FABRICATION OF ACTIVATED CARBON DISC AS FILTRATION MEDIA UTILIZING POLYETHERSULFONE

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Abstract. In this research, we describe the fabrication of activated carbon disc system utilizing activated carbon. The activated carbon is considered as potential adsorbents for the removal of organic compounds and residual disinfectants in water supplies due to its high microporous structure and a high reactivity of their surface. In order to exploit the advantages of activated carbon, we made the activated carbon into a compacted activated-carbon-disc shape (AC-disc). Polyethersulfone (PES) solution was used as bonding agent for the activated carbon powder. Different composition for the activated carbon and PES solution were used to find the best bonding ratio. The AC-discs were then treated under water submersion experiment for 48 hours. The experiment result shows that composition of 100% of activated carbon and 30% PES solution perform the lowest erosion after performing water stream test. The result of filtration test show the mixture of activated carbon with 30% of PES Solution adequate for the removal bacteria as much as 99.99%.

Introduction

Freshwater is a fundamental resource for human well-being and the natural environment; it is regarded as the most essential natural resource in the world [1]. Securing water supplies suitable for human consumption has become an increasingly complex undertaking in many parts of the world, particularly for communities in rural areas of less developed countries. Cholera, typhoid fever and dysentery are known as waterborne diseases, which can cause a number of deaths annually [2]. As a result of the depletion on water quality, the incidence of waterborne illnesses has increased in the last decade, representing up to 13% of the 15 million deaths caused by infection diseases worldwide [3]. In addition, drinking water has been suspected to have small amounts of a large number of synthetic organic compounds such as phenols, pesticides, herbicides, aliphatic, and aromatic hydrocarbons which may endangered human lives [4].

In order to improve the water quality of drinking water, researcher employed activated carbon as one of the filtration agents in water filtering device, due to its property as an absorbent for the removal of organic and inorganic compound from water supplies [4]. Previous research uses starch as a solidification material to form a disc shape activated carbon. However, the disc which was solidified using starch starts to crumble when in contact with water. In this research, we utilized Polyethersulfone (PES) solution to solve

the crumbling problem for the AC-disc. PES solution is a solution to make a PES membrane. The PES solution is widely used to fabricate nanoporous membrane in liquid filtration system. When PES solution is exposed to water, its molecular bond gets stronger and will further form nanoporous membrane which is very useful for filtration purpose. When PES solution is in direct contact with water, it will form a PES nanoporous membrane. Different composition for PES solution to form activated carbon disc is investigated in this experiment. Water stream test to find its weight loss of activated carbon with different ratio of PES solution is also studied.

Experimental Method

Activated Carbon Discs Fabrication. In order to have the activated carbon disc which sustain under the water environment, we solidified the activated carbon powder using insoluble Polyethersulfone (PES) solution. The Polyethersulfone (PES), Polyvinylpyrrolidone (PVP), and 1-methyl-2-pyrrolidone (NMP) were mixed at 20%, 20%, and 60% (wt.%) to form PES solution. The composition of PES solution follows the composition of PES to make a nanoporous PES membrane [5]. Commercial granula activated carbon was grounded prior use to have a fine powder of activated carbon. After grinding, 30%, 40% and 50 % weight of PES solution were added to the weight of the activated carbon to make a homogeneous mixture. The mixture was then compacted with pressure 50 kg/cm^2 in 40 mm diameter of mold to form an activated carbon disc. The discs were then dried at 100°C in a furnace. Once the disc is dry, the discs were then weighted, and its thickness is measured. The surface morphology of the fabricated disc were then observed by using macroscope before tested under water submersion experiment.

Water Immersion Experiment. A small glass was used to deliver the water directly to the tested AC-disc, as illustrated in Figure 1. The next step is to soak the disc in water for 48 hours to tie up a mixture of activated carbon particles with liquid PES. Immersion serves to bind the mix a solution of Polyethersulfone (PES) with activated carbon and test the strength of the bond between the blend. The water submersion testing done for all the activated carbon discs. After one hour test, the discs were dried inside the furnace at 100°C to remove the water content inside the disc. Weight loss ratio (WLR) of the AC-disc were measured according to the equation below:

$$WLR(\%) = \frac{W_b - W_a}{W_b} \times 100\% \quad \text{..... (1)}$$

Where, Wa is weight of the AC-disc before water immersion test, Wb is weight of AC-disc after water immersion test.

