Proceedings of the 8th International Conference of Recent Trends in Environmental Science and Engineering (RTESE 2024)
Chestnut Conference Centre - University of Toronto, Toronto, Canada – June 13 - 15, 2024
Paper No. 110
DOI: 10.11159/rtese24.110

Study on Electrospinning Mmimntf2/Polyacrylonitrile Membrane for Filtration of Volatile Organic Compounds

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Extended Abstract

Coal mining site is considered as one of major sources of air pollutant and carried out damage to the worker [1]. In the process of coal mining, the unique characteristic of operational sites with enclosed spaces require the implementation of heavy machinery and diesel engines [2]. Utilization of these instruments lead to the generation of coal mine dust and high concentrations of volatile organic compounds (VOCs) [3]. Therefore, development of a great management in coal mining for the maintenance of occupational health is important. Coal mining worker often protected by a respiratory protective equipment. Furthermore, commercial respiratory protective equipment typically applies ultrafine fibers which provide low air resistance along with limited pollutant capture capacity and restriction in VOCs removal [4]. This study observed development of respiratory protective equipment using the technology of electrospinning ionic liquid entitled MMImNTf2 / PAN fibers filter.

In this study, membranes with various concentrations of MMImNTf2 (30wt%, 40wt%, 50wt%, 60wt%) were developed and designated as IL30-P, IL40-P, IL50-P, and IL60-P, respectively. These membranes were examined for their morphological characterization through thermogravimetric analysis, Fourier transform infrared spectroscopy, and scanning electron microscopy. The thermogravimetric analysis revealed a three-stage weight loss pattern: IL30-P experienced a 2.2% weight loss up to 315°C, attributed to guest molecule evaporation. The subsequent stage, between 315°C and 518°C, displayed a 32.4% weight reduction, associated with PAN polymer chain dehydrogenation, breakage, and ionic liquid decomposition. Beyond 518°C, a 3.4% mass loss indicated complete decomposition of PAN and the ionic liquid, with a gradual levelling off of mass loss trends. Notably, higher ionic liquid content accelerated sample decomposition between 315°C and 518°C. The SEM images illustrated the morphology and fiber diameter distribution of the four types of ionic liquid composite membranes. With a shift in ionic liquid concentration from 30wt% to 50wt%, the average diameter increased from 300 nm to 500 nm. The respirable dust and methanol have been used to measure the filtration capacity of the different filters. The filtration capacity of the MMImNTf2 / PAN membrane is improved with the increase of the ionic liquid loading amount in the composites. Combination of PAN fibers with 45 wt% MMImNTf2 presented the highest VOC filtration capacity, which was 60.3% greater than that of pristine PAN fibers. Furthermore, this study also conducted a following analysis on the recovery and recycle of the ionic liquid to increase its efficiency and feasibility in real application. The result indicated that the applied ionic liquid could be recovered and recycled in the absorption process up to five times. Thus, the reagent cost during VOCs removal process could be minimized. Therefore, the ideal VOCs exclusion rate of the MMImNTf2 / PAN membrane filter can be considered as a promising candidate for respiratory protection equipment in the mining site.

Keywords: Coal mining dust, Respiratory protection, VOCs, Ionic liquid, Regeneration

References

[1] A. Saravanan, P. S. Kumar, R. V. Hemavathy, S. Jeevanantham, P. Harikumar, G. Priyanka, et al., "A comprehensive review on sources, analysis and toxicity of environmental pollutants and its removal methods from water environment," Science of The Total Environment, vol. 812, p. 152456, 2022/03/15/ 2022.

[2] A. Pronk, J. Coble, and P. A. Stewart, "Occupational exposure to diesel engine exhaust: A literature review," Journal of Exposure Science & Environmental Epidemiology, vol. 19, pp. 443-457, 2009/07/01 2009.

[3] A. Wang, R. Fan, X. Zhou, S. Hao, X. Zheng, and Y. Yang, "Hot-Pressing Method To Prepare Imidazole-Based Zn(II) Metal–Organic Complexes Coatings for Highly Efficient Air Filtration," ACS Applied Materials & Interfaces, vol. 10, pp. 9744-9755, 2018/03/21 2018.

[4] Q. Shen, Z. Lu, F. Bi, Y. Fang, L. Song, Y. Yang, et al., "Effect of actual working conditions on catalyst structure and activity for oxidation of volatile organic compounds: A review," Fuel, vol. 343, p. 128012, 2023.