Orthogonal regression experiment based on electroporation regeneration of macroporous silica gel

Changzheng Zhao [a], Xiaoyu Liu [b] and Changping Mu [c]

School of Shandong University of Science and Technology, Qingdao 266590, China;

[a]2751787023@qq.com, [b]1596638274@qq.com, [c]805837633@qq.com

Abstract

Regeneration of solid desiccants by electro-osmosis effect caught more and more attentions due to its energy saving、Environmental protection and safety in recent years. In this paper, the change of current during the electroosmosis regeneration of macroporous silica gel was used as the experimental index, and the orthogonal regression experiment was designed with voltage and moisture content as the influencing factors. The experiment established a polynomial regression equation between each factor and the experimental index, and analyzed the comprehensive influence degree of each factor on the experimental index. The results show that the macroporous silica gel has obvious electroosmotic effect at higher water content and suitable voltage. The experimental method provides a new idea for the study of electro-osmotic regeneration of solid desiccant.

Keywords

Macroporous silica gel, electro-osmosis regeneration, orthogonal regression.

1. Introduction

Macroporous silica gel is currently used more and more in air dehumidification in civil, chemical and coal mine fields. In order for the silica gel to be recycled, it must be regenerated. The traditional thermal energy regeneration method [1] consumes a lot of energy, and in order to meet the requirements of environmental protection, energy conservation and safety, the method of electroosmotic regeneration has received more and more attention [2-3].

The orthogonal test design is called orthogonal design. It is a method of scientifically arranging and analyzing multi-factor experiments using orthogonal tables. It is an experimental design and experimental data processing method that combines the advantages of orthogonal design and regression analysis. Through reasonable experimental design and fewer experiments, an effective mathematical model can be established, which can select appropriate experimental points within the experimental range of factors, and use less experiments to establish a high-precision, statistically good regression equation. Solve the problem of experimental optimization. Orthogonal regression experiment

Applied to the analysis of macroporous silica gel electroosmotic regeneration effect, it provides a useful reference in the field of research on the application of solid desiccant electrodialysis.

2. Orthogonal Regression Experiment

2.1 Selection Of Experimental Indicators.

The greater the water output of silica gel under electroosmosis, the better the electroosmotic regeneration effect. In some cases, the dehumidifier thickness, voltage, moisture content of the desiccant and other factors did not appear regenerating water, but it could not be explained. There is no electroosmotic regeneration effect of the desiccant. The current i generated in the process mainly consists of two parts, namely, the current i1 generated by the ion flow and the conduction current i2 of the water. Therefore, in this paper, the change of current is taken as the experimental index, because the conduction current i2 does not change substantially during the whole process, and the desiccant can be determined according to the current i1 generated by the change of the current i during the test, that is, the ion flow. The electroosmotic effect and the migration of moisture, the larger the current i, the stronger the electroosmotic effect.

2.2 Experimental method.

The orthogonal regression experimental device is shown in Fig.1. The experimental index is the current y. There are two main factors affecting the experimental index: voltage (V) and water content (g/g) [4]. Combined with the experimental research and reference to previous studies, the voltage has a great influence on the electroosmotic effect. The higher the voltage, the better the electroosmotic effect. Because of the Joule heating effect and electrode corrosion, the voltage range is 30 V to 60 V. It is known from Zhang Guiying et al. that the macroporous silica gel has a saturated water content of 1.13 g/g at 95% relative humidity and a small change in current at a water content of 0.9 g/g. The electroosmotic effect is not obvious, so the water content ranges from 0.9 g/g to 1.13 g/g. On this basis, the value of each factor can be measured by the device. The specific experimental methods are as follows:

(1) Measurement of voltage: Both ends of the silica gel are connected to the positive and negative poles of the DC power supply respectively. During the experiment, the voltage value is changed, the change of the current is observed, and the water output in the beaker is recorded, and the data collected by the data acquisition instrument is recorded.

(2) Determination of the water content of the silica gel: The water content of the silica gel was measured by a weighing method. During the electroosmotic regeneration process, the silica gel reacts with polar water electrochemically, and the electrical conductivity of the solution can be tested by a conductivity meter to further understand the electroosmotic regeneration effect of the silica gel.

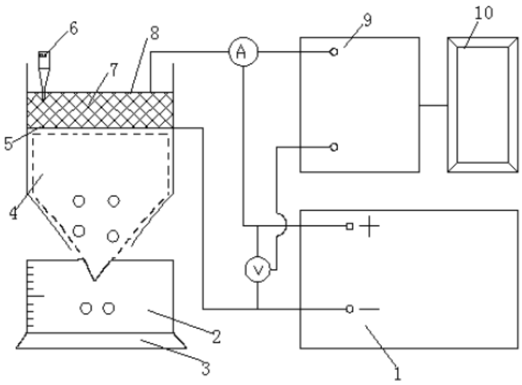

Fig.1 Electroosmotic regeneration test bench
1-DC power supply, 2-beaker, 3-high precision electronic balance, 4-funnel; 5- negative plate, 6-conductivity meter, 7-silica gel, 8-positive plate,
9-data acquisition instrument, 10-computer

