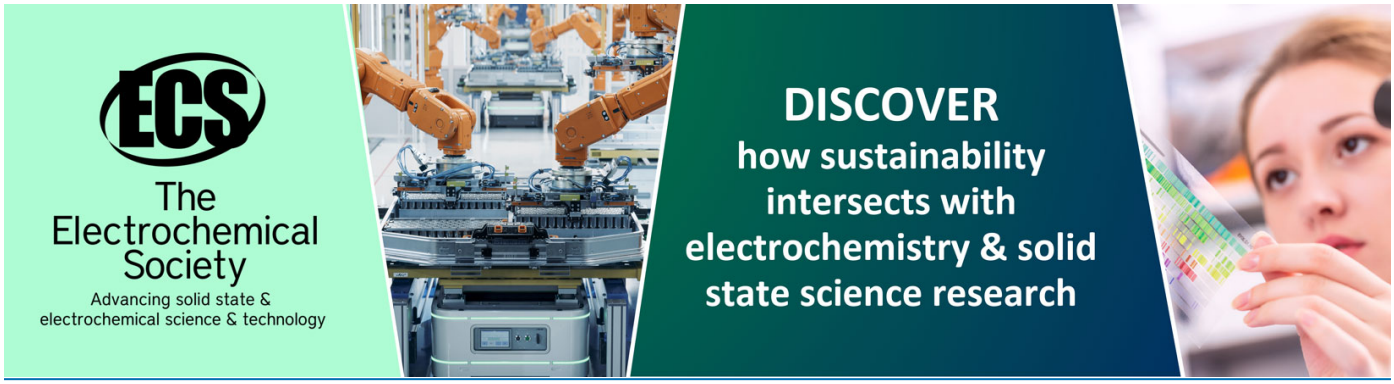
Research on Performance of a New-Type Percolation Equipment Used to Extract Effective Medicine Components



Research on Performance of a New-Type Percolation Equipment Used to Extract Effective Medicine Components

Juan Li*, Jun Wu, Xiaochun Wang

School of Environmental Science and Engineering, Suzhou University of Science and Technology, Jiangsu, China

*Corresponding author e-mail: lijuan@mail.usts.edu.cn

Abstract. A new-type of multi-layer percolation equipment was developed and utilized to extract effective component of a certain traditional Chinese medicine. Porosity and penetration rate of 100-mesh medicine powders were measured respectively. Moreover, the superiority of the performance of such equipment over single percolation method and repercolation method was studied where the total solids content in percolated fluid was utilized as the evaluation index. The results show that for 100-mesh medicine powders, porosity and penetration rate of medicine powder layer both decrease with the increase of particle layer height; total solids content in percolated fluid of 100-mesh medicine powders is high, and the new-type multi-layer percolation equipment has the best performance in the extraction of effective component in the medicine.

1. Introduction

Percolation is a significant stage during extraction and separation of effective components in traditional Chinese medicine, the principle is to extract such components by the solvent flowing through medicine layer. In traditional percolation equipments, it is required to ground the medicine material to be coarse powders, and the stack thickness shall not exceed 6~7 times of the diameter of percolation bottle. Or else, the solvent shall flow slowly with imperfect extraction performance and large consumption of solvent[1].

In recent years, percolation technology has been developed and improved rapidly, especially in the aspects of improvement of percolation efficiency, decrease of system energy consumption and saving of solvent[2,3]. In literatures [4] and [5], two kinds of traditional Chinese medicine are chosen to carry out percolation experiments, the results showed that the best percolation effect was achieved when medicine materials were ground into coarse powders and mid-coarse powders respectively. In literatures [6], retention rate of effective component was taken as the evaluation index, and volumetric percentage and usage amount of percolation fluid ethanol, particle size of powders and percolation speed were taken as the influencing factor, so as to optimize the percolate technology of a certain traditional Chinese medicine. In literatures [7], the best condition for percolation technology is to grind the medicine into coarse powders, 95% ethanol fluid was used as percolation solvent, percolation speed was 1mL/min. However, the research mentioned above is still aimed at conventional percolation equipment, and the operation and running parameters are used for optimization.

In this paper, in order to extract effective component in traditional Chinese medicine, particle size distribution and particle layer characteristics of 100-mesh fine medicine powders were measured by sieving method. Meanwhile, a new type of multi-layer percolation equipment was designed and its

performance advantage over traditional single percolation method and repercolation method was studied, so as to provide theoretical basis for selection of percolation technology as well as to direct production practice.

2. Equipments and Materials

The equipments include SF-20 medicine powder pulverizer, WZ-400 vibration sieve for pharmaceutical purposes, ZLPG-25 granulating machine for spraying desiccated Chinese medicine powder, DW-68DP micro-differential pressure transmitter, evaporating dish, weighing cell and graduated cylinder.

Materials include prescriptions of traditional Chinese medicine, pure ethanol solution without water and the ethanol solution with the volumetric percentage of 47%; in addition, diatomite is added during drying of medicine powders, so as to shorten the drying time.

