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Research on Preparation of Ethanol Coupled Olefins based on Control Variable Regression Analysis

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Abstract: It is of great significance and value to explore the influence of the preparation process of the catalyst. In this paper, the preparation of C4 olefins by catalytic coupling of ethanol was studied by means of mathematical statistics, person correlation coefficient, grey correlation analysis and multiple linear regression. In this paper, the yield of C4 olefin was found under the same experimental conditions with different catalyst combinations and different temperatures. According to multiple linear regression, the regression function of C4 olefin yield with catalyst and temperature was obtained, and the regression residual analysis diagram was made. Finally, the effects of four components of the catalyst and temperature on the yield of C4 olefins were obtained, and the control variable method was used to set the experimental parameters. The highest yield combination of C4 olefin was set as the control group, and the remaining four groups of experiments were carried out by controlling the load of Co and the concentration of ethanol respectively.

1. Introduction

Olefin in crude oil products is one of the most critical compounds, which has received extensive attention with the increasing development of economy. In daily life, C4 olefins can be used in the preparation of chemical products and as raw materials for medicine [1]. Under the premise of less pollution or zero pollution, the efficient preparation of C4 olefins is of great significance and value. In the process of preparation, ethanol is the raw material for the synthesis of C4 olefins, the combination of catalysts and temperature will affect the selectivity and yield of C4 olefins, which seriously affect the preparation of C4 olefins. The purpose of this paper is to carry out a series of experiments on different catalyst combinations at different temperatures, and then according to the experimental results, to find the conditions under which the yield of C4olefin is as high as possible [2].

2. Establishment of multiple linear regression model

The general form of multiple linear regression model is:

$$Yi = \beta 0 + \beta 1X1i + \beta 2X2i + \cdots + \beta_i x_i h_i + v_i = 1,2,\cdots,n \tag{1}$$

Where k is the number of explanatory variables, β_j=(j=1~2,...,k) is called the regression coefficient (regressioncoefficient) [3]. The above equation is also called the random expression of the population regression function. Its non-random expression is

$$E(Y \mid X1i, X2i, \cdots Xki,) = \beta0 + \beta1X1i + \beta2X2i + \cdots + \beta kXki \quad (2)$$

Under the same experimental conditions, the C4 olefin yield is as high as possible. A multiple linear regression model is established on the basis of five variables: Co / SiO2 content, CO loading, HAP content, ethanol concentration and temperature. The results obtained under loading mode I and loading mode II are obtained according to the scatter diagram

Table 1: Correlation test and coefficient of various factors under filling mode I

	Unstandardized coefficient		Standardized coefficient	t	Significance
	B	Standard error	Beta		
(Constant)	-4121.491	490.262		-8.407	0
Co/SiO2 Constant	-0.726	4.201	-0.052	-0.173	0.863
Co Load capacity	-85.21	53.031	-0.113	-1.607	0.113
HAP Content	5.048	4.008	0.383	1.26	0.212
Ethanol concentration	-106.265	129.624	-0.059	-0.82	0.415
Temperature	14.661	1.325	0.745	11.068	0

a.Dependent variable: Yield

The regression equation can be obtained.

$$Y = -0.726X1 - 85.210X2 + 5.048X3 - 106.265X4 + 14.661X5 - 4121.491 \quad (3)$$

Use multiple linear regression to draw the residual diagram (see Figure 7-1). It can be seen from the residual diagram that the residual of the data is close to the zero point, and the confidence interval of the residual includes the zero point, which shows that the regression model can better conform to the original data.

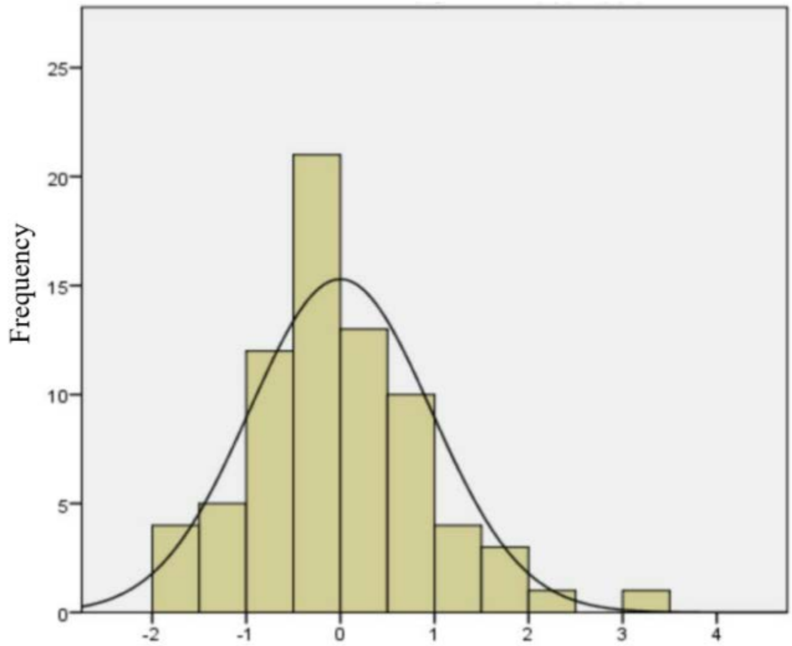

Figure 1: Standardized residual diagram under filling mode I

Table 2: Correlation test and coefficient of various factors under filling mode II

