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Mini Review

Indoor Air Quality Treatment Using Polymer Nanocomposite Adsorbents

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Abstract

Indoor air pollution is a great source of health risks for indoor population. Various indoor pollution removal strategies have been developed and employed to enhance indoor air quality. Polymeric nanocomposites have emerged as efficient adsorbent materials for the removal of indoor air pollutants. Conversely, the efficiency of traditional materials in removing indoor pollutants has been restricted due to poor adsorption capacity and low surface area. Predominantly, polymeric nanocomposites have been used to develop high-performance adsorption systems. This review briefly discussed advanced adsorption technologies for purifying the indoor air. Consequently, polymeric nanocomposite adsorbents have facilitated the achievement of safe indoor air quality level. This mini review is definitely helpful for the researchers working in this field to study, develop, and analyze better nanocomposite materials, compared with the traditional adsorbents.

Keywords: Polymer nanocomposite; Adsorbent; Indoor air quality; Adsorption capacity; Pollutants

Introduction

Indoor air pollutants like particulate matter ($PM_{2.5}$, PM_{10}), Volatile Organic Compounds (VOC), oxides of carbon (COx), nitrogen (NOx), and sulfur (SOx) have caused serious threats to human health including allergies, pulmonary diseases, cardiac diseases, cancer risks, etc. [1-3]. To prevent adverse effects of indoor pollutants, technologies need to be developed to improve indoor air quality [4]. Adsorbent materials have been researched for indoor air pollution remediation [5]. Polymeric nanocomposites have emerged as effective adsorbent materials for indoor pollutant absorption and to attain safe Indoor Air Quality (IAQ) level [6-8]. The structure, high surface area, and pore structure of the nanocomposites have been found efficient to remove the indoor air pollutants [9]. Various aspects of pollutant adsorption through nanocomposites have been explored. Incidentally, the mechanism for indoor pollution mitigation using polymer nanocomponent adsorbents has been investigated [10]. This mini review basically comprehends the advantages of using polymer nanomaterial adsorbents, as compared to traditional adsorption materials [11]. This article gives viewpoints on further development of indoor air mitigation technologies using advanced adsorbent materials.

Traditional Adsorbents for Indoor Pollutants

Adsorbents consist of solid substances which have the ability to remove gaseous pollutants through adsorption process [12-14]. In this regard, adsorbents must have a large surface area, appropriate pore dimensions, and strong adsorption capacity [15]. Traditionally, carbon-based adsorbent materials have been used [16]. These materials usually have low cost and good adsorption performance. Common adsorbent materials used are activated carbon [17], charcoal [18], zeolite [19], etc. The pore structure of these materials worked for remediation of air pollution [20]. The mitigation of indoor pollutants like VOC, large particulate matter,

and some noxious gases have been achieved using the traditional adsorbents [21,22].

IAQ Enhancement Using Polymer Nanocomposite Adsorbents

Efficiency of adsorbents for indoor air purification depends on the adsorption capacity of the material used, which is directly affected by their surface area [23-25]. Recently, polymers and polymeric nanocomposites have been researched as low-cost promising adsorbents for indoor pollutants [26]. The amalgamation of polymers and nanoparticles has enhanced the effectiveness of removing the pollutants from air [27]. The polymeric nanocomposite adsorbents have capability to remove particulate matter $PM_{2.5}$, PM_{10}, VOC, dust particles, smoke, and noxious gases like COx, NOx, and SOx [28-30]. Polymer nanocomposites have the ability to adsorb and decompose the indoor air pollutants (Figure 1). On the nanocomposite surface, adsorption mechanisms like physical adsorption (hydrogen bonding, dipole-dipole interactions, hydrophobic interactions, etc.) and chemisorption (covalent bonding) have been found responsible for the indoor pollutant adsorption [31]. Common polymeric nanocomposites used in this regard include polymer/graphene [32], polymer/metal oxide [33], polymer/nanoclay [34], polymer/MOF [35], etc. Thus, the combination of polymer and nanoparticles has been observed as an effective way to purify the indoor air and to attain high IAQ level. Here, the adsorption capacity of nanocomposite was found to have linear relationship with the surface area [36]. Compared with the traditional adsorbent materials [37-39], polymeric nanocomposites have fairly high adsorption efficiency to gain safe IAQ for residential houses and buildings.

