A Study on Micro Bubbles Influence on Human Skin Cleaning

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Abstract

The Micro Bubble, which is an air bubble with a diameter under 100㎛, easily sticks to other particles and generates heat and pressure at the moment when the bubble pops. The Micro Bubble can therefore be used to clean vegetables or purify contaminated water. In this research, the influence of Micro Bubbles on skin cleansing has been experimentally examined. To study the influence of Micro Bubbles on human skin, a generator of Micro Bubbles has been applied in the experiment. The effect of Micro Bubbles in skin cleansing and moisture concentration has been proven by measuring the removal of dead skin cells.

1. Introduction

As environmental pollution is deepened by industrialization, the number of patients with atopic skin disease increases, and women care more about skin treatment. Likewise, skin management methods using cleansing are attracting more interest. Skin cleansing generally uses detergents, such as soap, and a body cleanser to remove foreign substances. However, the use of detergents contaminates the water and causes abnormal effects in people who have sensitive skin. To solve these problems, there has been research on the cleansing effects of generating Micro Bubbles in water. A Micro Bubble is a bubble with the diameter under 100㎛, and it lasts longer than a regular bubble because it is smaller[1]. The smaller bubble more easily sticks to the surfaces of foreign substances[2]. Additionally, when a Micro Bubble pops, it generates heat of over 5,000℃ and a pressure of 500Pa for dozens of micro seconds. Thus, it can destroy any adjacent foreign substance[3]. Using this, Lee and Ikeura developed research applying Micro Bubbles to cleaning vegetables[4][5], and Shu utilized the bond characteristics with foreign substances to purify waste water[6]. These research projects focused on studying the characteristics of Micro Bubbles, but bubble generators have limitations due to their size and because of their many components. To apply Micro Bubbles to the cleansing of human skin, based on recent studies, subjective and scientific research must be sustained. In this research, an instrument that generates Micro Bubbles easily and effectively has been proposed, and the removal of dead skin cells and the moisture concentration have been measured in order to know the effects of Micro Bubbles on human skin.

2. Micro-bubble generator

2-1. A principle of micro-bubble generation

In this research project, the Micro Bubble generator has been designed to discover the effect of the bubbles on human skin. The Micro Bubble is temporarily generated by the turbulent flow when liquid passes through a flow channel that has a rapidly fluctuating diameter [7]. Fig. 1 is a conceptual scheme for applying this feature. The turbulent flow has been generated by changing the diameter of pipe 4 between inlet and outlet, and the bubbles have been generated more efficiently by controlling the pressure and the speed of the fluid. According to the size of flow channels D and d, the rate of flow and internal pressure dramatically changes. If the diameter of d continues to decrease, it will not be good for cleansing, because spray ability will deteriorate.

