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# Synthesis and Properties of a New Sulfonated Quaternary Ammonium Salt Amphoteric Surfactant

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***Abstract:*** *In this paper, a series of sulfonated quaternary ammonium salt amphoteric surfactants were obtained by using short-chain alkyl alcohol as the starting material, producing short-chain alkyl glycidyl ethers through nucleophilic substitution with epichlorohydrin, then generating short-chain alkyl tertiary amines through ring-opening reaction with dimethylamine, and finally undergoing quaternization reaction with 3-chloro-2-hydroxypropanesulfonate sodium. By controlling variables, the synthesis conditions of sulfonated quaternary ammonium salt type amphoteric surfactant were optimized; the structure was characterized by Fourier transform infrared spectrometer, and its surface and interface properties were evaluated. The results show that the structure of the synthesized product is consistent with the target product; the best catalyst required for the synthesis of the alkyl glycidyl ether intermediate is tetrabutylammonium bromide; the reaction conditions for ring-opening reaction to generate tertiary amine are optimized as follows: Pentyl glycidyl ether): n[NH(CH3)2]=4:3, the reaction temperature is 55°C, and the reaction time is 10h; the yield reaches the highest, when the quaternization reaction is carried out at the catalyst - binary compound acid and the reaction temperature is 65°C.; n-octyl sulfonated ammonium salt amphoteric surfactant has the highest surface activity, and can reduce the surface tension of water to 29.1mN/m under the concentration of CMC; the foam performance of n-octyl sulfonated ammonium salt Optimum, isopentyl sulfonated quaternary ammonium salt has the best low foam performance. A series of sulfonated quaternary ammonium amphoteric surfactants have excellent surface activity and interfacial activity, which provides a practical reference for the synthesis and application of this type of surfactant.*

***Keywords:*** *Sulfonated Quaternary Ammonium Salt Type, Amphoteric Surfactant, Synthesis of Short-chain Alkyl Alcohol, Performance Research*

## 1. Introduction

As the country attaches great importance to sustainable development, the production of environmentally friendly products is a necessary way for the long-term development of human and nature. Betaine-type Gemini amphoteric surfactants have the properties of sustainable development and high application value such as excellent biodegradability, emulsification, and alkali resistance that traditional surfactants do not have [1-4].

In the past ten years, researchers at home and abroad have carried out a lot of experimental research [5-9], theoretical research and progress research on betaine-type Gemini amphoteric surfactants[10-12]. These studies mainly highlight the novelty of molecular design of Gemini amphoteric surfactants, but The synthesis mechanism has little breakthrough, the cost of raw materials is high, the synthesis steps are relatively complicated, the final yield is not high, the performance measurement is single, the application field of single amphoteric surfactant is relatively narrow, the separation and purification are difficult, and the identification and measurement methods of effective substances are few. It hinders and restricts its commercial production in China. Moreover, the current research on the synthesis of Gemini surfactants has become complicated with the continuous improvement of application performance requirements in various fields. Finding compounds with new structures and high

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performance has become a difficult and hot topic in current research.

In order to solve the problem of poor cleaning effect and even a large amount of dirt remaining on the metal surface due to the excessive generation of existing surfactant foam in the production of metal industry, this paper uses short-chain alkyl alcohol, epichlorohydrin, dimethylamine and 3-chloro-2-hydroxypropanesulfonate as the initial raw materials, after design and through reactions such as ring opening, nucleophilic substitution, quaternization and sulfonation, a series of sulfonated quaternary ammonium salt type amphoteric compounds were synthesized. Surfactant. One of them was screened out through the preliminary performance test, and the synthesis process was optimized by using the three-factor variable method. The structure of the tertiary amine intermediate and the final sulfonated quaternary ammonium salt product was characterized by FTIR-650 Fourier transform infrared spectrometer, and the expected molecular structure was determined. Finally, the series products were evaluated by Krafft point measurement, surface tension γ measurement, CMC measurement and foam property measurement.

## 2. Preparation and Characterization of A Novel Sulfonated Quaternary Ammonium Salt Type Amphoteric Surfactant

### *2.1 Experimental Reagents and Equipment*

n-butanol, isoamyl alcohol, n-octanol, ethyl acetate, boron trifluoride ether, sodium hydroxide, ethanol, dimethylamine aqueous solution, oxalic acid, epichlorohydrin, acetone, lactic acid, tetrabutylammonium bromide, Sodium 3-chloro-2-hydroxypropanesulfonate.

Electric blast drying oven, collector type constant temperature heating magnetic stirrer, glass instrument airflow dryer, circulating water vacuum pump, Fourier transform infrared spectrometer.

