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Mini Review

Progressive Indoor Air Quality Management Using Nanocomposites Derived Filtration Media

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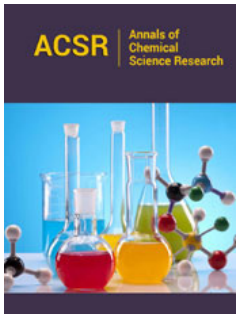

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Abstract

Indoor air pollution has gained attention from research communities due to increasing health risks. Consequently, indoor air quality (IAQ) management has been achieved using various cost effective and efficient clean air technologies. Use of indoor air filtration systems has been considered as an efficient earliest solution to maintain IAQ. Particularly, nanocomposites have been applied in high-performance filtration systems. This mini review article addresses nanomaterials-based filtration technologies for cleaning the indoor air and to attain high IAQ. The important nanomaterials used in this regard include nano-porous materials, membranes, hydrogels, etc. The nanocomposite filtration media based IAQ regulation techniques assisted well to achieve the safe IAQ level.

Keywords: Indoor air quality; Filtration; Technology; Nanocomposite; Pollutants

Introduction

Indoor air pollution in the living houses, residential places, offices, hotels, and other residential buildings badly influence human health [1]. In this regard, the World Health Organization (WHO) claimed that millions of people get affected by indoor pollution annually [2]. Most human beings spend more than 90% of their time indoors [3]. The major sources of indoor air pollution include indoor cooking, heating, cleaning, smoking and other indoor activities. The resulting indoor pollutants comprise particulate matter, aerosol, volatiles, carbon/nitrogen/sulfur oxides, etc. [4]. Due to health risks, there is an intensive need for indoor air quality (IAQ) management technologies. A very important and conventional technology used for indoor air pollutants is the filtration media [5]. The nanomaterials have been focused to form the indoor air filters. Consequently, nanocomposites based indoor air filters have been developed and used in the indoor air filters. Particularly, nano-porous nanomaterials, membranes, and hydrogels have been applied to form the filtration media to maintain IAQ. The future of the filtration based IAQ monitoring depends on the use of novel nanocomposites to remove the indoor air pollutants. In this review, the control of indoor air pollution using filtration media has been surveyed. The filtration media based on nanocomposites have been discussed.

Filtration media for indoor air pollutants

Indoor particulate matter and gaseous contaminants have been found to be a serious hazard to human health [6]. Filtration technologies have been found effective to maintain adequate IAQ level [7]. The materials used in the indoor filters have been considered important

to eliminate the indoor particulate matter and gaseous pollutants [8]. The surface area, mechanical strength, recycling efficiency, and filtration performance have been considered important to achieve a safe IAQ level [9]. Table 1 illustrates some common materials for filtration media for IAQ monitoring. The filtration media generally work on the mechanisms of diffusion and gravity effects. The mechanisms operate to separate particulate matter, volatile organic matter, and harmful gases [10]. It is suggested that the interactions between the filtration media and pollutants improve the pollutant removal efficiency [11].

Table 1: Filtration media to control indoor air pollution.

Material	2D filters	3D filters
Polymer Carbon based material	Sheets or papers	Sponges
Polymers	Fabrics	Hydrogels
Polymers Nanocomposite	Fiber based nets	Sponges/ hydrogels
Carbon materials Nanocomposite	Random meshes	Sponges/ layered structure

Nanocomposites based indoor air filters

Among nanocomposites, polymer-based materials have been used for the indoor air filtration systems [12]. Polymer-based nanomaterials, especially nanofibrous materials, have been applied in the indoor air filters [13]. The polymer nanofibers usually have high surface area, flexibility and mechanical stability [14]. The polymers employed to form the indoor air filters include polyacrylonitrile [15], nylon [16], polyimide [17], poly(vinylidene fluoride) [18], poly(methyl methacrylate) [19], poly(vinyl pyrrolidone) [20] and other polymers. Indoor air filters have been used to filter particulate matter and gaseous molecules. The polymeric fibers for filtration media have been fabricated through the electrospinning method [21]. The polymeric nanofiber filters have high filtration efficiency of >99% for particulate matter and other indoor pollutants [22]. In the polymeric materials, nanoparticles have been included to form the nanocomposite filters [23]. The nanocomposite-based filtration system is shown in Figure 1.