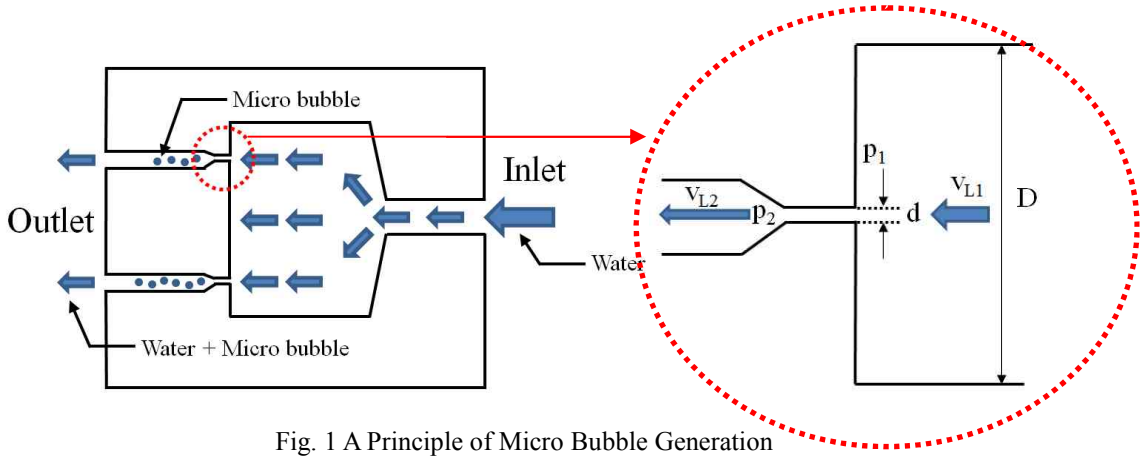


Fig. 1 A Principle of Micro Bubble Generation

As stated above, the fluid generates the turbulent flow while its speed and pressure are changed, and its governing differential equation follows the law of conservation of mass, Equations (1) and (2). The speed (v_{L1}) of the fluid that flows through the flow channel with the diameter of D increases up to v_{L2} when it moves through the flow channel with a diameter of d, and the pressure p_1 decreases down to p_2. In these conditions, the turbulent flow layer is generated, and the quantity of Micro Bubbles generated increases when the activity of the turbulent flow rises[8]. $p_{loss,\ in}$ is the pressure loss, which occurs when the fluid flows into the channel having a diameter of d, and ρ_L refers to supplied viscosity of the fluid.

$$v_{L2} = v_{L1} / \left\{1 - (\frac{d}{D})^2\right\} \tag{1}$$

$$p_2 = p_1 - \frac{\rho_L - (v_{L2}^2 - v_{L1}^2)}{2} - p_{loss,in}$$

$$= p_1 - \frac{\rho_L v_{L1}^2}{2}\left[\frac{1}{\left\{1 - (\frac{d}{D})^2\right\}^2} - 1\right] - p_{loss,in} \tag{2}$$

2-2. Simulation of Micro Bubble Generator Instrument (micro BGI)

To carry out the research, the Micro Bubble Generator Instrument (BGI) has been designed (Fig.2 (a)), and the effects of the fluctuation of pressure and velocity on the fluid of the generator instrument have been experimentally examined using computational fluid dynamics (CFD). The Micro BGI has been designed to have a diameter of 32mm (D) for the input channel and 0.8mm (d) for output channel. The unigraphics (UG) has been applied for design, and CFD analysis was performed with Fluent. Fig. 2 (b) shows the 3D design of the Micro BGI, and the number of the mesh is 484,915.