3. Measurement of Medicine Powder Layer Porosity and Penetration Rate

Firstly, porosity of medicine powder layer was measure. 100-mesh fine powders are weighted and then added into 0.5L graduated cylinders, the stack thickness is 0.05m, 0.10m and 0.15m, respectively. The density of medicine power layer is calculated according to the mass of volume, and the density prior to pulverization is founded in Chinese Pharmacopoeia. Porosity of medicine particle layer is calculated at various stack thickness as follows:

$$\varepsilon = 1 - \frac{\rho}{\rho_0} \tag{1}$$

Where, ε is porosity of medicine particle layer, %; ρ is the density of particle layer at different stack thickness, kg/m^3; ρ_0 is the density of particle powder prior to pulverization, kg/m^3.

Then, 95% ethanol fluid flows through conventional percolation bottle to measure penetration rate of medicine powder layer. Flow rate of ethanol is 1.2×10^{-3}m^3/h. penetration rate of particle layer is calculated according to Equation (2). Where, △P is the pressure drop when ethanol flows through particle layer, Pa; μ is viscosity of ethanol fluid, 2.89×10^{-3}Pa·s; Q is volumetric flow of ethanol fluid, m^3/s; L is stack thickness of particle layer, m; A is area of percolation layer.

$$\Delta P = \frac{\mu}{K} \times Q \times \frac{L}{A} \tag{2}$$

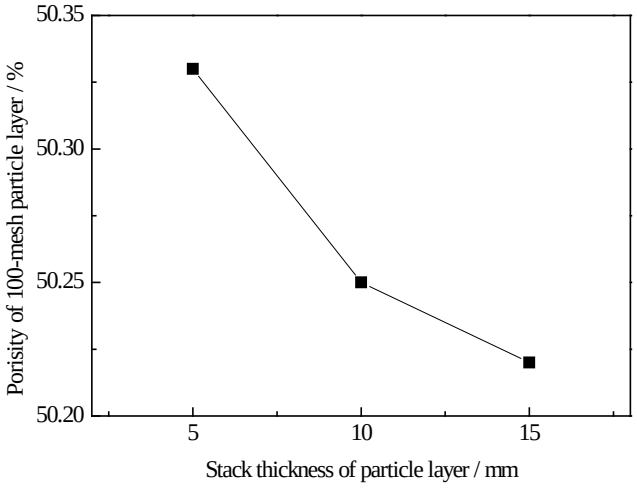


Figure 1. Measurement results of particle layer porosity

Measurement results of porosity of particle layer is shown in Fig.1, stack thickness is 0.05m, 0.10m and 0.15m, respectively. It can be seen that, porosity decreases gradually with the increase of stack thickness in all situations. That is because when stack thickness increases, particle layer is further compressed under the gravity action of particles above, which results in the decrease of porosity.

Furthermore, for 100-mesh fine particles, particle size distribution is uniform relatively, small particles are not liable to embed into the pores among large particles, which leads to increase of porosity.

Measurement results of penetration rate of particle layer is shown in Fig.2. Average penetration rate of 100-mesh particle layer at three different stack thickness is calculated to be $3.86\times10^{-11}m^2$, which means flow resistance for ethanol fluid is high. Meanwhile, penetration rate decreases with the increase of stack thickness, such trend coincides with that of porosity, and it is both because the particle layer is compressed and flow resistance increases. Furthermore, stack thickness has more significant influence on the finer particles[8].

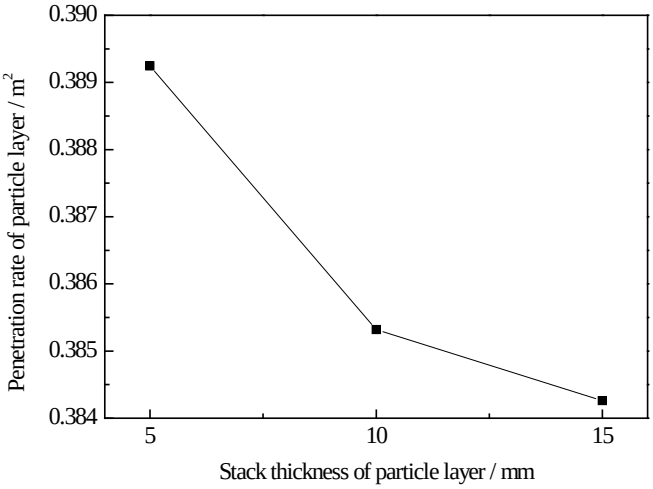


Figure 2. Measurement results of particle layer penetration rate

4. Design and Performance Measurement of Multi-layer Percolation Equipment

It can be conclude from above measurement results of penetration that the flow resistance of ethanol fluid in traditional percolation bottle is high. Therefore, a new type of multi-layer percolation equipment is designed in this paper, as shown in Fig.3. Percolation equipment has cylindrical shape, with total height of 0.8m and diameter at the bottom of 0.3m, and it is made of tempered glass. At the direction of height, the equipment is divided into 4 layers, stack thickness of particle powders on each layer is fixed at 0.15m. Solvent distribution appliance is installed above particle powders. Meanwhile, at vertical direction, each layer is divided into 16 independent modules with equal distance. Solvent spray nozzle is installed above each module. Each layer has the racking structure of drawer, medicine powder module can be taken out, installed and demounted separately. Because high concentration difference is maintained between ethanol solvent and medicine powder all the times, effective components in the medicine powder can penetrate into the ethanol solvent rapidly. Therefore, the percolation efficiency and system reliability are both higher[8].

