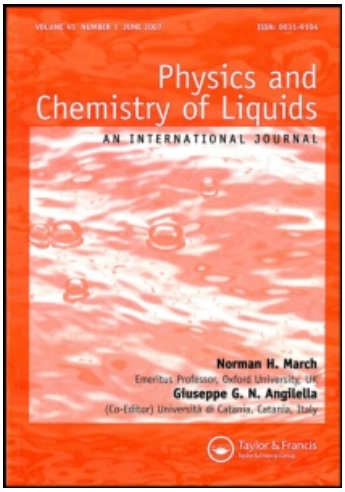

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Measurement of viscosity and electrical conductivity and a thermodynamic model

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MEASUREMENT OF VISCOSITY AND ELECTRICAL CONDUCTIVITY AND A THERMODYNAMIC MODEL

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According to the need of industrial design and application of new desulfurization technique, we determine viscosities and electrical conductivities of dilute SO_2 mixture gas in dimethyl sulfoxide mixture absorbents, and establish a thermodynamic model based on experimental data. The viscosities and electrical conductivities calculated by the model show good agreement with experimental data.

Keywords: Electrical conductivity; Viscosity; Thermodynamic model

INTRODUCTION

Removal of SO_2 and other acidic gas from flue gas has been a very important research project. In order to find an effective method, various desulfurization technique [1–6], such as activated carbon, molecular sieve, the electron-beam radiation technique, chemical method, physical solvents etc. have all been utilized. Compared with these methods, organic solvent absorption, to some degree, has such advantages as low investment, high SO_2 absorption efficiency and desorption efficiency and is worth further research. During the experiment we found that, after adding Mn^{2+} in dimethyl sulfoxide (DMSO), the SO_2 absorption efficiency can be further increased. This mixture absorbent has many advantages and may be used to remove SO_2 from flue gas to solve industrial problem in flue gas purification. Meanwhile viscosity and electrical conductivity are important physical properties during the process of removing SO_2, and their values are needed in industrial design and application for flue gas removal. The change of the absorbent's viscosity during the course of removal of SO_2 is one of the fundamental data in engineering design and industrial practice; and the change of the absorbent's electrical conductivity during the course of SO_2 removal may become a method of on-line monitor and long-distance control. The data available in literature were only the electrical conductivity and viscosity of the pure substance;

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very few experimental data for this system can be found, and no suitable correlation model for this system has been proposed. Therefore, bearing in mind the need of industrial design, in this article we determine viscosity and electrical conductivity of dilute SO_2 mixture gas in dimethyl sulfoxide mixture absorbents, and establish a thermodynamic model based on experimental data.

1 THE MEASUREMENT OF ELECTRICAL CONDUCTIVITY

1.1 The Experimental Instrument and Procedure

The instrument: DDS-307-type conductivity meter (The analytic instrument factory of Shanghai, China).

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

1.2 The Electrical Conductivity Measurement During the Process of DMSO Absorbing SO_2

A known amount of degassed absorbent is sucked into the absorption tube, and SO_2 goes through the absorption tube at a rate of 25 mL/min at different temperatures till its saturation. The uncertainty of mass was ± 0.00001 g. The whole apparatus was kept at a constant temperature inside a temperature-controlled bath. The uncertainty of temperature is ± 0.05 K. The electrical conductivity of absorption solution was determined by a DDS-307-type conductivity meter. The uncertainty of the conductivity is $\pm 0.05\,\mu s\,cm^{-1}$. The SO_2 in the liquid was analyzed by iodometry.

The measurement result of electrical conductivity is listed in Table I and Fig. 1.