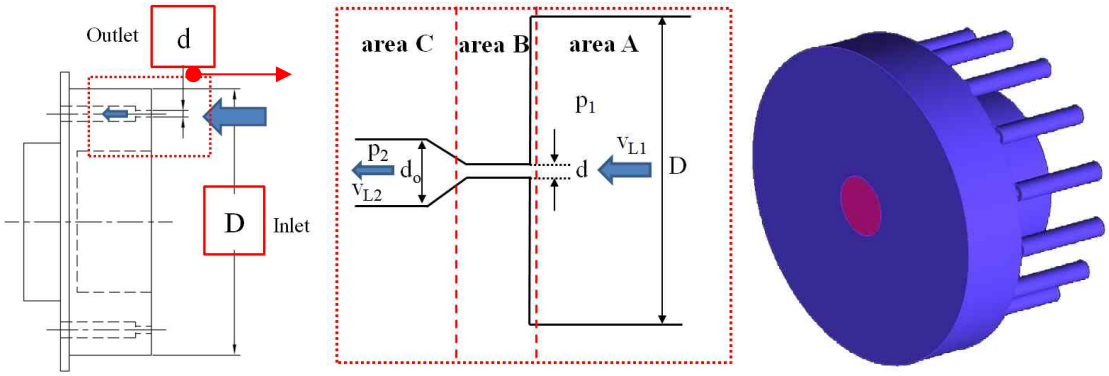


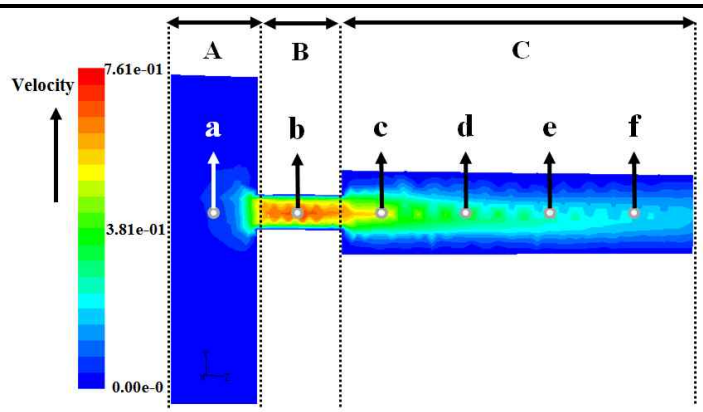
Fig. 2 Micro Bubble Generator Instrument (micro BGI) design and 3D modeling

Table 1. Variables for computational fluid dynamics analysis

Density(kg/㎥)	998.2
Cp(j/kg·K)	4182
Viscosity(kg/m·s)	0.001003
Temperature(K)	298
Inlet Velocity of water flow(m/s)	0.1213(maximum)
Inlet Pressure of water flow(Pa)	300
Q(㎥/s)	1.13866E-05

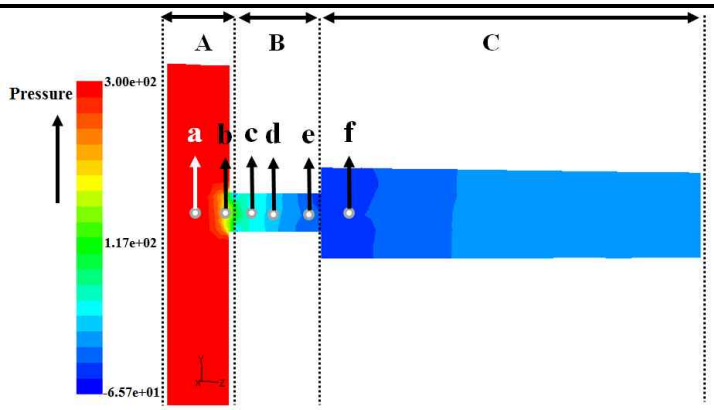
According to the result of the CFD, the fluid that flows from area A with diameter D to area B with diameter d had decreased pressure of 30Pa and an increased velocity of 0.761m/s. The pressure temporarily approached '0', while the fluid does not have apparent changes after passing the area B and being discharged into area C. The fluid increases its speed and decreases its pressure after passing through the flow channel of the proposed Micro BGI. After these changes in pressure and velocity, turbulent flow can be naturally generated, and Micro Bubble Generation can increase. Fig. 3 shows the analysis of the results of fluid behavior for the Micro BGI.

	a	b	c	d	E	f
Velocity(m/s) ×e-01	0.38	7.61	6.09	3.81	2.28	1.14



(a) Velocity results of the Micro BGI

	a	b	c	d	E	f
Pressure(Pa)	300	190	44	25	-10	-65



(b) Pressure results of Micro BGI

Fig. 3 Fluid behavior analysis of Micro BGI

2-3. The bubble generation ability of micro BGI

As Fig. 4 shows, all clinical tests of the proposed Micro BGI have been applied to the shower tool and experimentally examined. However, the Micro Bubble is too small to see with the eyes, so LASER diffraction phenomenon has been used. The LASER diffraction method measures particle size distribution by using the diffraction phenomenon. Thus, the scattering intensity is proportional to particle size and the scattering angle is inversely proportional to particle size. In this research, bubbles in the fluid with sizes from 0.08㎛ to 1,400㎛ have been targeted to be measured after absorbing a fixed amount.(Fig. 5) The size and quantity of bubbles can be measured. The quantity of Micro Bubble generated differs with the pressure and velocity of the fluid. Therefore, the pressure was varied from 1kgf/㎠ to 4kgf/㎠ in order to analyze the Micro Bubbles.

