JOURNAL OF MULTIFUNCTIONAL MATERIALS & PHOTOSCIENCE
9(2), December 2018, pp. 139-145

Recovery Characteristics of Nanocomposite Fluid Decontamination by Candle Filtration

Seung- Eun Kim, Seon-Byeong Kim and Chong-Hun Jung*

Decommissioning Technology Research Division, Korea Atomic Energy Research Institute, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, 305-353, Korea

Abstract: Effective removal of radioactive contaminants is necessary to prevent worker exposure in the event of dismantling large-scale equipment and large-scale nuclear facilities or large-scale repairs. In the case of complex internal surfaces, it is required to acquire technologies such as decontamination of nanocomposite fluids that are easier to apply than chemical decontamination and minimize secondary waste generation. In the nanocomposite fluid decontamination technology, it is necessary to efficiently treat nanoparticles, which are bubble stabilization substances generated after decontamination, by developing a technology that can further reduce the amount of secondary waste by reprocessing the decontamination waste solution.

In this study, we investigated the effect of surfactant and nanoparticles, which are components of nanocomposite fluids, on the efficiency of nanoparticle solids treatment and economic efficiency. A study on the solid-liquid separation performance of nanoparticles in fluid was carried out.

The turbidity was measured at a constant pressure of 3 to 3.5 bar for the treatment of waste water. The initial turbidity measurement and turbidity of the treated water were measured every 0.5 hour, and the test was conducted by circulating the treated water until the treated turbidity was removed to 99% or more. When a cake layer was formed on the filter and fouling and flow reduction were observed, it was separated after drying.

In order to recover various types of silica nanoparticles, the pore size of the filter was found to be important. during the treatment time of 10 hours, the recovery rate of the cake layer as a filtrate increased with time. It is believed that the surfactant closed the pores of the candle filter to reduce the waste liquid throughput, but the throughput was maintained constant for 10 hours.

Therefore, it was confirmed that the candle filtration method can be suitably used as a method for recovering nanoparticles in a nanocomposite fluid by facilitating the recovery during the formation of the cake layer.

Key words: Decontamination, Foam, Nanoparticles silica, Candle Filtration

* Corresponding author*: nchjung@kaeri.re.kr*

1. Introduction

Effective removal of radioactive contaminants is necessary to prevent worker exposure in the event of dismantling large-scale equipment and large-scale nuclear facilities or large-scale repairs.

In the case of complex internal surfaces, it is required to acquire technologies such as decontamination of nanocomposite fluids that are easier to apply than chemical decontamination and minimize secondary waste generation. In the nanocomposite fluid decontamination technology, it is necessary to efficiently treat nanoparticles, which are bubble stabilizers generated after decontamination, by developing a technique that can further reduce the amount of secondary waste by reprocessing the decontamination waste solution.[1-4)]

The surfactant present in the wastewater generated by the nanocomposite fluid is the most important for the treatment of the waste liquid containing the surfactant since the surfactant causes the foam to be difficult to process [5-8)]. In addition, detergent components such as surfactants generate a lot of bubbles when they enter the river to form a film on the surface of the water, thereby blocking air from flowing into the water. This may inhibit the synthesis of aquatic organisms and aerobic oxidation, thereby reducing the self-sufficiency of water quality.[8-14)] In order to solve the above problems, there are chemical agglomeration method, hydro cyclone method and tubular centrifuge method which are advantageous for small amount treatment. However, it is known that there is a limit in the treatment of oil component and detergent component. Therefore, in order to increase the processing efficiency and the throughput, it is processed using the application technique of the membrane filter method. In general, the filter can be classified into a micro filter, an ultrafine particle filter (UF), and an ultrafine particle filter (NF) according to the size of a particle to be treated. [15)]

The filter type used in this study is a candle filter (precoat type), which controls the pore size of the membrane by adhering target particles to the filter membrane in the pre-filter stage to control the pore size of the filter membrane. Candle filters can treat particles much smaller than the pore size of the membrane (media) by using the solid particles (nanoparticles) contained in the wastewater as a material for the precoat, without using other steric particles. At the beginning of the filtering process, the water quality of the treated water is similar to that of the raw water at the beginning of the formation of the precoat film, and after a certain time, the water quality (turbidity) of the treated water is improved as the coating film is formed.