### *2.2 Synthesis of New Sulfonated Quaternary Ammonium Salt type Amphoteric Surfactants*

#### *2.2.1 Synthesis of Intermediates*

##### *2.2.1.1 Synthetic route*

The preparation of short-chain alkyl intermediates is a typical nucleophilic substitution reaction. The advantages of this reaction are low raw material prices, low synthesis requirements, and easy synthesis of glycidyl ether under general laboratory conditions (See Figure 1).

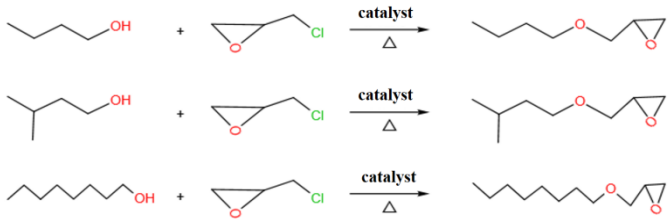


*Figure 1: Synthetic route of a series of glycidyl ethers*

##### *2.2.1.2 Synthesis steps*

(1) Synthesis of n-butyl glycidyl ether

Measure 40ml of n-butanol and 50ml of epichlorohydrin into a 250ml three-neck flask and dropping funnel respectively, weigh or measure the catalyst the corresponding amount of and add it to the reaction vessel—the three-necked flask, first stir and heat to 40°C, When the catalyst is completely mixed evenly, start to slowly titrate the epichlorohydrin, and after about 30 minutes, the dropwise addition is completed, and then the temperature is raised to 65°C again, and the reaction is refluxed for 6 hours. After the reaction is over, cool it still, filter to remove the solid catalyst, pour it into a round bottom flask, and distill the unreacted reactant under reduced pressure at 60°C to obtain a slightly yellowish transparent liquid substance, which is the n-butyl shrinkage glyceryl ether.

(2) Synthesis of isopentyl glycidyl ether

Measure 45ml of isoamyl alcohol and 50ml of epichlorohydrin into a 250ml three-necked flask and dropping funnel respectively, weigh or measure the corresponding amount of catalyst and add it to the reaction vessel—the three-necked flask, first stir and heat to 55°C, When the catalyst is completely

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mixed evenly, slowly add epichlorohydrin dropwise, after about 30 minutes, the dropwise addition ends, raise the temperature to 70-90°C, and reflux for 6 hours. After the reaction is over, let it stand to cool to room temperature, filter to remove the solid catalyst, pour it into a round bottom flask, and distill the residual reactant under reduced pressure at 85°C-90°C to obtain a slightly yellow transparent liquid substance, which is isoamyl Glycidyl ether.

(3) Synthesis of n-octyl glycidyl ether

Measure 65ml of n-octanol and 50ml of epichlorohydrin into a 250ml three-necked flask and a dropping funnel respectively, weigh or measure the catalyst corresponding to the catalytic amount and add it to the reaction vessel—the three-necked flask, first stir and heat to 60°C, When the catalyst is completely mixed evenly, add epichlorohydrin dropwise, and the dropwise addition is completed in about 15 minutes, then the temperature is raised to 60-75°C, and the reaction is refluxed for 6 hours. After the reaction, let it stand for cool to room temperatur, filter to remove the solid catalyst, pour it into a round bottom flask, and distill it under reduced pressure at 80°C-90°C to obtain a transparent liquid substance, which is the product n-octyl glycidyl ether.

#### *2.2.1.3 Discussion on the reaction*

In order to select the catalyst with the best reaction effect between n-butanol, isoamyl alcohol and n-octanol and epichlorohydrin, the synthesis yield was used as an index, and an experiment with catalyst as a single factor variable was designed.The product yields of the reaction of three alcohols and epichlorohydrin under different catalysts were obtained through synthesis experiments, and the recorded data are shown in Table 1.

*Table1: Effect of Catalyst on Yield*

| Reactant | Catalyst | Yield/% |
|---|---|---|
| Butanol | Boron trifluoride diethyl ether | 65.52 |
| | Tetrabutylammonium bromide | 60.24 |
| | sodium hydroxide | 52.89 |
| Isoamyl alcohol | Boron trifluoride diethyl ether | 46.04 |
| | Tetrabutylammonium bromide | 74.16 |
| | sodium hydroxide | 41.21 |
| n-octanol | Boron trifluoride diethyl ether | 40.92 |
| | Tetrabutylammonium bromide | 97.72 |
| | sodium hydroxide | 68.22 |

It can be seen from Table1 that the three catalysts, boron trifluoride diethyl ether, tetrabutylammonium bromide, and sodium hydroxide, correspond to different reactants—alkyl alcohols, and their catalytic effects are completely different. Under the condition of boron trifluoride ether as catalyst, n-butanol can reach the highest synthesis yield of 65.52%; isoamyl alcohol is catalyzed by tetrabutylammonium bromide, and its synthesis yield is higher than that of the other two catalysts, reaching 74.16%; n-octanol is under the action of the three catalysts respectively, and the catalytic effect of tetrabutylammonium bromide is also remarkable, reaching 97.72%. Comprehensive analysis of the catalytic effects of the three catalysts on the three alkyl alcohols shows that tetrabutylammonium bromide is the best catalyst for the reaction of n-butanol, isoamyl alcohol, n-octanol with epichlorohydrin.