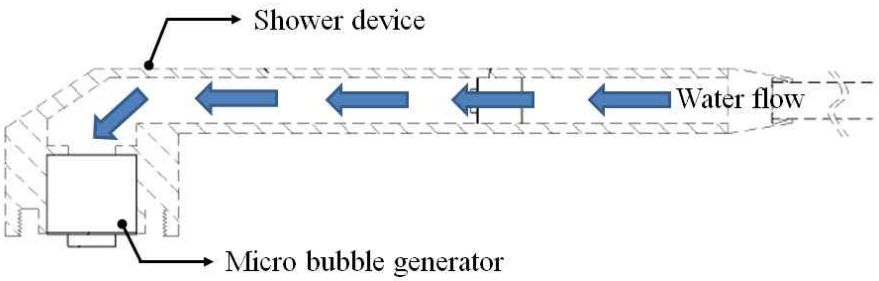


Fig. 4 Application of the Micro Bubble Generator

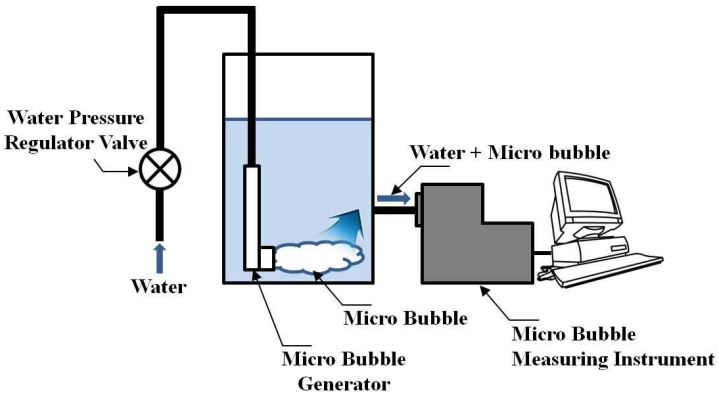
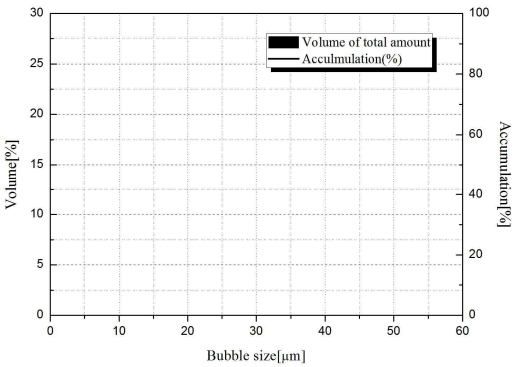
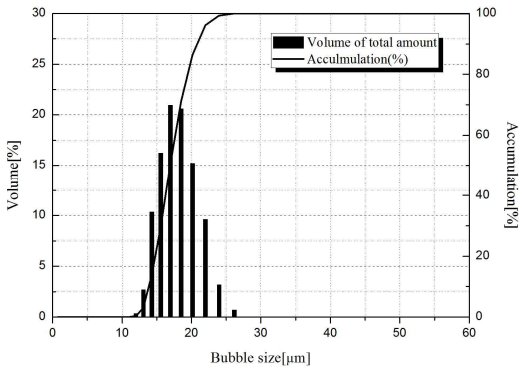


Fig. 5 Schematic illustration of the Micro Bubble measuring system

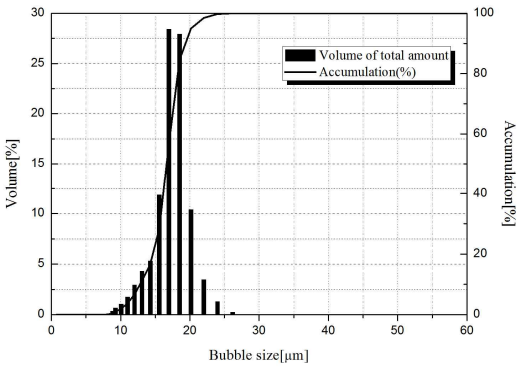
According to the results of measuring the generated Micro Bubbles with a LASER diffraction measuring instrument, there were no bubbles at a pressure of 1kgf/㎠. However, the initial bubble was observed at 1.5kgf/㎠. The quantity of bubbles increased at 2kgf/㎠ compared with Case 2, and the size of each molecule seemed to have become smaller. At a pressure of 3kgf/㎠ or 4kgf/㎠, enough bubbles were generated and the size of the bubbles varied. The Micro BGI generates bubbles at pressures over 2kgf/㎠ and is recommended to be used with pressures exceeding 3kgf/㎠. Moreover, all of generated bubbles were Micro Bubbles with diameters under 100㎛. Fig. 6 is the result of experiments regarding the generation of Micro Bubbles in accordance with pressure changes.



