

PrekotAC As A NEW FILTER AIDS MATERIAL FOR FABRIC FILTER IN AIR FILTRATION SYSTEM

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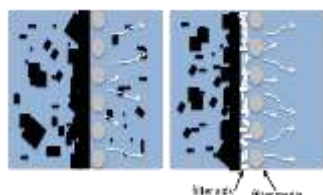
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Graphical abstract



Abstract

Fabric filter has a short life span due to wear and tear influenced by the operating conditions of the system. Treatment of fabric filter using pre-coating material is one of the simplest technique to overcome this problem where it works as a filtration aids that will coat a layer of inert material onto the surface of the fabric. Pre-coating acts as a barrier to block and remove undesired particles from gas stream but allowing a uniform air flow passing through the filter media. The morphology of dust cake that accumulated on the surface of the filter media depends on several properties of the particles such as shape and size. Hence, study presents the characterization of a newly formulated filtration aids known as PrekotAC consisting of a different combination of pre-coating material PreKot™ and activated carbon. The aim is to determine the best combination of PrekotAC admixtures as a filtration aids suitable for a fabric filtration system. Various characteristics of the formulated admixtures such as its particle size distribution, bulk density, moisture content as well as its morphology were investigated and presented in this paper.

Keywords: Filter aids; pre-coating material; fabric filter; PrekotAC

Abstrak

Penapis fabrik mempunyai jangka hayat aplikasi yang pendek akibat daripada fabrik yang haus dan lusuh kesan daripada keadaan sistem beroperasi. Salah satu teknik yang paling mudah untuk mengatasi masalah ini ialah dengan menggunakan bahan 'pra-lapisan' yang bertindak sebagai alat bantuan penapisan yang akan memberi satu lapisan pada permukaan fabrik. 'Pra-lapisan' ini bertindak sebagai 'halangan' untuk menghalang partikel yang tidak diinginkan daripada melalui saluran gas tersebut tetapi membenarkan satu aliran udara yang seragam melalui fabrik tersebut. Morfologi lapisan habuk yang terbentuk di atas permukaan fabrik tersebut bergantung terhadap beberapa ciri partikel seperti bentuk dan saiz. Oleh itu, kajian ini akan menerangkan tentang ciri-ciri alat bantuan penapisan yang baru dirumuskan, PrekotAC yang terdiri daripada kombinasi berbeza di antara bahan 'pra-lapisan' PreKot™ dan karbon yang telah diaktifkan. Matlamat kajian ini adalah untuk mengenalpasti kombinasi PrekotAC yang terbaik dan sesuai untuk diaplikasi pada sistem penapisan fabrik. Pelbagai ciri-ciri bahan tersebut seperti taburan saiz partikel, ketumpatan pukal, kandungan kelembapan serta morfologi telah dikaji dan diterangkan di dalam kertas kerja ini.

Kata kunci: Bahan bantuan penapisan; bahan 'pra-lapisan'; penapis fabrik; PrekotAC

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1.0 INTRODUCTION

2.1 Formulation of PrekotAC

Filter aids is used in air filtration system to fulfil the need to extend the life span of the medium, enhance as well as improve the efficiency of filtration and separation operations. Filter aids may be applied in various ways and pre-coat filter aids is one of the method involved which has been widely used in various air filtration processes. Barnett (2000) states that filter aids has the ability to increase the porosity and reduce the compressibility of the cake thus make the accumulated cake more permeable.

Filter aids such as diatomite, activated carbon, lime and perlite are a common type of material that has been used for so many years in filtration and separation process. Nowadays, it has been used in a wide number of industries including chemicals, food processing, and wastewater treatment (Sulpizio, 1999).

Figures 1 (a) and (b) depict the effect of filter aids as pre-coating material in handling particulate matter from penetrating through the filter media. As can be seen from Figure 1 (a), without filter aids material, extremely fine particles can bleed through the interstices of the fabric which allow some of it to become imbedded in the media and causing blinding of the filter. In comparison, as shown in Figure 1 (b), filter aids has built up an initial dust cake on the surface of the filter media which can reduce the premature failure of new filter media thus prevent blinding and clogging of the filter media by preventing dust particles from flowing into the pores and allows a uniform air flow passing through the filter media. (Li et al., 2002 and Ravert, 2006).