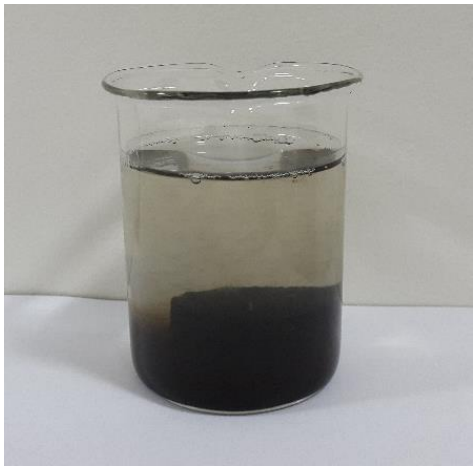

Figure 1. Experiment setup of water immersion test

Result and discussion

Surface morphology of fabricated activated carbon discs

Figure 2 shows the surface morphology of the fabricated AC-disc with different ratio of PES solution. As can be seen from Figure 2, the AC-disc which was made by 50% of PES solution shows a PES glue-like layer on the membrane surface. The more the PES solution used, the more the PES glue-like layer appears on the AC-disc.

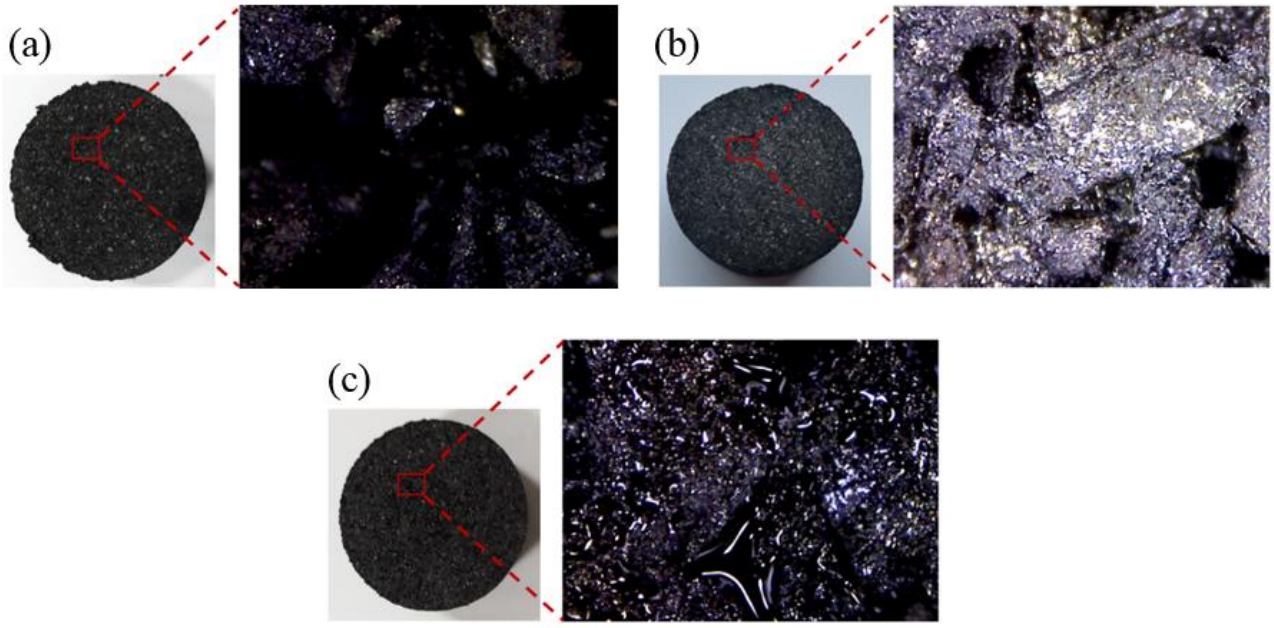

Figure 2 Fabricated AC-discs (a) 30% of PES solution, (b) 40% of PES solution and (c) 50% of PES solution

Table 1 present the result of the weight of AC-discs before and after water immersion test. As shown in Table 1, AC-disc with 50% of PES solution had the highest weight loss ratio, and it even higher compared to the AC-disc with 30% of PES solution. While AC-disc with 30% of PES solution gave the lowest weight loss ratio among other discs. This can be explained that the bond between the AC powder with and PES solution reached

maximum point at 30% of PES solution. Referring to Figure 2, the AC-disc with 50% of PES solution has more glue-like formed layer on the surface of the disc. This glue-like layer on the surface has formed stronger connection between the AC powders as well as preventing it from falling apart due to the water-immersion applied.

