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Measurement and Correlation of Electrical Conductivity of β-Cyclodextrin in Water Solution

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Abstract: The electrical conductivity of 4% β-cyclodextrin in water solution had been measured by electrode method from (323.65~353.65) K at atmospheric pressure. The experimental data were correlated with the modified Arrhenius equation, and the model estimations showed good agreement with the experimental data.

Key words: Electrical conductivity, β-cyclodextrin, Arrhenius equation.

1. Introduction

Cyclodextrin was cyclic oligosaccharide that was obtained from D-glucopyranose by α-1,4 glycosidic bond polymerization. β-cyclodextrin was a common one which was obtained by seven D-glucopyranose polymerization [1]. β-cyclodextrin with the special structure and properties of annular hollow cylinder, internal hydrophobic and outer ring hydrophilic, is widely used in food, pharmaceutical and cosmetic industries [2, 3]. But the electrical conductivity of β-cyclodextrin is less, which restricts its applications. The electrical conductivity is one of the fundamental data in engineering design and industrial practice [4, 5]. There is little report on the electrical conductivity of β-cyclodextrin solution. Therefore in this paper, the electrical conductivity of β-cyclodextrin solution was studied, and the experimental data were correlated with the Arrhenius equation, which provides reference for its application.

2. Experimental Section

2.1 Materials

β-cyclodextrin was of AR grade, it was obtained from Shanghai Chemical Reagent Co. In the experiment, the mass concentration of β-cyclodextrin was 4%.

The instrument: DDS-11A-type conductivity meter (The analytic instrument factory of Shanghai, China).

The electrode: DJS-1C-type platinum black electrode.

3. The Electrical Conductivity Measurement

(1) Calibration of instruments

(2) Measurement: platinum black electrode, whose electrode constant is 1, is used for measurement.

(3) It is first rinsed with distilled water for three times before the electrode is used, and then rinsed with the solution under test for three times, and then inserted into the solution to make the liquid level of the solution exceed 1~2 cm of the electrode. Then, the constant temperature is 15 min, and the value is read and the average of the three readings is taken.

4. Result and Discussion

The measured electrical conductivity of β-cyclodextrin solution at different temperatures were presented in Table 1. The experimental data were correlated with the Arrhenius equation:

$$\Lambda_m = A\exp(-\frac{E_{a,\Lambda}}{RT})$$

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where Λ_m is the molar conductivity of 4% of β-cyclodextrin. T is the absolute temperature. A, is the model parameters, $E_{a,\Lambda}$ is activation energy of migration process.

It can be seen from Table 1 and Fig. 1, the electrical conductivity of β-cyclodextrin increases with the increase of temperature. According to electrical conductivity with least square fitting, the equation of the parameter A, the migration process of activation energy Ea, Λ, average relative deviation (RAD) and correlation coefficient R^2 are shown in Table 2.

From Table 2, it can be found that the calculated electrical conductivity shows good agreement with the experimental data. The relative average deviation is 1.73%, which indicates that the equation is suitable to correlate the density data of β-cyclodextrin in water solution.

Table 1 The electrical conductivity of β-cyclodextrin solution.

T (K)	κ_i (ms·cm^{-1})	Λ_m (ms·cm^2·mol^{-1})
323.65	0.0405	1.1326
328.45	0.0476	1.3372
333.35	0.0571	1.6109
338.25	0.0662	1.8732
343.55	0.0778	2.2075
348.35	0.0863	2.4525
353.65	0.0998	2.8415

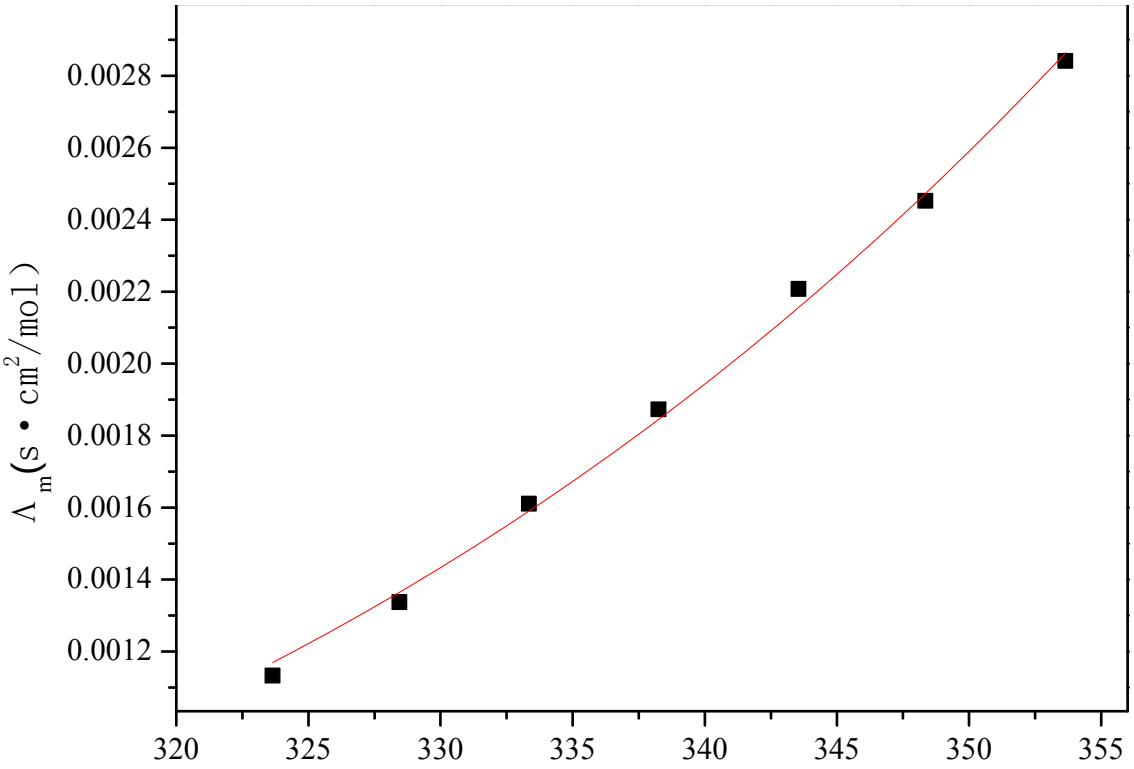

Fig. 1 The electrical conductivity of β-cyclodextrin at different temperature.

Table 2 The fitting parameter values of the electrical conductivity correlation equation and the average relative deviation RAD.

Solution	A	$E_{a,\Lambda}$ (kJ·mol^{-1})	R^2	RAD (%)
4% β-Cyclodextrin	45.0372	28.411	0.996	1.73

5. Conclusion

The electrical conductivity of 4% β-cyclodextrin solution had been determined from 323.65 to 353.65 K by conductivity meter method. Their equation was correlated respectively. The average relative deviation of electrical conductivity was 1.73%. The electrical conductivity by the model shows good agreement with the experimental data.

The experimental electrical conductivity as well as correlation equation in this work can be relevant for further applications of β-cyclodextrin.

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