Radon Mitigation Efficiency using Nano-size Carbon Colloid

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ABSTRACT

Among the indoor air pollutants, radon gas which is a natural radioactive material is known as the second leading lung cancer cause. 80~90% of infiltrated radon gas is caused by underground soil and foundation under houses, schools and buildings. Also, radon concentration can be worse in case of buildings where there are plenty of cracks on the walls or the floor and where there shows lack of ventilation rate. While in other developed countries and World Health Organisation(WHO) devise active counterplans, Korean government still has not shown a big step.

This study was about producing nano-size carbon colloid and applying it to filters. After the application, radon mitigation efficiency assessment was performed. Meanwhile, the efficiency assessment was compared to one of a normal medium filter and a carbon filter. For this study, the radon chamber designed with a strict condition was used. In case of normal filter and carbon filter, they showed about 22% of mitigation efficiency under high radon concentration. However, the filter treated with nano-sized carbon colloid mitigated about 37% of radon under the same condition.

Keywords: radon, nanocarbon, indoor air quality, lung cancer, air cleaner

1 INTRODUCTION

Indoor Air Quality (IAQ) refers to the effect, good or bad, of the contents of the air inside a structure on its occupants. Generally, temperature, humidity, and air velocity are considered 'comfort' rather than indoor air quality issues. Unless they are extreme, they may make someone unhappy, but they will not make a person ill. Nevertheless, most IAQ professionals will take these factors into account in investigating air quality situations. People nowadays spend about 90% of their daily life indoors, where the concentration of indoor air pollutants such as formaldehyde and most volatile organic compounds can increase and be harmful for people themselves [1-7]. Especially, researchers have found the average concentration of many organic compounds is over 2 times higher indoors than outdoors. In spite of that, the attention to indoor air quality is much less than one to outdoor (ambient) air quality [8].

Radon is a radioactive material and an inert gas which is colorless, odorless and tasteless, hence, it is not easy either to detect or remove this gas. Also, radon was classified as the second leading cause of lung cancer in America. Radon emits alpha, beta partiles and gamma rays during its decay. Once radon goes into human's lung and decays, the lung can get severe effects from those radiations.

Various mitigation methods have been applied to houses where high-concentration of radon gas was detected. Ventilation is a general method to reduce indoor radon intermittently, but cannot last for a long term. Therefore, other processes such as 'Passive/Active Subslab Depressurization (PSD/ASD)' are known for a semi-permanent method for radon mitigation. However, its cost is still 'not-cheap' for installation.

In this study, the goal was to produce nano-size carbon colloids using an electrochemical method and apply them in radon-removal efficiency assessments through a filter test [9]. In addition, the field applicability of filters treated with nano-size carbon colloids was evaluated through a comparison study by using a commercial carbon filter [10].

2 MATERIALS AND METHOD

2.1 Nano-size Carbon Colloids production

Three isotropic graphites are used as electrodes. There is a cathode between two anodes. Two anodes and one cathode between anodes are used to increase the surface of working electrodes and decrease the dimension of the device; thus, the amount of carbon nano colloids acquired is larger than in the case of a 'one cathode - one anode' process. The electrodes used in this study are 65 mm (W), 30 mm (H), and 15 mm (Th). The distance between the electrodes immersed in a bath of distilled water can be varied from 10 to 120 mm. The current density can also be varied from 0.1 to 3 mA/cm^2. The electric power applied to the electrodes is DC 50 ~ 60 V.

The device consists of an electrolytic cell 120 mm (W), 140 mm (H), and 105 mm (Th) that is made of a plastic containing distilled water as an electrolyte, and three graphite electrodes immersed into the electrolyte.

Deionized water is the most preferable to manufacture pure carbon colloids economically. The electrolytic cell is installed on the magnet stirrer, and the electrolyte is passed between the electrodes to provide the electrolyte with carbon particles and to discharge the gas generated by electrolysis from the electrodes.