### *2.2.2 Preparation of Tertiary Amines*

#### *2.2.2.1 Synthetic route*

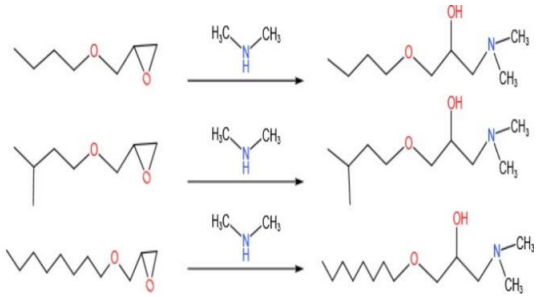

*Figure 2: Synthetic route of a series of tertiary amines*

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The main reactions involved in tertiary amination are ring opening and substitution reactions (See Figure 2).

#### *2.2.2.2 Synthesis steps*

Set the reaction volume, the molar ratio is glycidyl ether: dimethylamine = 4:3. Measure the corresponding molar ratio of glycidyl ether and 33% dimethylamine aqueous solution into a 250ml three-necked flask and dropping funnel respectively, heat up to 40-55°C, start to slowly add 33% dimethylamine dropwise, and the titration is completed in 40 minutes, and the reaction is refluxed for 6 hours. After the reaction is completed, the device is replaced with a vacuum distillation device, and the unreacted product and residual water are removed by vacuum distillation at 80° C, then a transparent oily liquid is obtained.

#### *2.2.2.3 Response Discussion*

In order to obtain the optimal reactants and conditions for the tertiary amination reaction and ensure that there are enough reactants tertiary amines in the third step, the author designed the $L_9(3^4)$ orthogonal experiment with the synthesis yield of tertiary amine as the index and the reaction temperature, reaction time and reactants with different alkyl chains as the influencing factors of tertiary amination reaction. The specific experimental design scheme and data results are shown in Table 2-3.

*Table 2: Orthogonal experimental design scheme for tertiary amination*

| Level | Factor | | |
|---|---|---|---|
| | A | B | C |
| | Reaction temperature/°C | Reaction time/h | Reactants |
| 1 | 45 | 6 | Isopentyl glycidyl ether |
| 2 | 50 | 8 | n-Butyl glycidyl ether |
| 3 | 55 | 10 | N-octyl glycidyl ether |

*Table 3: Tertiary amination orthogonal test data results*

| serial number | Influencing factors | | | yield/% | serial number | Influencing factors | | |
|---|---|---|---|---|---|---|---|---|
| | A | B | C | | | A | B | C |
| 1 | 45 | 6 | Isopentyl glycidyl ether | 53.41 | $K_1$ | 163.20 | 180.11 | 227.51 |
| 2 | 45 | 8 | n-Butyl glycidyl ether | 45.42 | $K_2$ | 214.16 | 204.56 | 184.51 |
| 3 | 45 | 10 | N-octyl glycidyl ether | 64.37 | $K_3$ | 246.64 | 239.33 | 211.98 |
| 4 | 50 | 6 | n-Butyl glycidyl ether | 52.46 | $k_1$ | 54.40 | 60.04 | 75.84 |
| 5 | 50 | 8 | N-octyl glycidyl ether | 73.37 | $k_2$ | 71.38 | 68.19 | 61.50 |
| 6 | 50 | 10 | Isopentyl glycidyl ether | 88.33 | $k_3$ | 82.21 | 79.78 | 70.66 |
| 7 | 55 | 6 | N-octyl glycidyl ether | 74.24 | R | 27.81 | 19.74 | 14.34 |
| 8 | 55 | 8 | Isopentyl glycidyl ether | 85.77 | | | | |
| 9 | 55 | 10 | n-Butyl glycidyl ether | 86.63 | | | | |

Analyzing the data in Table 3, it can be seen that the order of the influence of the three factors on the tertiary amination reaction is as follows: Reaction temperature > Reaction time > Reactants with different alkyl chains. Therefore, the optimal conditions for the tertiary amination reaction are $A_3B_3C_1$, that is, the reaction temperature is 55°C, the reaction time is 10h, and the reactant is isopentyl glycidyl ether.

In summary, the optimal reaction among the three series of tertiary amination reactions is: n (isoamyl glycidyl ether):n(dimethylamine)=4:3, the reaction temperature is 55°C, and the reaction time is 10h.