1.3 The Molecule Thermodynamic Model of Solubilities and Electrical Conductivities of SO_2 in DMSO

Since a limiting conductance equation was proposed by Kohlrausch, much development has occurred. The well-known equations are: Pites equation, Onsager–Fuoss–Chen equation, Fuoss equation, Lee-Wheaton equation, Niliang-Jiangwenhua-Hanshijun equation etc. [7]. The most classical equation is the Kohlrausch equation:

$$\Lambda_m = \Lambda_m^{\infty} - Ac^{1/2} \tag{1}$$

TABLE I The solubilities x_{so_2} and electrical conductivities κ of SO_2 in DMSO at 25°C

C_{so_2} (mol kg^{-1})	x_{so_2}	κ (μs cm^{-1})		*RD* (%)
		Experimental data	*Calculated value*	
0.0489	0.00381	1.97	2.09	−6.09
0.0744	0.00578	2.56	2.44	4.52
0.207	0.0159	3.47	3.39	2.18
0.381	0.0289	3.99	4.07	−1.93
0.460	0.0347	4.31	4.30	0.25
0.612	0.0456	4.7	4.68	0.46
0.939	0.0684	5.24	5.34	−1.82
1.07	0.0772	5.6	5.56	0.72
1.63	0.113	6.41	6.38	0.39

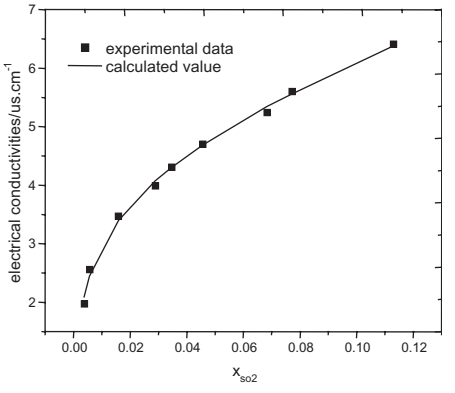

FIGURE 1 The relationship of solubilities x_{so_2} and electrical conductivities κ of SO_2 in DMSO at 25°C.

in which Λ_m, Λ_m^∞ is molar conductivity and molar equivalent conductivity respectively, c is molar volume concentration, A is an empirical constant.

Multiplying by c in Eq. (1), and considering $\kappa = \Lambda_m c$, we obtain

$$\kappa = \Lambda_m^\infty c - Ac^{3/2} \tag{2}$$

Thus if we take the differential of Eq. (2), we find

$$\frac{d\kappa}{dc} = \Lambda_m^\infty - \frac{3}{2}Ac^{1/2} \tag{3}$$

The experiment proves that [7–14], Eq. (3) is only suitable to part of dilute solution, majority of slight high concentration deviates from Eq. (3), and that accord is found with a generalized function relation as follows:

$$x\frac{d\kappa}{dx} = f(x) \tag{4}$$

Based on molecule structure theory of solution derived by the authors [11–14], the solution property lies in the interaction between molecules. Such effect is not simple plus between homogeneity molecule or heterogeneity molecule, but is a sort of complex coordination behavior. Compared with the pure liquid, the composition and property of solution is unusual, in that the special group statistical systems were formed among molecules.

In the solution of unit volume, if we assume

k_{ij} – interaction of energy between molecules, J;
V – the volume held of grouped molecule (solute molecule);
V_m – the volume held of grouped molecule when single molecule thronged;
x – mole fraction of solution;

Then according to group statistics theory, based on the method of Lagrange undetermined multiplier and quasi-chemical reaction mechanism, the molecular

thermodynamic equation for binary solution was taken to be as follows,

$$V = V_m[k_{12}x(k_{21} + k_{22}x)]/[k_{21}(k_{12}x + k_{11})] \tag{5}$$

The prediction model about surface tension, dielectric constant, coefficient of thermal conductivity and excess enthalpy of binary solution had been successfully established on the basis of Eq. 5. In this article we extend it to the calculation of electric conductivity of DMSO absorbing SO_2, x_{so_2} being the independent variable.