2.3 Model solving

In actual production and scientific experiments, the relationship between test indicators and test factors is often not described by a regression equation, so it is necessary to use a second or higher order equation to fit, so assume voltage x1, water content x2 and The binary quadratic regression equation of the test index y is:

$$y = a + b_1x_1 + b_2x_2 + b_{12}x_1x_2 + b_{11}x_1^2 + b_{22}x_2^2;$$

The canonical variable zj of each factor is obtained by encoding each experimental factor. Look up the table to calculate the values of each regression coefficient, so that you can get the regression equation with the canonical variable zj:

$$y = 2.812 + 0.87z_1 + 2.12z_2 + 0.66z_1z_2 - 0.04z_1' + 1.444z_2';$$

Finally, the regression equation is determined by the significance test:

$$y = 135.35 - 0.389x_1 - 267.18x_2 + 0.44x_1x_2 + 130.91x_2^2。$$

3. Result analysis

From the magnitude of the coefficients of the regression equation, the degree of influence of each factor on the current magnitude can be preliminarily judged, and the regression equation is expressed by a stereogram. It can be seen from Fig. 2 that the current increases as the water content increases, and the ion concentration increases in the water content, so that the current value increases. The larger the current value, the faster the rate of change. When the water content is constant, the current increases with the increase of the voltage. The larger the voltage, the larger the current value and the smaller the rate of change.

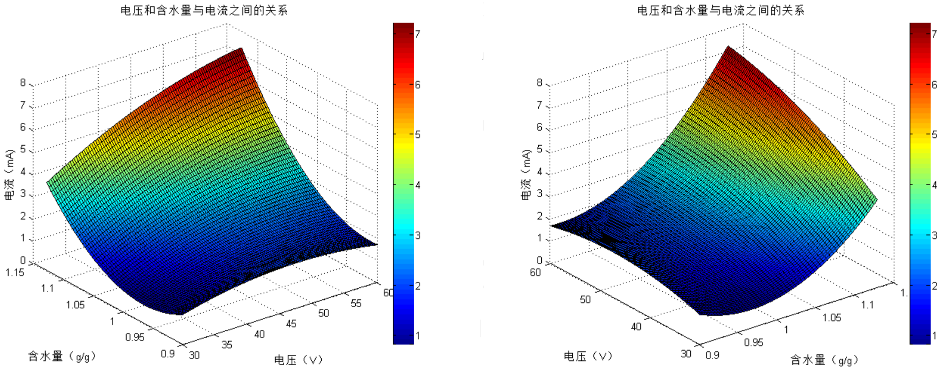

Fig.2 Voltage and water content versus current curve

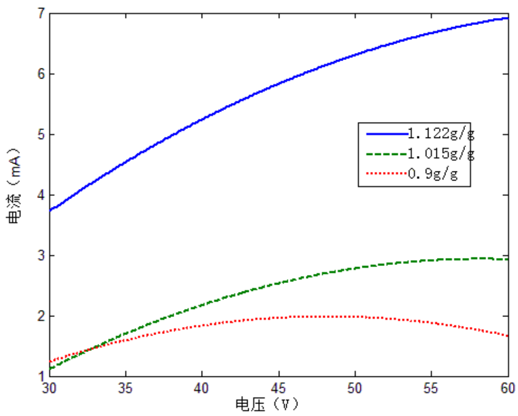

Fig. 3 voltage and current curve

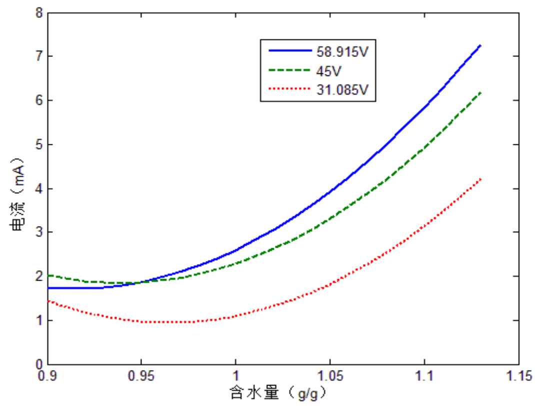

Fig. 4 Relationship between water content and current

It can be seen from Fig. 3 that as the voltage value increases, the current value first increases and then decreases. This is because the voltage cannot be increased indefinitely and the excessively high voltage value will cause severe Joule heating effect [5], which will destroy the desiccant. The function affects the desiccant dehumidification regeneration effect. Therefore, after the allowable range of voltage is exceeded, a reverse effect will occur, and the current value will decrease, which is not conducive to the occurrence of electroosmotic effect. In addition, as the water content increases, the current value increases, and the optimum voltage value gradually increases.

It can be seen from Fig. 4 that in the experimental range, as the voltage increases, the current value increases, and the minimum water content gradually decreases. This is because the voltage increases, the current value increases, and the ion concentration in the solution increases. The required water content is small and the electroosmotic effect is obvious.

4. Conclusion

The macroporous silica gel has a relatively obvious electroosmotic effect at a high water content and a suitable voltage, and the electrodialysis regenerating solid dehumidifying agent has certain feasibility. Orthogonal polynomial design regression experiments provide a new way to explore the influencing factors of electroosmotic regeneration.

References

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