#### *2.2.2.4 Structural characterization*

In the molecular structure of a series of tertiary amination reactions, only the hydrophobic group of the alkyl chain is different, and the functional groups and structures of other parts are the same, So here we will take the isopentyl tertiary amine obtained by the optimal reaction as an example, and carry out infrared structure characterization of it by potassium bromide tablet method,and obtain and analyze the Infrared Spectrum.

In Figure 3, 3432.12$cm^{-1}$ is the stretching vibration absorption peak of -OH; 2954.18$cm^{-1}$ and 2870.44$cm^{-1}$ are the antisymmetric and symmetric stretching vibration absorption peaks of C-H respectively; 1113.68$cm^{-1}$ is the C-O-C bond stretching vibration absorption peak. These absorption peaks prove that the first step intermediate reaction is successful. 1042.66$cm^{-1}$ is the stretching

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vibration absorption peak of C-N in tertiary amine, indicating that the secondary amine in dimethylamine has successfully reacted to tertiary amine. In summary, all the characteristics of the absorption peaks indicated that the tertiary amination reaction was successful and the conversion rate was high.

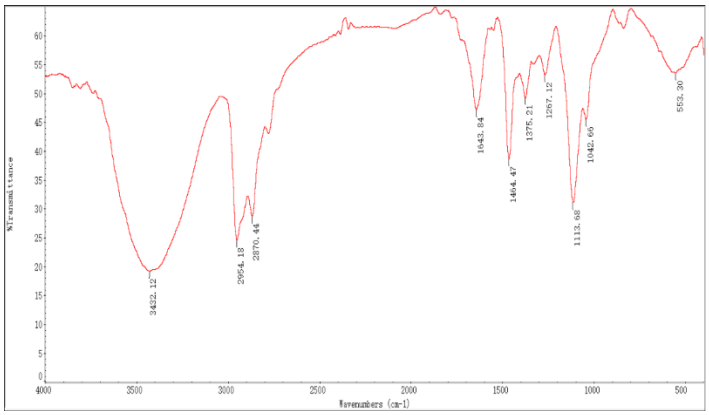


*Figure 3: Infrared spectrum of isopentyl tertiary amine*

### *2.2.3 Synthesis of Sulfonated Quaternary Ammonium Salt Type Amphoteric Surfactant*

#### *2.2.3.1 Synthetic route*

Quaternization and sulfonation of the synthesized tertiary amination product with 3-chloro-2-hydroxypropanesulfonate sodium. It is a simple one-step substitution synthesis (See Figure 4).

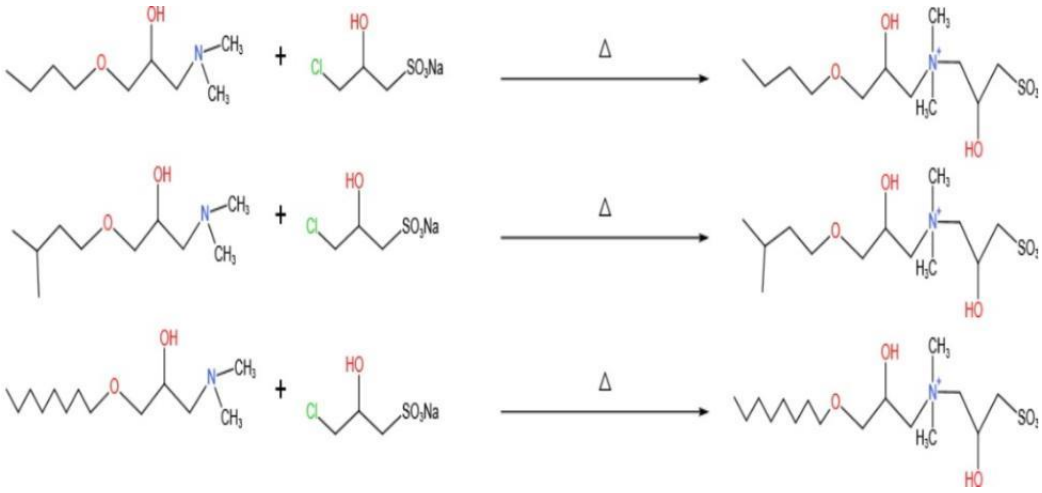


*Figure 4: Series of synthetic routes for sulfonated quaternary ammonium salts*

#### *2.2.3.2 Synthesis steps*

Set the reaction volume, the molar ratio is tertiary amine: sodium 3-chloro-2-hydroxypropanesulfonate=4:3. Measure the corresponding molar ratio of tertiary amine and 3-chloro-2-hydroxypropanesulfonate sodium into a 250ml three-necked flask, and then add water: ethanol = 1:3 mixture (ready to use) as a reaction solvent , heated to 55-65°C, and refluxed for 6h. After the reaction is complete, let it stand to cool to room temperature, filter to remove unreacted sodium 3-chloro-2-hydroxypropanesulfonate, wash the filtrate with ethyl acetate:ethanol=3:1 mixture, and filter again to remove the washed out unreacted solid, and then the filtrate was recrystallized with a mixture of ethyl acetate and ethanol, and finally a white powdery solid was obtained.