In Eq. (5), V is the bunched molecule (solute molecule) volume among the groups in the unit volume solution, then V_m is the function of solution composition x:

$$V = f(x) \tag{6}$$

We assume now the following relation:

$$f'(x) = jf(x) \tag{7}$$

and combining Eqs. (4)–(7) yields

$$\frac{d\kappa}{dx} = jV_m k_{12}(k_{21} + k_{22}x)/[k_{21}(k_{12}x + k_{11})]. \tag{8}$$

Integration of Eq. (8) under constant temperature and constant pressure leads to the result

$$\kappa - \kappa_0 = \frac{jV_m k_{22}}{k_{21}}x + jV_m\left(1 - \frac{k_{11}k_{22}}{k_{21}k_{22}}\right)\ln\left(1 + \frac{k_{12}}{k_{11}}x\right) \tag{9}$$

at definite temperature and pressure:

$$a = jV_m k_{22}/k_{21} \tag{10}$$

$$b = jV_m(1 - k_{11}k_{22}/k_{21}k_{12}) \tag{11}$$

$$c = k_{12}/k_{11} \tag{12}$$

The group statistical theory model of conductivity for binary solution:

$$\kappa = \kappa_0 + ax + b\ln(1 + cx) \tag{13}$$

where x is the solution composition, in this article x being explicitly the solubility of SO_2 in DMSO (mole fraction), κ is conductivity, κ_0 is conductivity of pure DMSO (the measurement value of pure DMSO is 0. 0300 $\mu s\,cm^{-1}$ at 25°C).

In Eq. (13), the adjustable parameters a, b, c, have been obtained from simplex optimization. With $F = \min \sum |\kappa_{exp} - \kappa_{cal}|^2$, the results are $a = 14.09$, $b = 0.8336$, $c = 2658$. The calculated result is shown in Table I based on these a, b, c parameters. The average relative deviation is 2.04%, the conductivities calculated by the model showing good agreement with the experimental data. Obviously, the thermodynamic

model of solubilities and conductivities of SO_2 in DMSO established in this article is quite successful.

1.4 The Electrical Conductivity Measurement of DMSO+Mn^{2+} Mixture Absorbent Absorbing SO_2

A known amount of mixture solvents are sucked into the absorption tube, mixture solvents were dimethyl sulfoxide and 0.96546 mol/L $MnSO_4$ solution, which were mixed in ratio 1 : 0.03 by volume and mixture gas containing $SO_2 \cdot O_2$ go through the absorption tube at a rate of 25 mL/min at different temperatures till its saturation. The uncertainty of mass was ± 0.00001 g. The whole apparatus was kept at a constant temperature inside a temperature-controlled bath. The uncertainty of temperature is ± 0.05 K. The electrical conductivity of absorption solution was determined by the DDS-307-type conductivity meter. The uncertainty of conductivity is $\pm 0.05\,\mu s\,cm^{-1}$. The SO_2 in the liquid was analyzed by iodometry. The concentration of sulfate radical in the liquid was determined by barium chromate spectrophotometry (UNICO ultraviolet visible spectrophotometer).

The measurements of conductivity are presented in Table II and Fig. 2.

1.5 The Thermodynamic Model of Solubilities and Conductivities of SO_2 in DMSO + Mn^{2+} Mixture Absorbent

The essential component developed mixture absorption by this article is DMSO, small quantity is $MnSO_4$ solution. The desulfurated gas is dilute SO_2 mixture gas containing O_2 with N_2 as dilution agent, it can generate H_2SO_4 in the desulfuration process, i.e., the desulfurated solution is the complicated system made of DMSO $\cdot$ Mn^{2+},

TABLE II The total solubilities x_T and conductivities κ_m of SO_2 in DMSO + Mn^{2+} mixture absorbent at 25°C