Figure 1: Nano-size Carbon Colloid production

The working process of the device consists of two stages: the first stage is electrolysis for 10 ~15 minutes, and the second stage is stirring the electrolyte for 30 - 60 seconds. In brief, the operation process consists of activating the anode and generating carbon nano particles.

This process is repeatedly performed automatically by a timer. A twin timer ST-T is used to control of the process. To change each stage automatically, a timing relay (KTM-3M, Koino) is used.

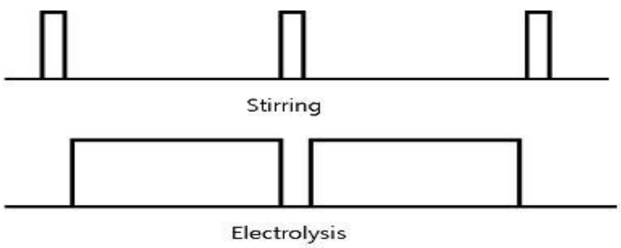

Figure 2: Two stages for NCC production

2.2 Radon Mitigation Efficiency Test

A designed radon chamber was used for this test: (1)emission of high concentration of radon gas into the chamber (2)radon mitigation effiiciency test using each type of filter. A filter applied with NCC(650 ppm) was compared to other types of filter such as carbon filter(which is commercially on stock) and a filter treated with 30% of Grafton(Japan).

Figure 3: NCC filter application

This study was performed with an air-tight plastic chamber, and pre-test was also gone through to check if there is any external factors which can affect steady radon concentration. Temperature and relative humidity were always under steady state to obtain a precise data as much as possible.

Radon concentration test was performed about 48 hours. RAD7(Durridge INC.) was used for detection (calibrated on June, 2011). To enhance the performance of desiccant and to obtain more accurate data, desiccant was baked in the oven before/after radon test.

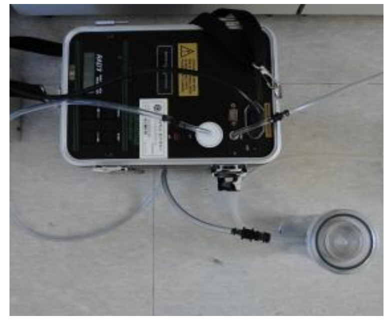

Figure 4: RAD7

Figure 5: Baking desiccant

3 MATERIALS AND METHOD

3.1 NCC production

As the reaction proceeded, the conductivity of the electrolyte increased abruptly. The electric current increased up to 10 ~ 15 mA/cm^2 and higher, and the oxidization reaction activated. As a consequence, the carbon particles were finely separated, and then covered by the carboxyl group. At this stage, the voltage between the electrodes must be low, about 15 ~ 30 V, to decrease the electric current to 8 - 10 mA/cm^2. At a current density bigger than 8 - 10 mA/cm^2, the rate of oxygen evolution was bigger than that of its diffusion through the electrode; thus, there was a pressure build-up within the electrode, causing the electrode to disintegrate. Correspondingly, at a current density less than 8 - 10 mA/cm^2, the rate of oxygen evolution was such that, although some pressure built up in the electrode, the gas was able to diffuse out of the electrode before disintegration occurred – small pieces of carbon broke off in the process to form carbon colloids and very small amount of slurry. As a result, the current increased to 140 ~ 150 mA, the pH of the NCC produced was about 2.8 ~ 3.0, and the TDS or concentration of NCC was about 500 ppm.