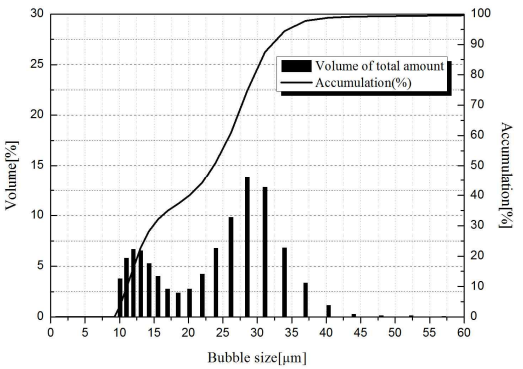
(a) Case 1 : Pressure (1kgf/㎠) at Inlet



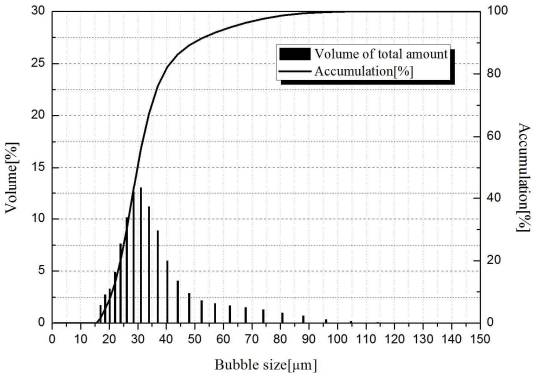
(b) Case 2 : Pressure (1.5kgf/㎠) at Inlet



(c) Case 3 : Pressure (2kgf/㎠) at Inlet



(d) Case 4 : Pressure (3kgf/㎠) at Inlet



(e) Case 5 : Pressure (4kgf/㎠) at Inlet

Fig. 6 Micro Bubble measurement according to fluid pressure

3. Body skin cleaning test using Micro Bubbles

To analyze the effect of Micro Bubbles on human skin, the skin cleansing results of using the shower device with the Micro BGI and the general shower device have been compared for normal subjects. Ten women from 20 to 49 years old (36.7±9.2 on average) were picked from many volunteers. To analyze the influence of skin cleansing, the removal of dead skin cells after cleansing, and the cleansing efficiency for cosmetics have been referred to compare each shower devices. All clinical tests were performed based on the Good Clinical Practices and SOP of Dermapro Col., LTD, which is the organization that regulates clinical tests.

3-1. Removal of dead skin cells

To measure the removal of dead skin cells, dead skin cells from the cheek have been harvested and analyzed using the Black D-squame, which is a tool to be used to harvest skin samples, after using each shower device. Harvested skin samples were analyzed via pixels on the surface area taken by dead skin cells using an optical microscope, which magnified them 700 times the original. Table 2 shows the experimental results of each shower tool. According to the result, the quantity of dead skin cells was proven to be decreased by the cleansing, and the cleansing was more effective when Micro BGI was applied.