SO_4^{2-} Content $C_{SO_4^{2-}}$ (mol/kg)	C_{so_2} (mol/kg)	$x_{so_4^{2-}}$	x_{so_2}	x_T Total solubilities	κ(μs/cm)		RD (%)
					Experiment value	Calculated value	
0.229	0.106	0.0174	0.00806	0.0255	2360	2344	0.68
0.264	0.122	0.0200	0.00926	0.0293	2520	2510	0.40
0.294	0.136	0.0223	0.0103	0.0326	2710	2647	2.32
0.331	0.153	0.0249	0.0115	0.0364	2850	2799	1.79
0.358	0.166	0.0269	0.0125	0.0394	2890	2910	−0.69
0.395	0.183	0.0296	0.0137	0.0432	2960	3048	−2.97
0.426	0.198	0.0318	0.0147	0.0465	3090	3157	−2.17
0.454	0.210	0.0337	0.0156	0.0493	3240	3248	−0.25
0.490	0.227	0.0362	0.0168	0.0530	3370	3358	0.36
0.519	0.240	0.0383	0.0177	0.0560	3420	3442	−0.64
0.553	0.256	0.0406	0.0188	0.0595	3470	3534	−1.84
0.592	0.274	0.0433	0.0201	0.0634	3590	3630	−1.11
0.619	0.297	0.0451	0.0217	0.0668	3710	3706	0.11
0.657	0.315	0.0477	0.0229	0.0706	3820	3783	0.97
0.684	0.328	0.0495	0.0237	0.0732	3940	3834	2.69
0.723	0.347	0.0521	0.0250	0.0771	3990	3900	2.26
0.748	0.476	0.0533	0.0339	0.0872	4040	4039	0.02
0.810	0.515	0.0573	0.0364	0.0938	4060	4101	−1.01
0.984	0.740	0.0677	0.0509	0.119	4140	4152	−0.29

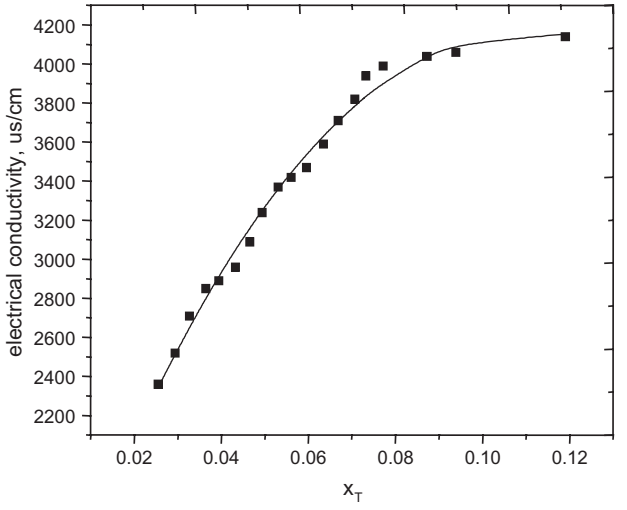

FIGURE 2 The relation of electric conductivity κ_m and SO_2 solubility x_T in the process of mixture absorbents absorbing SO_2. ■: Experimental data; —:calculated value by model.

$SO_4^{2-} \cdot H^+ \cdot H_2O$ etc. Considering the engineering goal in this article is removal of SO_2, we shall assume the total solubility x_T (i.e. the sum of physical solubility x_{SO_2} and chemical reaction solubility $x_{SO_4^{2-}}$) is the independent variable. The mixture absorbent is as fictitious solute, therefore the above-mentioned molecule group model of electric conductivity about binary solution can be extended to this fictitious binary system. Writing

$$\kappa_m = \kappa_m^0 + \alpha x + \beta \ln(1 + gx), \tag{14}$$

in Eq. (14) x denotes the total solubility of SO_2 in mixture absorbents, κ_m is the electric conductivity corresponding to x, κ_m^0 is electric conductivity at $x = 0$, i.e. absorbents unabsorbed SO_2 ($\kappa_m^0 = 1 \times 10^3$ μs/cm determined by experiment at 25°C). In Eq. (14), the adjustable parameters α, β, g can be obtained from simplex optimization.

The function

$$F = \min \sum \left| \frac{\kappa_{\text{exp}} - \kappa_{\text{cal}}}{\kappa_{\text{exp}}} \right|^2,$$

the results being $\alpha = -3.108 \times 10^5$, $\beta = 2.097 \times 10^5$, $g = 1.773$. The calculated results are shown in Table II. The average relative deviation ARD is 0.03%, the maximum relative deviation is less than 2.97%, the conductivities calculated by the model show good agreement with the experimental data. Certainly we can also predict SO_2 solubility with the experimental value of electrical conductivities according Eq. (14). Obviously, the thermodynamic model of solubilities and conductivities of SO_2 in mixture absorbents established in this article is quite successful.