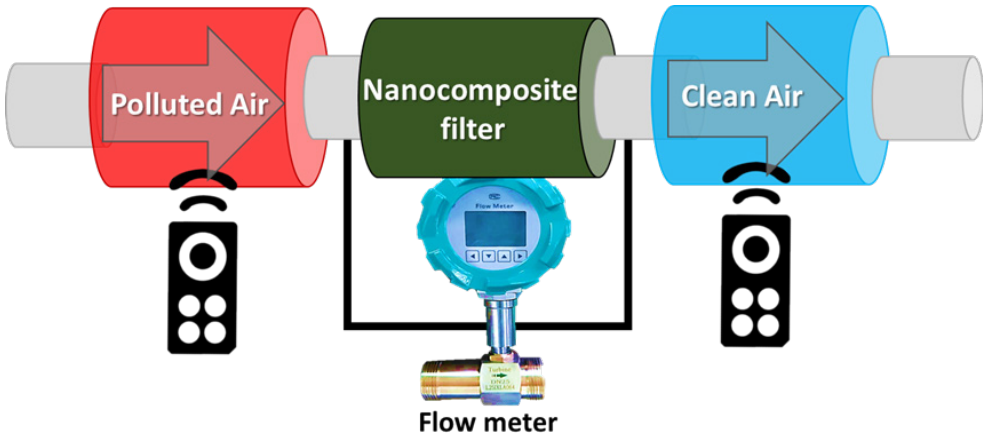

Figure 1: Filtration system with nanocomposite.

Polyacrylonitrile nanofibers have been developed to form indoor air filters using electrospinning process [24]. The filtration efficiency for filtering the particulate matter was >99%. Therefore, the harmful health hazards due to indoor pollutants have been avoided. The polyacrylonitrile/TiO_2 nanofibers have been formed by electrospinning [25]. The nanofiber-based filtration media has high filtration efficiency for the particulate matter. The polyamide 6/nanoclay nanocomposite nanofibers have been prepared by electrospinning [26]. The nanocomposites were used for maintaining the IAQ level. The poly(vinyl alcohol) /nanoclay nanocomposite has also been used for IAQ monitoring [27]. The poly(vinyl alcohol)/silver nanoparticle membranes were formed by electrospinning method [28]. To maintain IAQ level, the filtration media was efficient to separate the reactive oxygen species like OH· radical and H_2O_2. The filtration media was also effective for the removal of *E. coli* and *S. aureus* bacteria. The filtration efficiency was ~99%. Green filters based on cellulose or chitosan nano-filters have also been developed for IAQ monitoring [29,30]. The indoor nanocomposite filter based on the chitosan/polyvinyl alcohol/ halloysite nanotube has been developed [31]. The indoor filtration media had ~97% filtration efficiency for particulate matter. Moreover, the filter was applied to separate the *E.coli* and *S. aureus* bacteria from the indoor air. Hence, the anticipated nanocomposite filters were found promising due to mechanical stability, durability, reusability and filtration efficiency to preserve the high IAQ level, as per WHO standards.

Conclusion

Current filtration technologies for indoor air quality monitoring demonstrates the effectiveness of using advanced nanocomposites. The development of nanocomposites based indoor air filters define the final IAQ level. Use of nanocomposites-based filters in the indoor buildings support the IAQ standards. The future of IAQ monitoring relies on the performance of filtration media in houses, buildings and indoor residences. In short, this review focuses filtration as essential IAQ monitoring technologies. The

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article presents advanced nanomaterials for filtration based IAQ monitoring systems. Application of nanocomposites in the filtration systems opens ways towards safe indoor environment.

Conflict of Interest

Authors declared no conflict of interest.

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