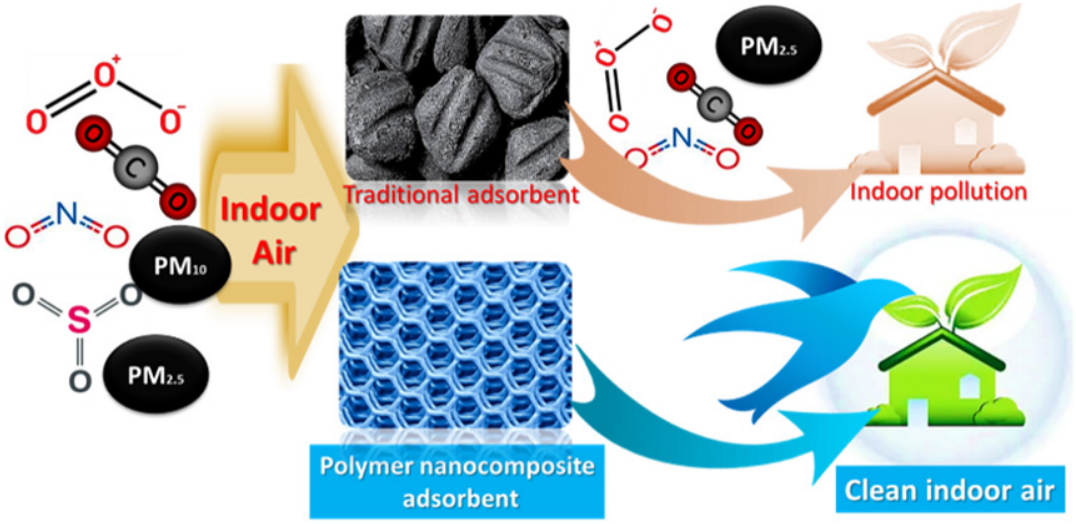

Figure 1: Mechanism of polymer nanocomposite adsorbent adsorbing indoor air pollutants.

According to our analysis, polymer nanocomposite adsorbents possess the advantages of low cost, facile synthesis, high efficiency, wide selection of precursors, and low energy inputs, in comparison to traditional carbon-based adsorbents [40]. Some studies are focused on the lifecycle assessment and economic analysis of polymer nanocomposite adsorbents [41]. Moreover, cost and performance analysis of the raw precursors, solvents, and operation parameters need to be assessed [42]. However, more efforts are recommended for the evaluation of the cost and environmental effects using the experiment and simulation methods [43,44]. All these features help to replace the conventional adsorbents for industrial applications [45,46]. Despite the progress made in this field, several existing challenges and possible solutions can be proposed. For future improvement, more combinations of polymers and nanomaterials need to be developed to efficiently separation of indoor pollutants [47]. Moreover, the synthesis-structure-performance relationships of novel adsorbents must be investigated [48,49].

Conclusion

Traditional adsorption materials possess limits of low adsorption capacity. The adsorption capacity of adsorbents depends on the material type, pores, and surface area. Hence, there is a need to remove indoor air pollution by developing and applying polymer nanocomposite adsorbents. Polymeric nanomaterials have been studied for adsorbing PM, VOC, and noxious gases, due to larger specific surface area and appropriate pore size. Polymeric nanocomposites act as functional molecular materials with ultra-high adsorption capacity for indoor pollutants. Hence, nanomaterial adsorbents have helped to achieve high IAQ for indoor inhabitants and buildings.

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