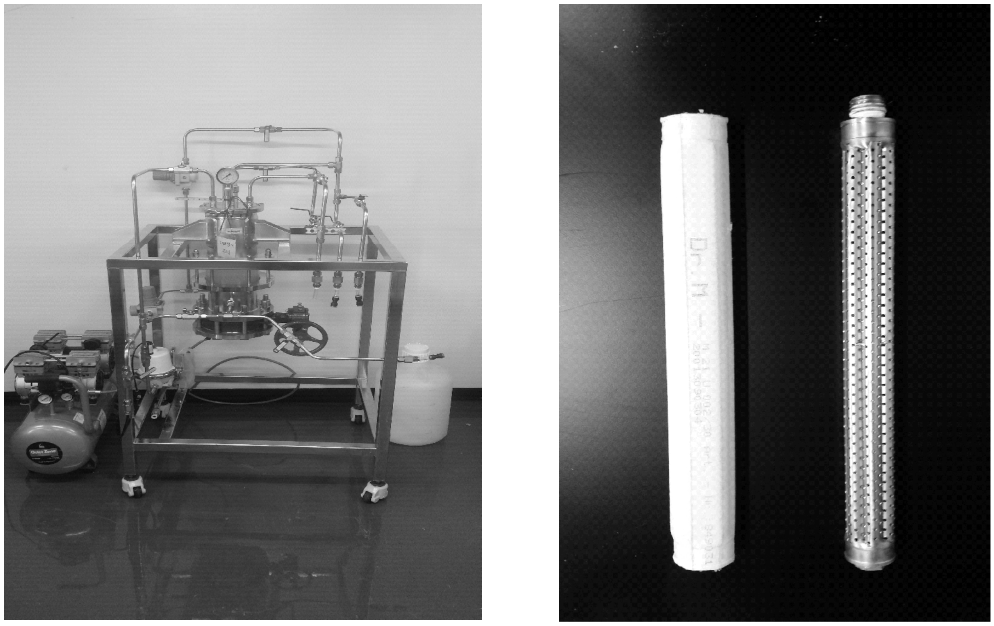
2. Experimental

The main component of the nanoparticle collection device is a high-liquid separator for nanocomposite fluid decontamination waste liquid. Candle filtration method has been found to be capable of collective solid treatment without filtration after filtration. Nano-composite fluid decontamination wastes were prepared using 1% (v/v) Elotant ™ Microslide 100 (EM 100, LG H & H) and 1 wt.% silica nanoparticles (M-5, Cabosil). First, we analyzed the particle size of wastewater to be treated first and examined the filter media to be used based on this analysis. Based on the results of the study, the candle filtration system was established for the pressure filter media specification for solid - liquid separation design, and the filter size, pressure and capacity were set. As it showed in Fig. 1(a), it was made up reaction and injection parts. The filter module located inside the reaction part is loaded with the left media inside the module presented in right side of Fig. 1(b). The filter was M21U002 model of Dr.M, and turbidimeter (DRT-15CE, HF Scientific) was used for separation and recovery of nanoparticles. The primary operation test was carried out by confirming the operation status of the nanocom fluid wastewater at 100 L (feed pressure 2 bar) and confirming the characteristics of the treated water by operating conditions. The first test is operated by setting the feed pressure to the initial 2 bar to maximize the solid removal efficiency. The feed pressure was controlled by the pressure of the static pressure pump and the water quality of the treated water was checked to verify the effect. The feed pressure of 2 bar was found to be low throughput. The relationship between the filtration of fine particles and the pressure was confirmed.