Table 2. Analysis image of skin scaling before and after cleansing

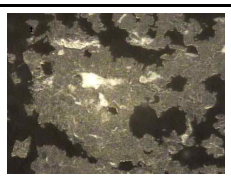
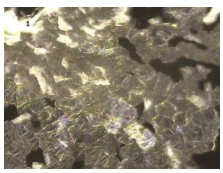
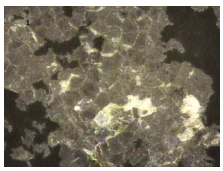
	Before cleaning	After cleaning
Micro BGI		
Non-micro BGI		

Fig. 7 shows a graph of the number of pixels taken by dead cells before and after cleansing. 17.83% of dead skin cells were removed after using the shower tool with the Micro BGI, and 17.11% were removed by the normal shower device. The improved effect of utilizing the Micro Bubbles has been discovered.

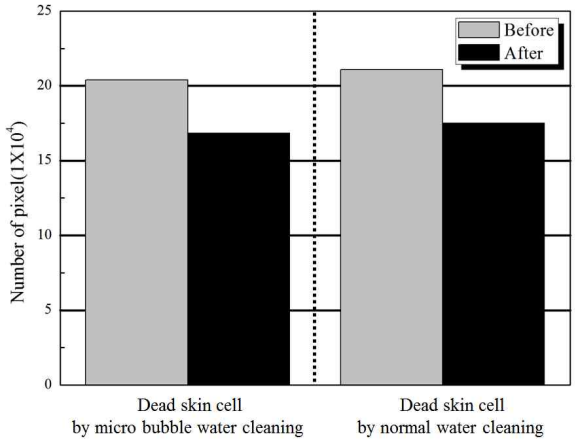


Fig. 7 Dead skin cells number according to the product applied

3-2. Skin moisture analysis

When the skin becomes dry, pruritus and inconvenience are felt first, and more serious skin troubles, such as infections and bedsores, can occur later. The moisture concentrations were compared via values obtained by using a Corneometer(CM825) after using each shower tool. The Corneometer measures the capacity of the condensing load of the electric current that is conducted by an electrode separation attached to the skin's surface, and the figure becomes higher when the skin has a greater concentration of the moisture, because the moisture concentration is proportional to the capacity of the condensing load[9]. The measure unit is the Arbitrary Unit, which is a relative value of moisture concentration. Fig. 8 shows the moisture concentration before and after cleansing. According to the results of the experiment, the moisture concentration increased by about 1.35% after using the shower tool with the Micro BGI. However, the general shower tool decreased moisture concentration by about 1.56%. Therefore, it has been proven that Micro Bubbles are helpful to raising the moisture concentration on the skin.

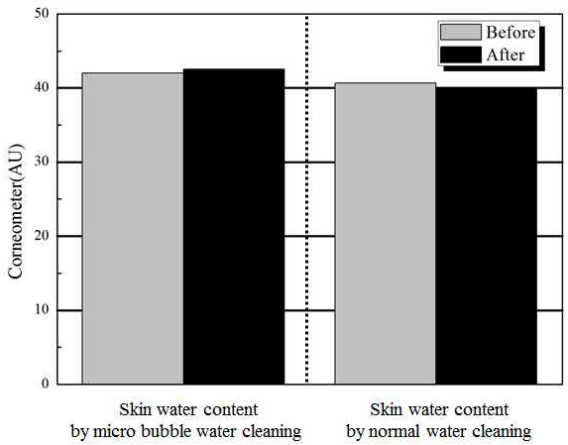


Fig. 8 Skin water content according to the product applied

4. Conclusion

In this research, a Micro BGI has been proposed, and using this, a study of the effect of Micro Bubbles on human skin has been completed. Since the proposed Micro BGI generates enough bubbles in pressures over 3kgf/㎠ and the pressure of water for family use is about 3kgf/㎠, the situation is quite encouraging. The cleansing effect of Micro Bubbles was determined the removal of dead skin cells. For pure water, the effect of skin cleansing appeared as a 17.11% removal of dead skin cells. However, it was 17.83%, a 0.72% increase, when Micro Bubbles were utilized. Moreover pure water reduces the moisture, but the Micro Bubbles were proven to increase moisture concentration by 1.35%. According to these results, the Micro Bubble is not only effective for skin cleansing, but also effective for skin moisturizing in that it increases moisture concentration. Thus, Micro Bubbles are proven to be beneficial for skin health.

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