor). The higher the FF value, the better the fit between the test mask and the face. The results show that the fit factor values of the NHRI-PDAPCF-003 are higher than those of general flat masks, which are the same as the interview results.

Conclusions

- The NHRI-PDAPCF-003 has been optimized and has the dual functions of blocking particles and adsorbing VOCs.
- Particle penetration test and VOCs breaking test show that NHRI-PDAPCF-003 are better than commercial medical or activated carbon masks
- Comfort interview NHRI-PDAPCF-003 is similar to the commercial face masks, and the Quantitative fitness test is better than the commercial face masks.
- The patent application has been completed in the National Health Research Institute, Case Number: S-1090021.