#### *2.2.3.3 Response Discussion*

In order to explore the influence of catalyst and reaction temperature on the quaternization reaction of tertiary amine and sodium 3-chloro-2-hydroxypropanesulfonate, the single factor variable method was used to explore the synthesis scheme of quaternization.

(1) Effect of presence or absence of catalyst on quaternization

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*Table 4: Experimental results of the influence of presence or absence of catalyst*

| Reactant | Catalyst | Yield/% |
|---|---|---|
| n-butyl tertiary amine | none | 3.87 |
| | Binary compound acid (oxalic acid: lactic acid = 2:1) | 58.49 |
| Isopentyl tertiary amine | none | 12.56 |
| | Binary compound acid (oxalic acid: lactic acid = 2:1) | 75.68 |
| N-octyl tertiary amine | none | 9.43 |
| | Binary compound acid (oxalic acid: lactic acid = 2:1) | 58.56 |

According to the data in Table 4, the data graph of the influence of catalyst on the quaternization reaction is drawn, as shown in Figure 5.

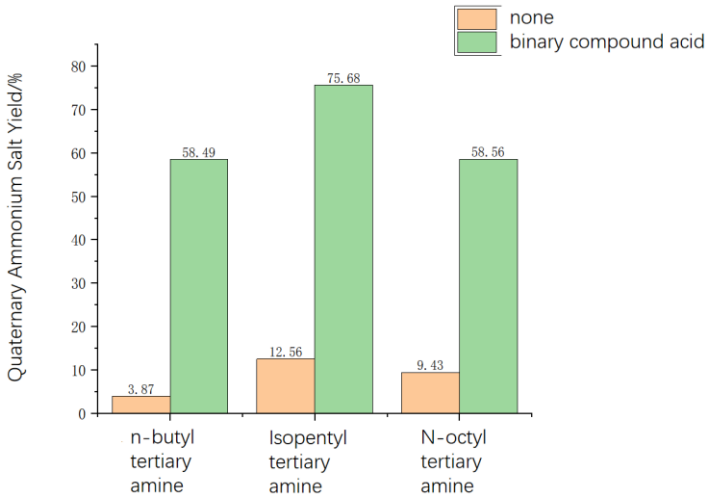


*Figure 5: Effect of Catalyst on Yield*

Analysis of Table 4 and Figure 5 shows that the quaternization reaction of a series of tertiary amines, compared with the case of no catalyst, under the condition of a binary compound acid as a catalyst, the synthesis yield of a series of quaternary ammonium salts has been greatly improved .

(2) Influence of reaction temperature

*Table 5: Effect of reaction temperature on experimental results*

| Reactant | n-butyl tertiary amine | | | Isopentyl tertiary amine | | | N-octyl tertiary amine | | |
|---|---|---|---|---|---|---|---|---|---|
| reaction temperature/°C | 55 | 60 | 65 | 55 | 60 | 65 | 55 | 60 | 65 |
| Yield/% | 44.81 | 53.05 | 56.29 | 64.35 | 77.05 | 75.41 | 57.02 | 59.4 | 59.22 |

According to the data in Table 5, the data graph of the influence of reaction temperature on the quaternization reaction is drawn, as shown in Figure 6.

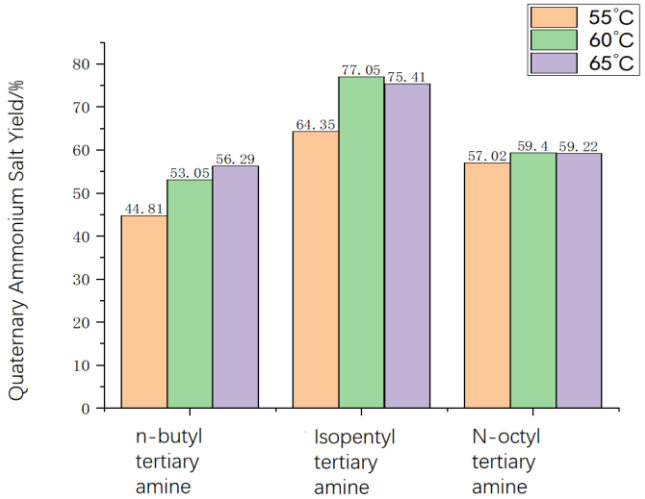


*Figure 6: Effect of reaction temperature on yield*

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Analysis of Table 5 and Figure 6 shows that the synthesis yield of quaternary ammonium salt increases with the rise of temperature in the quaternization reaction of a series of tertiary amines, so the temperature has a positive effect on the quaternization reaction.

