Analyzing and Predicating PH value in Nature Rubber Solidification Process Using Multiple Regression Method

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Abstract. Acid coagulation is the most common process in nature rubber(NR) processing and the acid concentration in latex is a key factor that will decide the quality of processed rubber. In order to invalid the change of PH value processed with acid concentration on latex clots, a group division experiment is designed to obtain the data of PH value, smell and color in latex clots under different solidification time, mode, and temperature. Then a multiple regression model based on Statistical Product and Service Solutions (SPSS) is used to analyse and predicate the PH value in different conditions. The result shows that predication method can have a good result and the average relative error of PH value is 4.60%.

1. Introduction

Nature rubber is one of the basic industrial raw materials, which is usually produced with fresh latex through a series of processes including solidification, pressing, granulating and drying. However, there are a great many of modes in solidification process, involving nature solidification, acid solidification, vacuum solidification and so on. Since the equality of nature rubber product varies from different these modes, the PH value decided by adding the amount of formic acid or vitriol plays a key role during the acid solidification process. [1-4]

In order to study the effect of PH value to latex clots, a series of group division experiment is designed to observe the change of PH value, smell and color under different temperature, times and solidification modes. Besides, a multiple regression method is proposed to analyze the relationship between PH value and the other factors involving smell, color, time, temperature, and solidification model. Through the multiple regression model, the PH value can be real time monitored and predicated, which can not only provide scientific data for dynamic regulating the acid concentration, but also have a positive impact on the controlling of product equality. [5-8]
2. Material and Experiment

2.1 Material
The fresh nature rubber latex is from the second production team, Chinese academy of tropical agricultural sciences proving ground, Danzhou, Hainan province in China. The original PH value of fresh latex material is 7 and the one wanted to preserve over 10 hours is about 10 which will adding some ammonium hydroxide.

2.2 Experiment method

2.2.1 Sample preparation
Firstly, we divide 25 kg fresh latex into 5 groups whose quality is 5kg. These five samples are processed by natural coagulation, proper formic acid coagulation, over formic acid coagulation, proper sulfuric acid coagulation, and over sulfuric acid coagulation, and the first PH value of each sample are 7, 6.5, 5, 5.5 and 5 respectively.

2.2.2 Experimental measurement
The PH value is determined by the precision PH-meter, pH/ORP-7500, which was made by Hebei Create Instrumentation Technologies co., LTD. The temperature is recorded the very day by thermometer, which includes the lowest and highest one. The color of the NR clots is presented by photos and graded from white to deep yellow into 5 levels. While the smell of the clot is described in sensory terms to determine the six level of odor of the clot from odorless to very smelly,

2.2.3 Result
Table 1 shows the data of PH value, temperature, color, and smell with the change of coagulation time.

| Group | Coagulation time (Day) | PH value | Temperature (℃) | color | smell |
|-------|------------------------|----------|-----------------|-------|-------|
| 1     | 1                      | 7.0      | 18-24           | 2     | 6     |
|       | 8                      | 7.0      | 15-20           | 3     | 6     |
|       | 15                     | 8.0      | 14-25           | 3     | 5     |
|       | 30                     | 8.0      | 20-24           | 4     | 5     |
| 2     | 1                      | 6.5      | 18-24           | 2     | 6     |
|       | 8                      | 6.5      | 15-20           | 3     | 6     |
|       | 15                     | 7.5      | 14-25           | 3     | 3     |
|       | 30                     | 8.0      | 20-24           | 4     | 3     |
| 3     | 1                      | 5.0      | 23-27           | 1     | 1     |
|       | 3                      | 5.5      | 18-24           | 2     | 1     |
|       | 11                     | 6.0      | 15-20           | 3     | 1     |
|       | 18                     | 6.5      | 14-25           | 3     | 2     |
|       | 33                     | 7.0      | 20-24           | 4     | 2     |
| 4     | 1                      | 5.5      | 18-24           | 2     | 6     |
|       | 8                      | 6.5      | 15-20           | 3     | 6     |
|       | 15                     | 7.5      | 14-25           | 3     | 3     |
|       | 30                     | 8.5      | 20-24           | 4     | 3     |
| 5     | 1                      | 5.0      | 23-27           | 2     | 1     |
|       | 3                      | 5.0      | 18-24           | 2     | 3     |
|       | 11                     | 6.5      | 15-20           | 3     | 4     |
|       | 18                     | 7.0      | 14-25           | 3     | 4     |
From this table, Group 1 to 5 means the fresh latex processed by natural coagulation, proper formic acid coagulation, over formic acid coagulation, proper sulfuric acid coagulation, and over sulfuric acid coagulation separately. With the extension of coagulation time, the PH value will show an increasing trend, which means the fresh latex change to alkalinity form acidity. For instance, as the coagulation time of Group 3 changes from 1 day to 30 days, the PH value of the sample increases from 6.5 to 8.0. Besides, the color of the sample will become deeper and deeper as time goes on, such as the color of group 3 turns white to deep yellow. As for the smell, the pattern is not obvious.