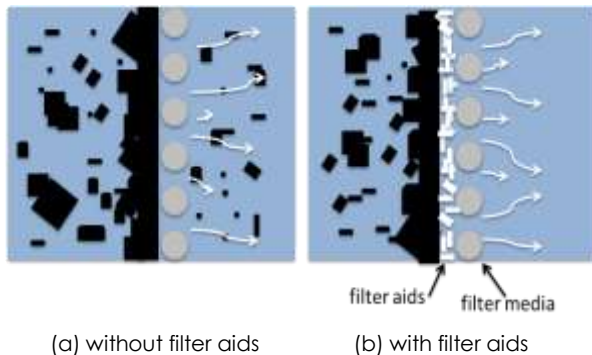


Figure 1 Fabric filtration without and with filter aids. (a) without filter aids and (b) with filter aids

This paper presents a study on the characteristics of a newly formulated filter aids material known as PrekotAC in terms of particle size distribution, morphology, bulk density as well as its moisture content. The characteristics of PrekotAC were then compared with its respective original materials in an attempt to find the most suitable combination of both materials.

2.0 EXPERIMENTAL

2.1 Formulation of PrekotAC

In this study, coal based activated carbon was used due to its readily available and relatively low cost compared to the others (Knaebel, 2012). PreKot™ is a commercially available pre-coating material for fabric filtration system. Table 1 presents the basic specifications of the materials used in the formulation.

Table 1 Specifications of activated carbon and PreKot™

Activated carbon	PreKot™
Form and color: Powder and black	Form and color: Powder and snowy white
Origin: Coal based	Fusion point: 1300-1400°C
pH: 9-11	Softening point: 900-1100°C
Ash content: 8%-max	Thermal conductivity: Less than 0.0500 kcal/mh °C at 0°C
Surface area: 850 m ² /g	

Note: PreKot™ is a proprietary of AMR Environmental Sdn. Bhd.

Activated carbon and PreKot™ were dried in an oven (Memmert, Model UNB 200) for 24 hours at 110°C to discard the moisture content before formulating. Both materials were then mixed through a normal mixing process according to the proposed compositions as listed in Table 2.

Table 2 Formulation ratio of PreKot™ to activated carbon

Ratio (dry wt%) PreKot™:Activated carbon
10:90
20:80
30:70
40:60

2.2 Determination Of Particle Size Distribution

Table 3 presents the three different ranges of particle size distribution applied on each of the sample using a sieving technique (Endecotts shaker, model 2000/2). A 50 g of the sample was sieved for a period of 10 minutes and the particle size of sample on each tray was determined gravimetrically. The sieving test of each material was repeated thrice and the average weight of each of the segregated particle size was taken and plotted. The filter tray size was arranged accordingly, with the largest size tray was placed on the top and followed by the smaller size tray.

Table 3 Particle size distribution ranges

	Particle size (d_p)
1	$d_p \geq 600 \mu\text{m}$
2	$150 \mu\text{m} \leq d_p \leq 600 \mu\text{m}$
3	$75 \mu\text{m} \leq d_p \leq 150 \mu\text{m}$
Bottom tray	$d_p < 75 \mu\text{m}$

2.3 Determination Of Material Morphology

Phenom ProX Benchtop SEM was used to study the physical view of the activated carbon, PreKot™ and all the PrekotAC samples. The samples were tested under various magnifications from 200X to 2500X where shape, size and relative particles size were observed.