Error analysis: Observing the two experimental charts, it is not difficult to find that the yield of quaternary ammonium salts produced by the quaternization reaction of isopentyl tertiary amine and n-octyl tertiary amine at 65 ° C has decreased. The chain length of the n-octyl group is relatively longer than that of the n-butyl group, and the total molecular weight after quaternization is larger, which increases the viscosity of the synthesized products - quaternary ammonium salts. In the process of separating the product from the experimental device, due to insufficient washing of the part of the product attached to the vessel, more product was lost, resulting in errors in the data.

#### *2.2.3.4 Structural characterization*

In the molecular structure of a series of quaternization reactions, only the hydrophobic group of the alkyl chain is different, and the functional groups and structures of other parts are the same, So here we will take the isopentylsulfonated quaternary ammonium salt obtained by the reaction as an example, and carry out infrared structure characterization of it by potassium bromide tablet method, and obtain and analyze the Infrared Spectrum.

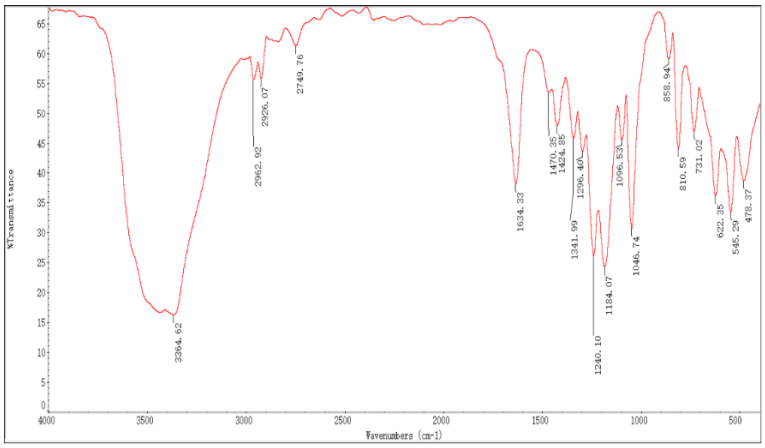


*Figure 7: Infrared spectrum of isopentylsulfonated quaternary ammonium salt*

In Figure7, 3364.62cm$^{-1}$ is the stretching vibration absorption peak of -OH; 2962.92cm$^{-1}$, 2926.07cm$^{-1}$ and 2749.76cm$^{-1}$ are the antisymmetric and symmetric stretching vibration absorption peaks of C-H respectively; the strong absorption peak at 1240.10cm$^{-1}$ is the stretching vibration absorption peak of C-O-C; 1470.35cm$^{-1}$ is the asymmetric variable angle absorption peak of quaternary ammonium; 1184.07cm$^{-1}$ is the absorption peak of -$SO_{3-}$ ion group.

In summary, all the characteristics of the absorption peaks indicated that the quaternization reaction was successful, but the intensity of the absorption peak at the characteristic functional group quaternary ammonium of the product is small, and the yield of the synthetic product is relatively low.

## 3. Performance Research of New Sulfonated Quaternary Ammonium Salt Type Amphoteric Surfactant

### *3.1 Experimental Reagents and Instruments*

Butyl sulfonated quaternary ammonium salt, isopentyl sulfonated quaternary ammonium salt, n-octyl sulfonated quaternary ammonium salt, NaOH, aviation kerosene, absolute ethanol.

Electronic balance, automatic surface tension meter, digital display conductivity meter, booster electric mixer, collector type constant temperature heating magnetic stirrer.

### *3.2 Performance Research Method*

#### *3.2.1 Determination of Surface Tension γ*

In this paper, the Wilhelmy plate method is used to measure the surface tension of a series of new

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sulfonated quaternary ammonium salt amphoteric surfactants.The specific experimental operation is as follows: first prepare three series of liquids to be tested with corresponding gradient concentrations of 1mol/L, 0.1mol/L, 0.01mol/L, and 0.001mol/L, and place them in a thermostatic water bath at 25°C for heat preservation , and then use the BZY-13 automatic surface tensiometer at room temperature 25 ° C to measure the surface tension of the three series of solutions corresponding to different concentrations by the Wilhelmy plate method, record the data, and draw graph of the surface tension with the concentration by computer.