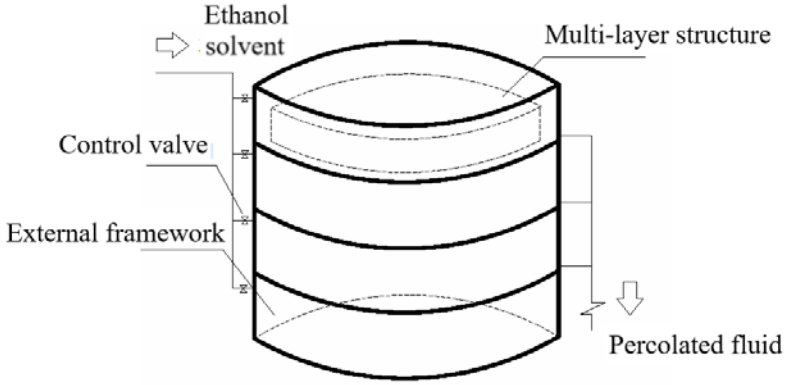


Figure 3. Schematic diagram of new-type multi-layer percolation equipment

In order to measure and determine the performance of the new-type percolation equipment, according to prescription dosage of traditional Chinese medicine, 100-mesh fine medicine powders are

utilized to carry out new-type percolation, traditional single percolation and repercolation experiments and make comparison. Ethyl alcohol with volumetric percentage of 47% is used as solvent. Every experiment is repeated for 6 times. Percolation effects of such three kinds of percolation methods are compared by the index of total solids contents in percolated fluid.

Measurement results of total solids contents in percolated fluid are shown in Table 1. It can be seen that in three kinds of percolation equipments and technology, total solids content in percolated fluid for 100-mesh fine powders are relatively high, which means the more finer the medicine powders are ground, the more adequate extraction of effective component in the medicine, and the higher the extraction efficiency. The reason is that when medicine powder particle is fine, its specific surface area is large relatively, the contact area with ethyl alcohol solvent is larger at the same stack thickness, so the percolation performance is favourable. Furthermore, new-type multi-layer percolation equipment has the highest total solids contents in percolated fluid, which means it has the best extract effect at the same stack thickness. The reason is when medicine powers are divided into 4 layers, ethyl alcohol solvent can flow through the medicine powders in an uniform manner, the flow resistance is not so high, and high concentration difference is always maintained between ethanol solvent and medicine powders. While in traditional percolation equipments, when ethyl alcohol solvent flows to the bottom part of percolation bottle, it has already lost a large part of extraction capacity, which results in a low extraction efficiency.

Table 1. Measurement results of total solids contents in percolated fluid during three kinds of percolation methods (%)

Sample No.	Single percolation method	Repercolation method	New-type multi-layer percolation method
1	0.762	1.086	1.736
2	0.759	1.083	2.077
3	0.702	1.172	1.5221
4	0.639	1.112	1.4167
5	0.833	1.155	1.5779
6	0.902	1.065	1.5872
Average	0.766	1.112	1.653

5. Conclusions

In order to improve extraction efficiency of percolation technology, a new-type percolation equipment is designed and tested. A certain traditional Chinese medicine was taken as the material to carry out percolation experiments, such material is ground to 100-mesh fine particle powders. Porosity and penetration rate of the medicine powders are measured and calculated. Then, total solids content in percolated fluid is taken as the index to evaluate the performance advantage of the new-type percolation equipment designed over traditional single percolation method and repercolation method. Such new-type percolation equipment has the shape of cylinder, and is divided into 4 parts along the height direction.

According to measurement and calculation results, it can be found that porosity and penetration rate of medicine powder particle layer both decreases with the increase of stack thickness. Average penetration rate of 100-mesh fine powders is $3.86\times10^{-11}m^2$, and stack thickness has larger influence on such rate.

Compared with single percolation method and repercolation method, the new-type multi-layer percolation equipment acquires the maximum total solids content in percolated fluid due to large concentration difference between medicine powder and ethyl alcohol solvent. It is evident that such new-type equipment has large performance advantage and can be applied to actual production practice.

6. Acknowledgments

This work was financially supported by National Natural Science Foundation for Youths of Jiangsu Province (No. BK20170382) and the Technology Research and Development Program of Suzhou (SNG2018048).

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