Table 1
Solid-liquid separation technology

Division	*Solid-liquid separation technology*				
	Hydro cyclone	*Tubular centrifuge*	*Membrane filter*	*Cross flow filter*	*Candle filter*
Principle	*Specific weight difference*	*Centrifugal force + Specific weight difference*	*Membrane*	*Ceramicfilter*	*Surface filtration*
Solids removal rate	X	△	○	○	○
Treated water recycling		X	○	○	○
Processing rate		60%	90~95%	90~95%	99%
Solid processing		△	Separate processing	Separate processing	Batch processing

The turbidity was measured at a constant pressure of 3 to 3.5 bar for the treatment of waste water. The initial turbidity measurement and turbidity of the treated water were measured every 0.5 hour, and the test was conducted by circulating the treated water until the treated turbidity was removed to 99% or more. When a cake layer was formed on the filter and fouling and flow reduction were observed, it was separated and treated after drying.



(a) (b)

Figure 1: (a) Candle filtration experiment device, (b) Filter module.

3. Results and Discussion

As a result, the concentration of wastewater was 642.5 ppb, which was higher than expected, but it was judged that the pore size did not decrease because the density of the formed filter layer was low due to the low pressure. The pressure was increased from 2 bar to 3 ~ 3.5 bar and the treated water quality was found to be satisfactory. Therefore, the density of the cake formed in the candle filter is increased, and the effect of decreasing the pore size of the filter can be obtained. Also, it was confirmed that the concentration of waste solution decreased to 2.45 ppb level with increasing pressure. As shown in Fig. 2, in the nanocomposite fluid waste solution treatment, over 99% recovery rate of both the surfactant-containing solution and the non-containing solution was observed over a period of 0.5 hours to 10 hours. In order to separate the silica nanoparticles. Also, the recovery rate of nanoparticles increased with increasing filtration time.

The effect of the surfactant contained in the waste solution was investigated and it was shown in Fig 3. The throughput of surfactant containing solution and surfactant free solution was 0.142 L / min and 0.161 L / min, respectively, during 10 hours treatment time, and the throughput of surfactant containing solution was reduced by about 12%.

Solids treatment method at a pressure of 1 bar showed a water content of 37% due to inhibition of crack formation by cake as shown in Fig. 4, compared with the solid treatment by high pressure drying of 3 bar or more (water content 74%). From these results, and the treated water and nanoparticles were found to be reusable.