2.4 Determination Of Material Bulk Density

The bulk density of the sample was determined based on the Equation 1 (Theydan and Ahmed, 2012). The sample was filled and compacted in a pre-weighed 10 mL standard measuring cylinder up to the specific volume. Then it was re-weighed in order to determine the bulk density of the sample of interest. Each sample test was repeated thrice and calculated based on Equation 1.

$$\text{Bulk density} = W_m/V_c \dots \text{Equation 1}$$

Where;

W_m = weight of the dried material (g)

V_c = volume of the cylinder (10 mL)

2.5 Determination of Moisture Content

The moisture content or water adsorption capacity test of the formulated sample was determined based on a standard measurement (ASTM D2867-09). An approximately 2 g of the formulated sample was placed in a pre-weighed petri dish and exposed to the atmosphere for a period of five days. Then the sample was dried in an oven at 110°C for 24 hours to discard the moisture content in the sample. Later, the sample was removed from the oven and cooled to an ambient temperature in a desiccator before it was re-weighed. The experimental procedure was repeated thrice and the average moisture content was taken. The moisture content of the sample was then calculated using Equation 2 as written below.

$$\text{Moisture content (\%)} = [(S_i - S_d) / (S_i - W_p)] \times 100 \dots \text{Equation 2}$$

Where;

W_p = weight of the petri dish (g),

S_i = initial weight of petri dish with sample (g)

S_d = weight of petri dish with sample after drying (g)

3.0 RESULTS AND DISCUSSION

3.1 Characteristics In Terms Of Particle Size Distribution And Morphology

Figures 2 (a) and (b) are the micrographs of activated carbon and PreKot™, respectively used in the study under different magnification which illustrate the physical view of the raw materials. It is confirmed that activated carbon has a finer particle size fraction

compared to PreKot™ in which the latter has an irregular shapes of a loosely pack material with larger size particles.

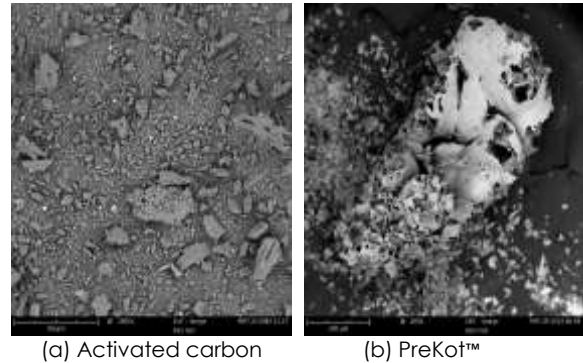


Figure 2 Micrographs of activated carbon and PreKot™ used in the study. (a) Activated carbon, (b) PreKot™

Figures 3 (a), (b), (c), and (d) present the micrographs of the newly formulated filter aids material, PrekotAC under the same SEM magnification which showed that as the ratio of PreKot™ increases, the fine particle sizes fraction presence in the mixture decreases. As shown in the figures, the physical view of the micrographs analysis, for each combination of activated carbon and PreKot™ leads to form a good balance of particle size distribution in the formulated mixture.

Hajar et al. (2013) and Hajar et al. (2014) reported that activated carbon has a very fine particle size distribution compared to PreKot™ where approximately 80% of the former is smaller or equal to 75 μm or $d_p \leq 75 \mu m$. While the latter accounts for only 40% within the size range.

Filter aids that has a substantial amount of fine particle can easily cause blinding and clogging of the filter media which is difficult to remove resulting in higher pressure drop across the filter media (Al-Otoom, 2005). However, filter cake that formed from a filter aids consisting of coarse particle can be easily removed from the filter media as compared to filter aids that has fine particles. This is because it possess sufficient inertia to break free from the filter media during a cleaning process (Leith and Ellenbecker, 1982).

Figure 4 presents the particle size distribution of the formulated PrekotAC which showed that each material fitted perfectly well between the two original materials in terms of their particle size distributions. Thus, it is expected that the mixture would form a porous cake on a filter media, which is a prerequisite for a good filter aids.