3. Multiple regression analysis

3.1 Multiple regression model
SPPS has the function of correlation analysis, descriptive statistics, regression analysis, time series analysis, and clustering analysis. This paper used multiple regression model based on SPSS to study and analyze the relationship between the PH value with other factors involving smell, color, time, temperature, and solidification model. And the soft version of SPSS is v16.0.

Based with the data of Table 1, we put the data into SPSS and deal the PH value as dependent variant and the others as independent, and then use the multiple regression model to do analyzing and regression. Figure 1 shows the model summary and Figure 2 shows the coefficients of the model.

| Correlations | PH | Zscore(Mode) | Zscore(Time) | Zscore(LTTemperature) | Zscore(HTTemperature) | Zscore(Color) | Zscore(Smell) |
|--------------|----|-------------|-------------|-----------------------|-----------------------|--------------|--------------|
| Pearson Correlation | PH | 1.000 | -0.377 | 0.755 | -0.228 | -0.980 | 0.801 | 0.333 |
| | Zscore(Mode) | -0.377 | 1.000 | -0.008 | 0.128 | 0.193 | -0.688 | -0.306 |
| | Zscore(Time) | 0.755 | -0.008 | 1.000 | 0.665 | 0.945 | 0.923 | 0.088 |
| | Zscore(LTTemperature) | -0.228 | 0.128 | 0.665 | 1.000 | 0.471 | -0.136 | -0.299 |
| | Zscore(HTTemperature) | -0.980 | 0.193 | 0.945 | 0.471 | 1.000 | -0.299 | -0.413 |
| | Zscore(Color) | 0.801 | -0.688 | 0.923 | -0.136 | -0.299 | 1.000 | 0.127 |
| | Zscore(Smell) | 0.333 | 0.306 | -0.008 | -0.299 | -0.413 | 0.127 | 1.000 |

Figure 1. The correlations between every two variables

| Model Summary | Mode | R | R Square | Adjusted R Square | Std. Error of the Estimate | Change Statistics | Durbin-Watson |
|---------------|-----|---|----------|-------------------|--------------------------|------------------|--------------|
|               | 1   | 0.926 | 0.851 | 0.895 | 0.055 | 0.961 | 15.433 | 6 | 15 | 0.002 | 1.528 |

a. Predictors: (Constant), Zscore(Smell), Zscore(Time), Zscore(Temperature), Zscore(Mode), Zscore(HTemperature), Zscore(Color)

b. Dependent Variable: PH

Figure 2. Model Summary
Figure 3. The coefficients of the Model

After normalization processing these independent variants, the analysis result can be seen in Figure 1, Figure 2 and Figure 3. Figure 1 shows the correlations between every two variables, for example, the correlations between PH value and mode, time, the highest temperature, the lowest temperature, color, smell are -0.212, -0.050, -0.193, 0.409, 0.897, and 0.223 respectively. Figure 2 presents the model summary, the value of R is over 0.9 and equals 0.98, which means the regression model has a good achievement. Figure 3 demonstrates the regression equation which can be described as formula (1), and the variants $X_1$-$X_6$ are the value of mode, time, the highest temperature, the lowest temperature, color, and smell after normalization processing respectively.

$$PH = 6.686 - 0.212X_1 - 0.050X_2 - 0.193X_3 + 0.409X_4 + 0.897X_5 + 0.223X_6 \quad (1)$$

3.2 Error Analysis

After analyzing by the above multiple regression model, the predicted PH value will be generated automatic in the data set. Then the actual PH value can be compared with predicted PH value as Figure 4.

![Comparison of Actual PH value and Predicated PH value](image-url)
From Figure 4, the maximum relative error of the predicated value is 11.03%, which belongs to the Group 4 at the 15th day of the coagulation time. The minimum one is 0.14%, which belongs to Group 3 at the third day of coagulation time. And the average relative error of all these samples is 4.60%.

4. Conclusion
This paper has presented the change of PH value during the solidification produced with different coagulation process. Firstly 5 groups fresh latex solidification experiments are designed to acquire the basic data of PH value, color and smell, as well as the corresponding temperature and coagulation time. After that, a multiple regression model is utilized to analyze the correlation among these data and get the predication equation of PH value. The error analysis shows this model can approximately do some predicing for the PH value during the solidification process and the average relative error is 4.60%. The result of the above study will provide the theoretical basis for the preparation of solidification technology of fresh NR latex, as well as the solidification devices.

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