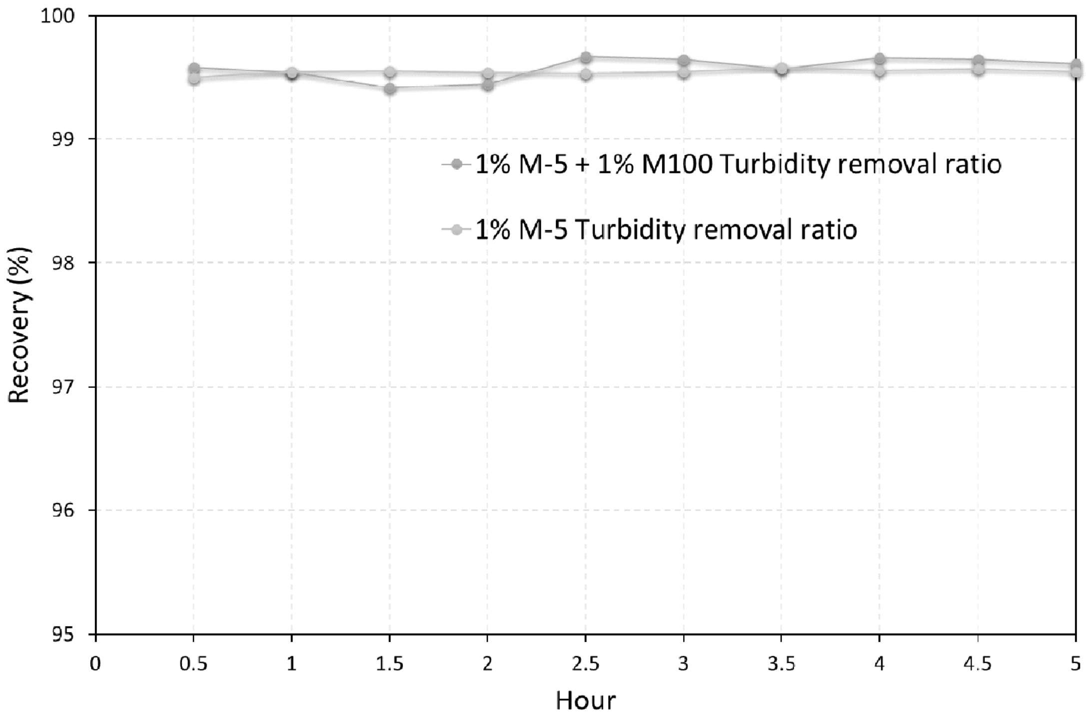


Figure 2: Effect of surfactants on nanoparticle recovery (%).

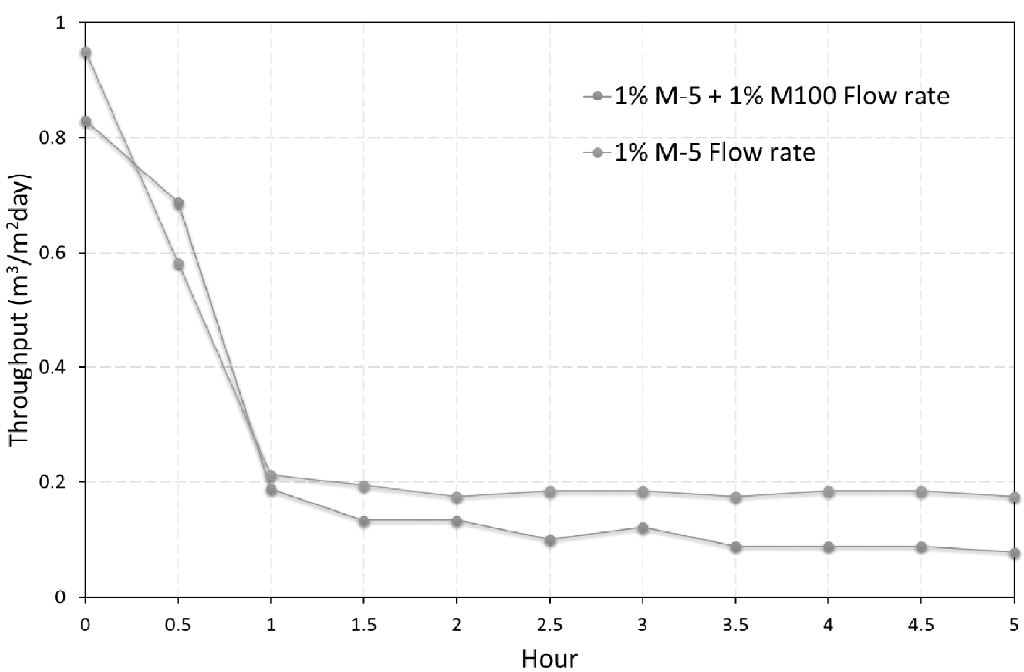


Figure 3: Effect of surfactants on waste liquor throughput.