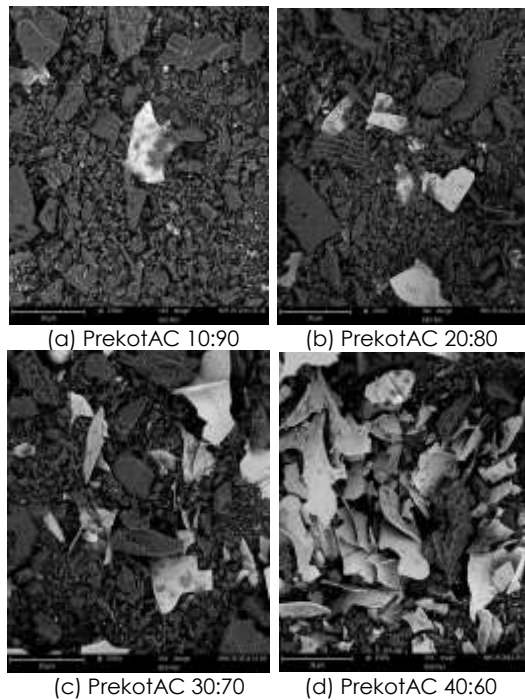


Figure 3 Micrographs of a newly formulated PrekotAC materials. (a) PrekotAC 10:90, (b) PrekotAC 20:80, (c) PrekotAC 30:70, and (d) PrekotAC 40:60.

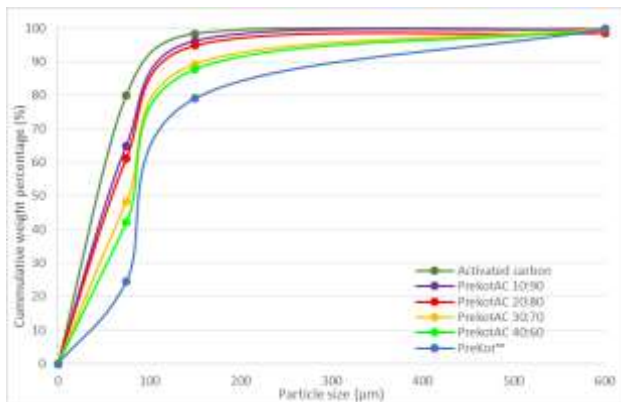


Figure 4 Particle size distribution of raw materials and PrekotAC

It seems that the formulated mixture is not too fine nor too coarse in terms of its particle size distribution that will form a porous and highly permeability cake on a filtration media. This at the same time helps to prevent fine dust from penetrating through the filter media hence increases its filtration efficiency. Furthermore, this will reduce the pressure drop across the filter media which directly relates to the maintenance cost of the filter bag. Thus, applying PrekotAC in the filtration system would help to reduce the maintenance cost by extending the life span of the fabric filter.

3.2 Characteristics In Terms Of Bulk Density

Figure 5 presents the graphical presentation of the bulk density of all the materials which clearly showed that there is a linear trend of bulk density with respect to addition of PreKot™. The raw material, activated carbon has the highest density of 440 kg/m³ while PreKot™ has the lowest density of 119 kg/m³.

On contrary, PrekotAC admixture laid nicely between these two materials with PrekotAC 10:90 has the highest bulk density of 336 kg/m³ and PrekotAC 40:60 the lowest bulk density of 185 kg/m³. As expected, as the amount of PreKot™ in the admixture increases, the bulk density decreases for all PrekotAC materials confirming that PreKot™ has the capability of reducing the bulk density of a PrekotAC and enhancing the porosity of the material for better filtration.

As reported by Simon *et al.* (2010), there is a high possibility that some detached particle might be re-deposited again on the filter media during cleaning process. A similar phenomena was observed by Leith *et al.* (1977) who stated that most of the dust freed from the filter media during process re-deposits rather than falls to the dust hopper. A continuous re-deposition of dust on the filter media increases the pressure drop across the filter cake and media.

It was reported, agglomerated dust that possesses higher bulk density would take shorter time to fall to the dust hopper compared to material with lower bulk density. Hence, in this case, PrekotAC 20:80 and PrekotAC 30:70 could be the ideal mixture between the two extremes densities.