	Unstandardized coefficient		Standardized coefficient	t	Significance
	B	Standard error	Beta		
(Constant)	-2651.26	558.684		-4.746	0
HAP(Constant)	4.664	2.127	0.244	2.192	0.035
Ethanol concentration	-131.674	203.926	-0.072	-0.646	0.523
Temperature	9.363	1.19	0.762	7.866	0

a.Dependent variable: Yield

The regression equation is obtained:

$$Y = 4.664X3 - 131.674X4 + 9.363X5 - 2651.260 \quad (4)$$

3. Solution of model

3.1 Analysis of loading mode I

X1 (CO/SiO2 content) = 33,67,50200, X2 (co loading) = 0 5, 1, 2, X3 (HAP content) = 0, 33, 67, 50200, X4 (ethanol concentration) = 0.3,0.9,1.68,2.1, X5 (temperature) = 250,275,300,325,350,400, regression equations 1 and 2 are calculated with Python to obtain the optimal solution: when X1=10, X2=0 5, X3=200, X4=0. 3, X5 = 450, that is, the Co / SiO2 content is 10 and the co load is 0 5. The content of HAP is 200 and the concentration of ethanol is 0 3. When the temperature is 450, the yield of C4 olefin is 34 05%.

3.2 Analysis of loading mode II

X1 (CO / SiO2 content) = 10, 25, 50, 75100, X2 (co loading) = 1, X3 (HAP content) = 10, 25, 50, 75100, X4 (ethanol concentration) = 0 9, 1. 68, 2. 1, X5 (temperature) = 25027530325350400, regression equations [4] 1 and 2 are calculated with Python to obtain the optimal solution: when X1 = 10, X2 = 0 5, X3=200, X4=0. 3, X5 = 450, i.e. the Co / SiO2 content is 10 and the co load is 0 5. The content of HAP is 200 and the concentration of ethanol is 0 3. When the temperature is 450, the yield of C4 olefin is 24 55%.

4. Assembly combination scheme based on control variables

4.1 Data preprocessing

Table 3: Sorted by C4 olefin yield

Catalyst combination number	Co/SiO2 content	Co Load	HAP content	Ethanol concentration	Temperature	C4 Olefin yield
A3	200mg	1wt%Co/SiO2	200mgHAP	Ethanol concentration 0.9ml/min	400	4472.805978
A3	200mg	1wt%Co/SiO2	200mgHAP	Ethanol concentration 0.9ml/min	450	4311.844167
A4	200mg	0.5wt%Co/SiO2	200mgHAP	Ethanol concentration 1.68ml/min	400	3627.781909
A6	200mg	5wt%Co/SiO2	200mgHAP	Ethanol concentration 1.68ml/min	400	3111.366512
A5	200mg	2wt%Co/SiO2	200mgHAP	Ethanol concentration 0.3ml/min	400	2906.238183
A2	200mg	2wt%Co/SiO2	200mgHAP	Ethanol concentration 1.68ml/min	350	2654.080464
B7	100mg	1wt%Co/SiO2	100mgHAP	Ethanol concentration 0.9ml/min	400	2648.998
A7	50mg	1wt%Co/SiO2	50mgHAP	Ethanol concentration 0.3ml/min	400	2527.911589
A8	50mg	1wt%Co/SiO2	50mgHAP	Ethanol concentration 0.9ml/min	400	2324.340866
B6	75mg	1wt%Co/SiO2	75mgHAP	Ethanol concentration 1.68ml/min	400	1927.714862
A3	200mg	1wt%Co/SiO2	200mgHAP	Ethanol concentration 0.9ml/min	350	1803.330095

4.2 Solution of model

4.2.1 Descriptive analysis

From the above table, it can be concluded that the largest combination of C4 olefin yield is charging mode 1, so we all use mode 1 charging in 5 new experiments. From the above linear regression equation, it can be seen that the smaller the Co loading and ethanol concentration, the higher the yield of C4 olefins. Therefore, we carried out four experiments on the control variable, Co load and ethanol concentration variable of the highest C4 olefin yield in the experimental group and the optimal group after data processing. Finally, the combination of catalyst and temperature for five experiments is shown in the figure.

Group name	Co/Sio2 content	Co load	HAP content	Ethanol concentration	Temperature
Best group	200	1	200	0. 9	400
1	200	0. 5	200	0. 3	450
2	200	1	200	0. 3	400
3	200	1	200	0. 3	450
4	200	0. 5	200	0. 9	400
5	200	0. 5	200	0. 9	450

Figure 2: Increase the combination mode of catalyst and temperature for 5 experiments

5. Conclusion

In this paper, the problem of coupling preparation of olefins from ethanol is studied. Firstly, the loading modes of An and B catalysts are set for multiple linear regression, and the regression function of C4 olefin yield with catalyst and temperature is obtained, and the regression residual analysis diagram is made, which can ensure the stability of the regression function. The A filling scheme is calculated by using python programming to calculate the optimal solution. The yield of C _ 4 olefin of Xi= {10 ~ (th) L(10), 0.5 ~ (0.5), 200 ~ (0.4450) is 34.05%. When the temperature is below 350 degrees Celsius, the A packing scheme is: Xi= {200LINGONE 0.1450}, the C4olefin yield is 18.02% and the Xi= is 0.4450}, and the C4olefin yield is 5.53% when the temperature is lower than 350C, the B packing scheme is: Xi= {10rect 0.5 200jue 0.4450}, the C4olefin yield is 24.55%; when the temperature is lower than 350 degrees Celsius, the A packing scheme is: C4 olefin yield is 18.02% X B packing scheme: C4 olefin yield is 5.53%. Finally, the effects of four components of catalyst and temperature on the yield of C4 olefins were obtained. The experimental parameters were set by control variable method, and the remaining four groups of experiments were carried out by controlling Co load and ethanol concentration respectively.

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