TABLE III The experimental data of viscosity η of absorption solution

P_{SO_2}(kPa)	C_{SO_2} (mol kg^{-1})	$C_{H_2SO_4}$ (mol kg^{-1})	$\eta \times 10^3$ (Pa s)	P_{SO_2}(kPa)	C_{SO_2} (mol kg^{-1})	$C_{H_2SO_4}$ (mol kg^{-1})	$\eta \times 10^3$ (Pa s)
20°C				25°C			
0.0220	0.0120	0.0300	2.42	0.0190	0.0105	0.0310	2.20
0.0440	0.0252	0.0600	2.51	0.0380	0.0209	0.0620	2.29
0.0660	0.0386	0.0900	2.59	0.0580	0.0319	0.0930	2.37
0.0880	0.0510	0.120	2.68	0.0760	0.0418	0.124	2.44
0.110	0.0643	0.150	2.76	0.0960	0.0528	0.155	2.51
0.133	0.0778	0.180	2.88	0.110	0.0605	0.186	2.59
0.155	0.0906	0.210	2.98	0.130	0.0715	0.217	2.68
0.180	0.105	0.240	3.07	0.150	0.0825	0.248	2.72
0.220	0.129	0.300	3.19	0.190	0.105	0.310	2.85
0.266	0.156	0.360	3.42	0.230	0.127	0.372	3.00
0.310	0.181	0.420	3.63	0.260	0.143	0.434	3.20
0.350	0.205	0.480	3.83	0.310	0.171	0.496	3.31
0.390	0.228	0.540	4.04	0.340	0.187	0.558	3.49
0.530	0.310	0.600	4.22	0.430	0.237	0.620	3.65
0.590	0.345	0.660	4.42	0.470	0.259	0.682	3.84
0.640	0.345	0.720	4.62	0.520	0.286	0.744	4.07
0.700	0.410	0.780	4.87	0.560	0.308	0.806	4.28
0.740	0.433	0.840	5.15	0.600	0.330	0.868	4.50
0.760	0.445	0.900	5.40	0.640	0.352	0.930	4.71
0.800	0.468	0.960	5.65	0.670	0.369	0.992	4.93
0.850	0.497	1.02	5.91	0.690	0.380	1.05	5.17
0.900	0.527	1.08	6.27	0.700	0.385	1.12	5.41
0.950	0.556	1.14	6.53	0.720	0.396	1.18	5.66
1.00	0.585	1.20	6.91	0.800	0.440	1.24	5.98
30°C				35°C			
0.0160	0.00823	0.0317	1.90	0.0140	0.00644	0.0307	1.72
0.0320	0.0165	0.0634	1.98	0.0270	0.0124	0.0614	1.79
0.0480	0.0247	0.0951	2.02	0.0410	0.0189	0.0921	1.85
0.0630	0.0324	0.127	2.10	0.0540	0.0248	0.123	1.90
0.0790	0.0407	0.159	2.15	0.0680	0.0313	0.153	1.98
0.0950	0.0489	0.190	2.21	0.0810	0.0373	0.184	2.02
0.110	0.0566	0.222	2.28	0.0950	0.0437	0.215	2.09
0.130	0.0669	0.254	2.35	0.110	0.0506	0.246	2.15
0.160	0.0823	0.317	2.51	0.140	0.0644	0.307	2.29
0.190	0.0978	0.381	2.63	0.160	0.0736	0.368	2.41
0.220	0.113	0.444	2.78	0.190	0.0874	0.430	2.54
0.250	0.129	0.507	2.93	0.220	0.101	0.491	2.68
0.290	0.149	0.571	3.08	0.240	0.110	0.553	2.84
0.320	0.165	0.634	3.21	0.270	0.124	0.614	3.00
0.350	0.180	0.698	3.41	0.300	0.138	0.675	3.13
0.480	0.247	0.761	3.58	0.330	0.152	0.737	3.32
0.520	0.268	0.825	3.77	0.350	0.161	0.798	3.51
0.550	0.283	0.888	3.96	0.420	0.193	0.859	3.71
0.600	0.309	0.951	4.15	0.450	0.207	0.921	3.90
0.630	0.324	1.01	4.41	0.480	0.221	0.982	4.15
0.670	0.345	1.08	4.66	0.510	0.235	1.04	4.31
0.710	0.365	1.14	5.05	0.540	0.248	1.11	4.49
0.750	0.386	1.21	5.39	0.570	0.262	1.17	4.75
0.790	0.407	1.27	5.73	0.610	0.281	1.23	5.09