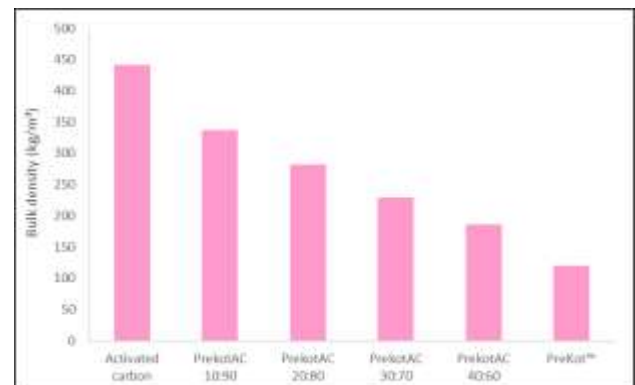


Figure 5 Bulk density of raw and formulated PrekotAC materials

3.3 Characteristics In Terms Of Moisture Content

Figure 6 presents the moisture content of the raw materials and formulated PrekotAC materials after being exposed to the ambient air for five days and oven dried to determine the moisture content. As shown in figure, activated carbon has the highest moisture content of 23% while PreKot™ has the lowest moisture content of 1%. The formulated PrekotAC were consistent in terms of their moisture content with PrekotAC 40:60 presents the lowest and

PrekotAC 10:90 show the highest among these four combinations. It seemed that the adsorption of moisture from the atmosphere is contributed by the presence of activated carbon in the formulation. However, the addition of PreKot™ helps to reduce the moisture content in the formulation which is prerequisite for a good filter aids property.

It was reported that the existence of moisture in activated carbon is conventionally not good for normal applications. Kinnarinen *et al.* (2013) stated that filter aids in air filtration system not only works as a barrier to capture dust but it also help to reduce the moisture content of the accumulated cakes as well as to increase the corresponding filtration capacities. Farzad *et al.* (2007) reported that the existence of moisture, trapped in the activated carbon pores could lead to decrease in the amount of methane adsorption. This is due to the fact that existence of moisture in the adsorbent leads to the occupation of the active sites of the adsorbent which significantly reduce adsorption and desorption process.

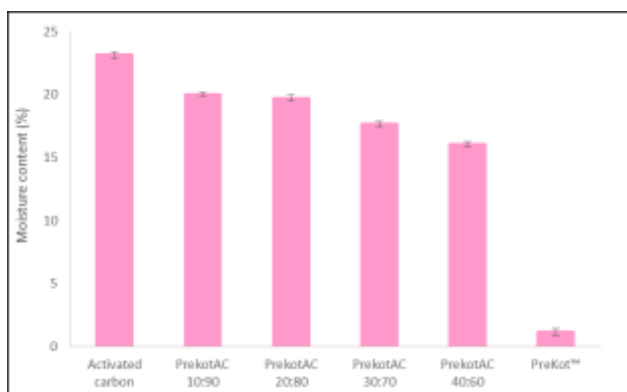


Figure 6 Moisture content of raw materials and formulated PrekotAC materials exposed to the ambient air for a week

In addition, applying a carbon absorbent that contained high water content in filtration process will lead to longer mass transfer zone process which is referring to part where the transfer of the adsorbate from the gas phase to the solid is taking place. Organic molecules to be adsorbed will have to diffuse slowly through adsorbed water to reach the carbon surface if the water content in the carbon absorbent is high (Marsh and Reinoso, 2006).

However, the application of PrekotAC mixture as filter aids and flue gas cleaning agent in a hot environment such as in incineration process may not be influenced by the moisture content of the material. This is due to the fact that the moisture presence in the adsorbent will be quickly evaporated upon in contact with the hot flue gas environment. Thus the performance of the adsorbent is compensated when it is applied in high temperature condition.

4.0 CONCLUSION

The newly formulated filter aids material PrekotAC showed a promising characteristics as a two in one flue gas cleaning agent and pre-coating material. The non-uniform particle size distribution of PrekotAC forms a porous and high permeability cake that prevent fine dust from penetrating through the filter media hence increases its filtration efficiency. In addition, the improvement in terms of its bulk density would reduce the possibility of its re-deposition during cleaning process of the filtration system. The addition of PreKot™ to the PrekotAC admixtures also helps to reduce the moisture content in the newly formulated filter aids. Although with the existence of moisture in filter aids is conventionally not ideal for filtration process, the application of PrekotAC mixture as filter aids and flue gas cleaning agent in hot environment such as in incineration process may not be influenced by the moisture content due to the fact that the moisture present in the adsorbent will be quickly evaporated. Hence, the performance of the newly formulated PrekotAC material is compensated when it is applied in high temperature environment. The characteristics of PrekotAC showed that it presents a good combination as a filter aids and flue gas cleaning agent which is suitable to be applied in filtration processes.

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