#### *3.2.2 CMC Determination*

The minimum concentration of surfactants in solution at which micelles form is called the critical micelle concentration (CMC). CMC is an important parameter to measure the surface activity of surfactants, and the conductivity of surfactants is closely related to CMC. When the solution concentration of surfactants reaches the critical micelle concentration, its conductivity will drop sharply. Therefore,this special property is used to measure CMC. The specific experimental operation is as follows: at room temperature, prepare three series of liquids to be tested with corresponding gradient concentrations of 0.1mol/L, 0.01mol/L, 0.001mol/L, 0.0001mol/L, and 0.00001mol/L, and then use DDS-11 conductivity meter measures the conductivity at the corresponding concentration respectively, and records the measurement data.Repeat the above operation three times to obtain an average value,and draw the graph of the change of the conductivity with the concentration by computer.

#### *3.2.3 Determination of Foam Property*

Foam performance includes two aspects of foaming and foam stability. In this paper, the shake flask method is used to measure the foam performance. The specific experimental operation is as follows: at room temperature, respectively configure the corresponding series of 100ml aqueous solution with a concentration of 0.1wt%, pipette 20ml of it into a 100mL graduated cylinder with a rubber stopper, and then Shake vigorously for 30s (shake immediately after starting timing), stop shaking and place the measuring cylinder on a horizontal surface, stand still and quickly read the foam height h at this time (start a new timing while standing still and stop timing when the foam disappears). The above operation was repeated, and the average value was obtained for three parallel determinations.

### *3.3 Results and Discussion*

#### *3.3.1 Surface Tension*

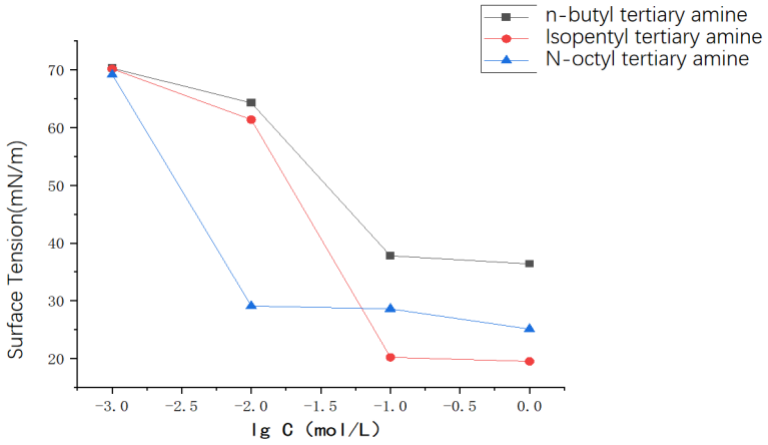


*Figure 8: Surface tension—lgC curves of a series of sulfonated quaternary ammonium salt type amphoteric surfactants*

From the analysis of Figure 8, it can be found that n-octyl sulfonated quaternary ammonium salt amphoteric surfactant has a stronger ability to reduce surface tension of water and the highest surface activity; n-butyl sulfonated quaternary ammonium sal tamphoteric surfactant has the worst ability to reduce the surface tension of water and the lowest surface activity. Normally, the longer the chain length of the hydrophobic end, the larger the molecular weight of the hydrophobic group, the stronger the hydrophobicity of the molecule, and the greater the ability to reduce the surface tension of water; therefore, the ability to reduce surface tension: n-octyl sulfonate quaternary ammonium salt > isopentyl sulfonated quaternary ammonium salt > n-butyl sulfonated quaternary ammonium salt.

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### *3.3.2 Critical Micelle Concentration CMC*

From the analysis of Figure 9, it can be found that the concentration of the conductivity mutation point of n-octyl sulfonated quaternary ammonium salt is 0.01mol/L, and that of n-butyl sulfonated quaternary ammonium salt and isopentyl sulfonated quaternary ammonium salt is 0.1mol/L. So the CMC of n-octyl sulfonated quaternary ammonium salt is 0.01mol/L, and the CMC of n-butyl sulfonated quaternary ammonium salt and isopentyl sulfonated quaternary ammonium salt is 0.1 mol/L. The CMC of n-octyl sulfonated ammonium salt is smaller than that of n-butyl sulfonated ammonium salt and isopentyl sulfonated ammonium salt. This is because the critical micelle concentration of the surfactant is affected by the chain length of the hydrophobic group of the molecule, whether there is a branched chain, and the degree of branching. For a series of surfactants, their critical micelle concentration decreases as the chain length of the molecular hydrophobic group increases, and increases as the branching of the hydrophobic group increases.