TABLE III Continued

P_{SO_2}(kPa)	C_{SO_2} (mol kg^{-1})	$C_{H_2SO_4}$ (mol kg^{-1})	$\eta \times 10^3$ (Pa s)
	40°C		
0.0110	0.00413	0.0298	1.60
0.0210	0.00788	0.0597	1.64
0.0290	0.0109	0.0895	1.69
0.0420	0.0158	0.119	1.73
0.0530	0.0199	0.149	1.78
0.0630	0.0236	0.179	1.83
0.0740	0.0278	0.209	1.89
0.0850	0.0319	0.239	1.94
0.110	0.0413	0.298	2.07
0.130	0.0488	0.358	2.20
0.150	0.0563	0.418	2.34
0.170	0.0638	0.477	2.48
0.190	0.0713	0.537	2.60
0.210	0.0788	0.596	2.70
0.230	0.0863	0.656	2.83
0.260	0.0976	0.716	2.99
0.270	0.101	0.775	3.16
0.300	0.113	0.835	3.37
0.320	0.120	0.895	3.58
0.340	0.128	0.954	3.78
0.400	0.150	1.01	3.99
0.430	0.161	1.07	4.21
0.450	0.169	1.13	4.41
0.480	0.180	1.19	4.68

2 THE VISCOSITY OF ABSORBENT

2.1 The Instrument and Viscosity Measurement

The instrument: NDJ-79 type rotary viscosimeter (Shanghai Tongji University).

Measurement procedure: A known amount of mixture absorbent ($DMSO + Mn^{2+}$) is sucked into the absorption tube, and mixture gas of containing $SO_2 \cdot O_2$ goes through the absorption tube at a rate of 25 mL/min at different temperatures till its saturation. The uncertainty of mass was ± 0.00001 g. The whole apparatus was kept at a constant temperature inside a temperature-controlled bath. The uncertainty of temperature is ± 0.05 K. The viscosity of absorption solution was determined by a NDJ-79 type rotary viscosimeter. The uncertainty of viscosity is ± 0.05 Pa s. The SO_2 in the liquid was analyzed by potassium permanganate titration. The concentration of sulfate radical in the liquid was determined by barium chromate spectrophotometry (UNICO ultraviolet visible spectrophotometer). The measurements of viscosity are presented in Table III.

2.2 The Mathematical Model of Viscosity

1. The mathematic model of viscosity for mixture absorbent absorbing SO_2 by experimental data correlation is as follows:

$$\eta = 8.32X_{\mathrm{H_2SO_4}}^2 + 28.42X_{\mathrm{H_2SO_4}} + 43.05X_{\mathrm{SO_2}} + 0.397X_{\mathrm{DMSO+MnSO_4}} + 36.91/(T - 273.15)$$

The calculated value by the model is shown in Table IV. It appears that the maximum relative deviation among all these values does not exceed 5.95%, and the average relative deviation ARD is 3.96%. The viscosity calculated by the model shows good agreement with the experimental data.