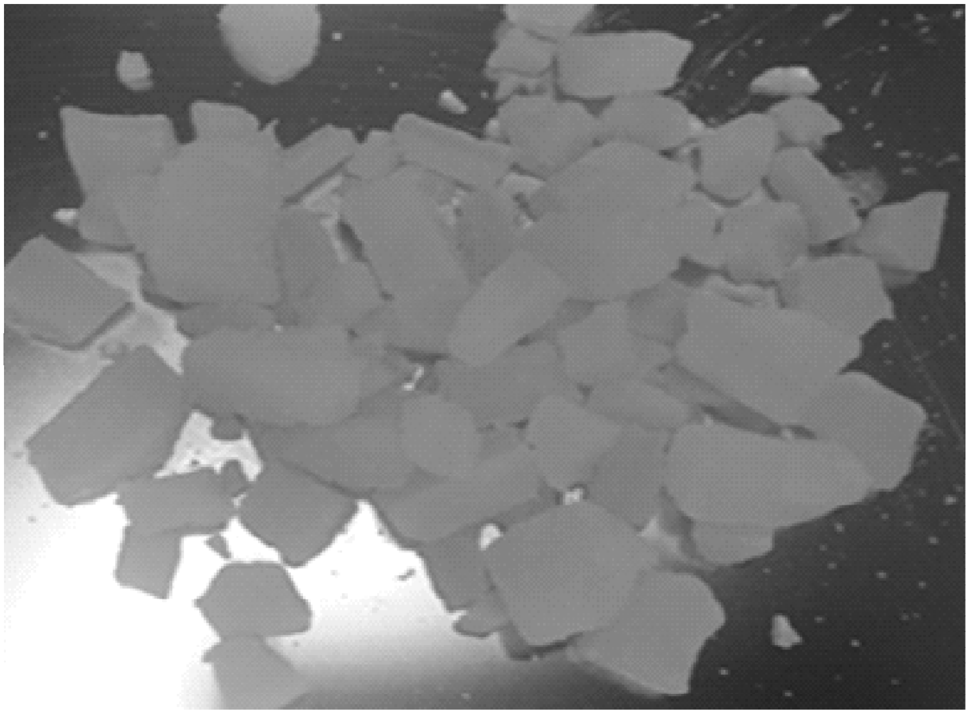


Figure 4: The cake solids treatment

4. Conclusions

In this study, we investigated the solid / liquid separation performance of nanoparticles by using a candle filter, which was proved to be excellent in solubilization efficiency and the type of nanoparticles. The pore size of the filter was found to be important for recovering various types of silica nanoparticles. And During the treatment time of 10 hours, the cake layer appeared to act as a filter body, thereby increasing the recovery rate over time. It is believed that the surfactant closed the pores of the candle filter to reduce the waste liquid throughput, but the throughput was maintained constant for 10 hours.

Therefore, it was confirmed that the candle filtration method can be suitably used as the nanoparticle recovery method in the nanocomposite fluid due to the easy formation of the cake layer during recovery.

References

[1] Kruglyakov, P. M., Taube, P. M., Kolloidn Z., 34, 1972, 228.

[2] Sviridov, V. V., SkrylevIzv, L. D., Vuzov (Gorn Zhurn), 7, 1976, 168.

[3] Binks, B., Curr. Opin. Colloid Interface Sci., 7, 2002, 21.

[4] Gonzenbach, U. T., Studart, A. R., Tervoort, E., Gauchkler, L. J., Langmuir, 22, 2006, 10983.

[5] B.P. Binks, Curr. Opin. Colloid Interface Sci., 7, 21-741 (2002).

[6] I.H. Yoon, C.H. Jung, S.B. Yoon, S.Y. Park, J.K. Moon, W.K. Choi, Ann. Nucl. Energy, 73, 168-174 (2014).

[7] C. Dame, C. Fritz, O. Pitois, and S. Faure, Colloids Surf., A, 263, 210-218 (2005).

[8] EUNDETRAF II, "European nuclear decommis-sioning training facility", project No: FI6OCT- 2003-509070, SCK·CEN, Belgium (2006).

[9] P.M. Kruglyakov, P.R. Taube, Coll. J.-USSR, 34, 194-196 (1972).

[10] G.W. Sears, 28, Anal. Chem. 1981-1983 (1956).

[11] U.T. Gonzenbach, A.R. Studart, E. Tervoort, L.J. Gauckler, Angew. Chem., Int. Ed. 45, 3526-3530 (2006).

[12] T.N. Hunter, R.J. Pugh, G.V. Franks, G.J. Jameson. Adv. Colloid Interface Sci. 137, 57-81 (2008).

[13] C.H. Jung, I.H.Yoon, C.R. Kim, H.B. Yang, W.K. Choi, J.K. Moon, Asian J. Chem. 27, 4254-4256 (2015).

[14] S. Faure; B. Fournel; P, Fuentes. US patent US 7,662,754 B2 (2010).

[15] I. Penfold, R. K. Tucker, and J. Zhang, Langmuir 21 10061 (2005).