Table 1 Weight loss ratio of the AC-discs after the immersion test

No	AC types	Disc weight (grams)		Weight loss ratio (%)
		Before	After	
1	AC-30%PES	25.72	22.42	12.83
2	AC-40%PES	26.9	22.89	14.9
3	AC-50%PES	29.27	24.43	16.53

Filtered river using activated carbon disc

Figure 3 shows the results of river filtration using AC-powder and AC-disc. We used biological and physical parameters in river filtration test. The parameter biological used total coliform, and parameter physical used odor, turbidity, and pH. As can be seen from Figure 3, the AC-disc which was made by 30% of PES solution shows filtered the total bacteria colifom the highest compared to AC-disc with 40% and 50% of PES Solution. The result of filtration total coliform used activated carbon powder show the lowest compared to activated carbon disc. Total coliform test was in the Balai Lingkungan Hidup Yogyakarta by using methods of APHA 2012, Section 9221-B.

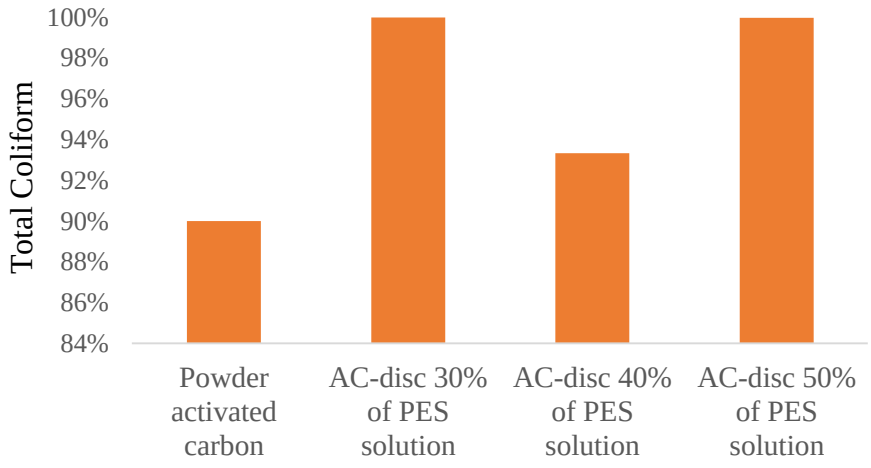

Figure 3. Results of the treatment using AC-powder and AC-disc

Table 2 present the result of filtration total bacteria coliform used AC-powder and AC-disc. As shown in Table 2, AC-powder filtrated total coliform amount 90%, AC-disc with

30% of PES solution filtrated amount 99.99%, AC-disc with 40% PES Solution filtrated total coliform 93.33%, and AC-disc with 50% PES solution filtrated total coliform amount 99.97%.

Table 2 Filtration used AC-powder and AC-disc with parameters total coliform

Parameter	Unit	Result				
		River	AC-powder	AC-disc with 30% of PES	AC-disc with 40% of PES	AC-disc with 50% of PES
Total Coliform	100 ml	240×10^5	240×10^4	140×10^1	160×10^4	540×10^1

Table 3 present the result of filtration used AC-powder and AC-disc with parameter odor. The test of parameters odor was in Balai Lingkungan Hidup Yogyakarta by using methods In House Methods. On the methods In House testing method is done with a sense of smell that is kissed directly smell in water filtration. As shown in Table 3, result of filtration used AC-powder not smell, but filtration used AC-disc with 30%, 40%, and 50% of PES solution had smell. The smell approximately caused compounds of solvents PES solution.

Table 3 Filtration used AC-powder and AC-disc with parameters odor

Parameter	Result				
	River	AC-powder	AC-disc with 30% of PES	AC-disc with 40% of PES	AC-disc with 50% of PES
odor	Not smell	Not smell	Smell	Smell	Smell

Figure 4 present the result of filtration used AC-powder and AC-disc with parameter turbidity. The test of parameters turbidity was in Balai Lingkungan Hidup Yogyakarta by using methods SNI 06-6989.25-2005. The result of test river turbidity 14 NTU. The result of filtration used AC-powder turbidity amount 10 NTU, result filtration used AC-disc with 30% of PES turbidity amount 5 NTU, filtration used 40% of PES amount 4 NTU, and filtration used 50% of PES amount 3 NTU. As can be seen from Figure 4, the AC-disc with 50% of PES solution had the lowest of turbidity compared to the AC-disc with 40% and 50% of PES, and it even higher compared to the AC-powder.