Voltage (V)	Current (mA)	pH	TDS (ppm)
50 ~ 60 (First stage)	40	5.6	14
	45	4.6	17
15 ~ 30 (Second stage)	20	4.5	17
	40	3.9	74
	60	3.5	102
	70	3.5	113
	75	3.5	138
	85	3.4	152
	100	3.3	193
	120	3.1	268
	125	3.1	316
	130	3.1	340
	145	2.9	458
	150	2.8	530

Table 1: NCC according to concentration

Figure 6: Splitting Carbon Nano Colloid from the Surface of Graphite Electrode

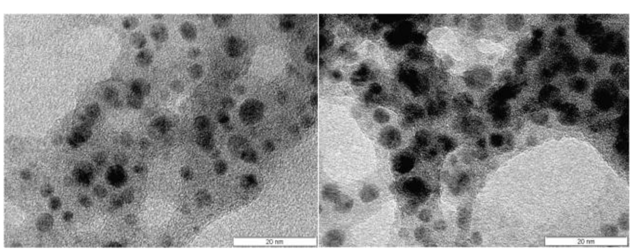

Figure 7: TEM image of NCC

3.2 Radon Mitigation Efficiency Test

3.2.1 Blank Test

To test the chamber if there is any leakage or factor which can affect radon detection in the chamber was performed. As one can see the graphs below, the blank radon level ncreases.

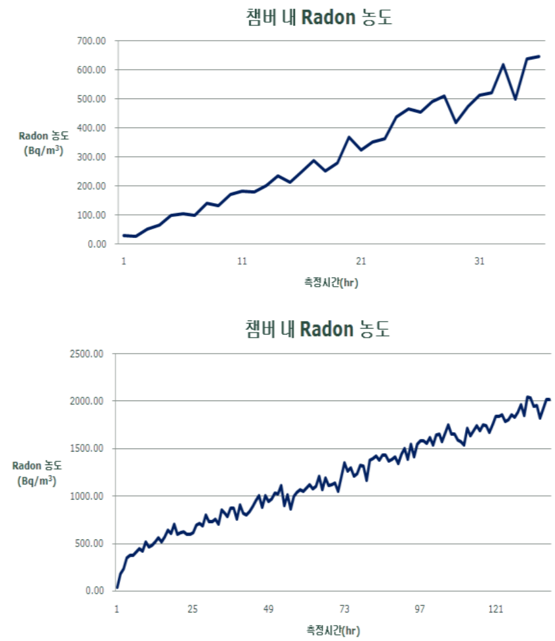

Figure 8: Chamber blank test

3.2.2 Blank filter and 650 ppm of NCC filter

Blank radon level went up to 2007 Bq/m^3, and the radon level decreased to 1558 Bq/m^3 when a blank medium filter was applied. However, in case of 650 ppm of NCC, radon level went down to 1252 Bq/m^3. Medium filter showed about 22% of mitigation efficiency, and 650 ppm of NCC filter showed about 37% of mitigation efficiency.

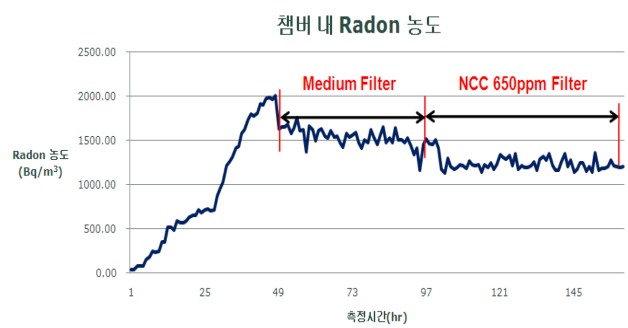

Figure 9: Filter performance test

4 CONCLUSION

Radon is the second leading cause of lung cancer, and there have been numerous trials to mitigate this radioactive gas such as PSD, ASD and ASP. However, those solutions can help with the initial threat, not the radon gas already existing indoors.

Nano-size Carbon Colloid has plenty of surface area, hence, it can be used as indoor gas adsorption. Also, because NCC can be produced cheap and easily, it has a potential in market.

According to above tests, NCC treated filters showed about 37% of radon mitigation efficiency while normal carbon medium filter showed about 22% mitigation efficiency. Considering the high blank radon concentration, that filter reduced plenty of radon gas.

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