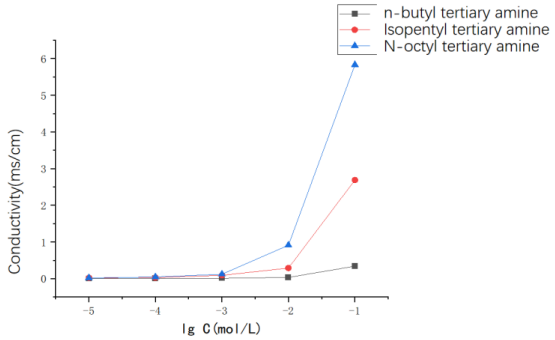


*Figure 9: The conductivity-lgC curve of a series of sulfonated quaternary ammonium salt type amphoteric surfactants*

### *3.3.3 Foam Properties*

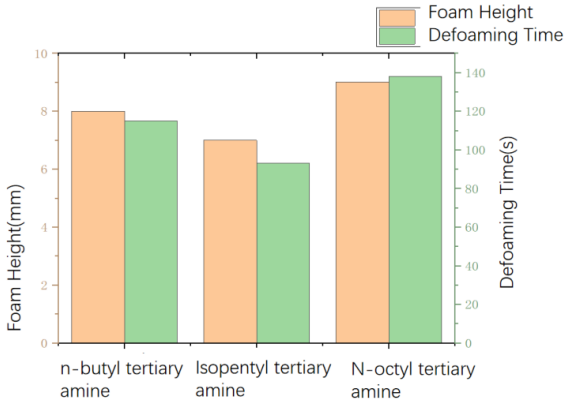


*Figure 10: Foam performance of series sulfonated quaternary ammonium salts*

From the analysis of Figure 10, it can be seen that the foaming properties of the three sulfonated quaternary ammonium salts are not much different, and the foaming properties of the isopentyl sulfonated quaternary ammonium salt are slightly lower. This is because the three sulfonated quaternary ammonium salts are the same series of surfactants, and the foaming performance is related to the chain length of the hydrophobic group. The longer the hydrophobic chain, the better the foaming performance, so it can be seen from the figure that the foamability of n-octyl sulfonated quaternary ammonium salt is better than that of n-butyl sulfonated quaternary ammonium salt; and because the branched chain of hydrophobic chain will reduce the membrane viscosity, resulting in a decrease in foaming performance, so the foaming properties of isopentyl sulfonated quaternary ammonium salt are lower than those of n-octyl sulfonated quaternary ammonium salt.

The foam stability is also affected by the structure of the hydrophobic group. The longer the hydrophobic chain, the greater the surface viscosity of the liquid film and the better the foam stability; in addition, the branching of the hydrophobic group will reduce the surface viscosity of the liquid film and decrease the elasticity, resulting in a decrease in stability. Therefore, the defoaming time of n-octyl sulfonated quaternary ammonium salt is long, and the foam stability is the best; the defoaming time of n-butyl sulfonated quaternary ammonium salt is short, and the foam stability is poor; the defoaming

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time of the isopentyl sulfonated quaternary ammonium salt is the shortest, and the foam stability is the lowest.

## 4. Conclusion

(1)In the synthesis process of a series of new sulfonated quaternary ammonium salt amphoteric surfactants, under the same conditions of reaction temperature, molar ratio of reaction substances and reaction time, tetrabutylammonium bromide is the best catalyst for the reaction of n-butanol, isoamyl alcohol, n-octanol and epichlorohydrin to form alkyl glycidyl ether. The best reactant of tertiary amination reaction is isopentyl glycidyl ether, and the factor that has the greatest influence on tertiary amination reaction is temperature; the best reaction condition of tertiary amination is exactly n (isoamyl glycidyl ether): n (Dimethylamine)=4:3, the reaction temperature is 55°C, and the reaction time is 10h. The best condition of quaternization reaction is the presence of catalyst - binary compound acid, and the reaction temperature is 65°C.

(2) The CMC of n-butyl sulfonated quaternary ammonium salt, isopentyl sulfonated quaternary ammonium salt and n-octyl sulfonated quaternary ammonium salt are 0.1mol/L, 0.1mol/L, 0.01mol/L respectively; the surface tensions corresponding to CMC are 37.8mN/m, 20.2mN/m, and 29.1mN/m, respectively. After comprehensive analysis, the surface activity of n-octyl sulfonated quaternary ammonium salt is the highest, and that of n-butyl sulfonated quaternary ammonium salt is the lowest.

(3) The foamability and foam stability of isopentyl sulfonated quaternary ammonium salt are the lowest, and the foamability and foam stability of n-octyl sulfonated quaternary ammonium salt are the best. Since the design of the experimental scheme requires an excellent low-foaming amphoteric surfactant, the comprehensive analysis shows that the isopentyl sulfonated quaternary ammonium salt is the optimal product.

To sum up, the synthesized series of sulfonated quaternary ammonium salt amphoteric surfactants have good surface activity and low foaming performance, so it is expected to realize industrial production through more detailed synthesis process optimization to alleviate the problem of poor cleaning effect and residue on the metal surface in the current metal industry.

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