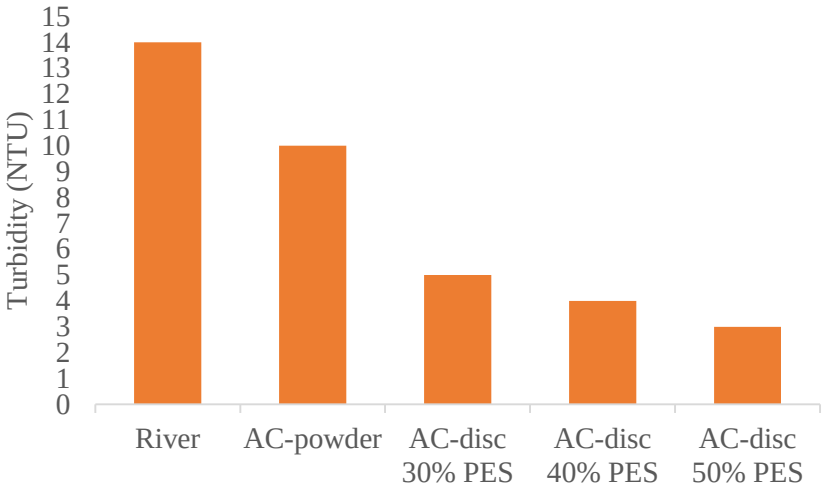

Figure 4. The results of treatment using AC-powder and AC-disc eith parameter turbidity

Figure 5 present the result of filtration used AC-powder and AC-disc with parameter pH. The test of parameters pH was in Balai Lingkungan Hidup Yogyakarta by using methods SNI 06-6989.11-2004. The result of pH test for river amount 6.5. The result of filtration used AC-powder value pH is 7.3, filtration used AC-disc with 30% of PES value pH is 7.7, filtration used AC-disc with 40% of PES value pH is 6.7, and filtration used AC-disc with 50% of PES value pH is 6.5. As can be seen from Figure 5, the result of filtration test using AC-disc with 30% of PES had the highest pH compared to the AC-disc with 40% and 50% of PES, and it even higher compared to the AC-powder. Oxygen on the surface of the active charcoal, sometimes derived from the raw materials or can also occur in the activation process with steam (H_2O) or air. This State usually can cause the charcoal is acidic or alkaline.

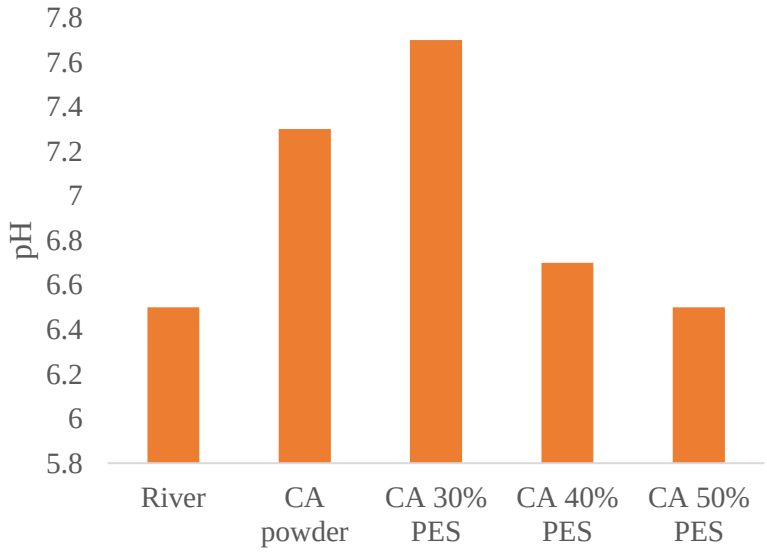

Figure 5. The results of treatment using AC-powder and AC-disc with parameter Ph

Conclusion

Based on the experimental result, we conclude that AC-disc with 30% of PES solution provides the lowest weight loss ratio compared to the AC-discs with 40% and 50% of PES solution. This composition ratio of AC powder and PES solution could be used as fixed composition to fabricate AC-disc. The result of river filtration used activated carbon disc shows the highest adsorption of total bacteria coliform reach 99.99% compared to the powder activated carbon only 90%. The activated carbon disc show the highest adsorption of turbidity reach 3 NTU compared to the powder activated carbon only 10 NTU.

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