TABLE IV The comparison of experimental data and calculated value

T (K)	X_{so_2}	$X_{DMSO+MnSO_4}$	$X_{H_2SO_4}$	$\eta \times 10^3$ (Pa s)		RD (%)
				Experimental data	*Calculated value*	
293.15	0.000934	0.997	0.00234	2.42	2.35	2.98
293.15	0.00196	0.993	0.00466	2.51	2.46	1.99
293.15	0.00299	0.990	0.00696	2.59	2.57	0.77
293.15	0.00393	0.987	0.00925	2.68	2.67	0.37
293.15	0.00494	0.984	0.0115	2.76	2.78	−0.72
293.15	0.00596	0.980	0.0138	2.88	2.88	0.00
293.15	0.00692	0.977	0.0160	2.98	2.99	−0.34
293.15	0.00801	0.974	0.0183	3.07	3.10	−0.98
293.15	0.00973	0.968	0.0227	3.19	3.30	−3.45
293.15	0.0117	0.961	0.0270	3.42	3.51	−2.63
293.15	0.0135	0.955	0.0314	3.63	3.71	−2.20
293.15	0.0152	0.949	0.0356	3.83	3.90	−1.83
293.15	0.0168	0.943	0.0398	4.04	4.09	−1.24
293.15	0.0226	0.934	0.0438	4.22	4.45	−5.45
293.15	0.0250	0.927	0.0478	4.42	4.67	−5.66
293.15	0.0249	0.923	0.0519	4.62	4.78	−3.46
293.15	0.0293	0.915	0.0558	4.87	5.08	−4.31
293.15	0.0308	0.910	0.0597	5.15	5.26	−2.14
293.15	0.0314	0.905	0.0636	5.40	5.40	0.00
293.15	0.0329	0.900	0.0675	5.65	5.58	1.24
293.15	0.0347	0.894	0.0713	5.91	5.76	2.54
293.15	0.0366	0.888	0.0750	6.27	5.95	5.10
293.15	0.0383	0.883	0.0787	6.53	6.13	6.13
298.15	0.00323	0.987	0.00957	2.44	2.28	6.56
298.15	0.00406	0.984	0.0119	2.51	2.38	5.18
298.15	0.00464	0.981	0.0143	2.59	2.47	4.63
298.15	0.00546	0.978	0.0166	2.68	2.57	4.10
298.15	0.00629	0.975	0.0189	2.72	2.67	1.84
298.15	0.00791	0.969	0.0235	2.85	2.87	−0.70
298.15	0.00952	0.963	0.02798	3.00	3.07	−2.33
298.15	0.0107	0.957	0.0325	3.20	3.25	−1.56
298.15	0.0127	0.950	0.0368	3.31	3.46	−4.53
298.15	0.0138	0.945	0.0412	3.49	3.63	−4.01
298.15	0.0173	0.937	0.0454	3.65	3.90	−6.85
298.15	0.0188	0.932	0.0497	3.84	4.09	−6.51
298.15	0.0207	0.926	0.0538	4.07	4.29	−5.41
298.15	0.0221	0.920	0.0579	4.28	4.47	−4.44
298.15	0.0236	0.914	0.0620	4.50	4.65	−3.33
298.15	0.0250	0.909	0.0661	4.71	4.83	−2.55
298.15	0.0260	0.904	0.07007	4.93	4.99	−1.22
298.15	0.0267	0.899	0.0741	5.17	5.13	0.77
298.15	0.0269	0.895	0.0781	5.41	5.26	2.77
298.15	0.0276	0.890	0.0820	5.66	5.40	4.59
298.15	0.0304	0.884	0.0857	5.98	5.63	5.85
303.15	0.000641	0.997	0.00247	1.90	1.72	4.95
303.15	0.00128	0.994	0.00492	1.98	1.82	4.29
303.15	0.00191	0.991	0.00736	2.02	1.92	2.33

(*continued*)

TABLE IV Continued

T (K)	X_{so_2}	$X_{DMSO+MnSO_4}$	$X_{H_2SO_4}$	$\eta \times 10^3$ (Pa s)		RD (%)
				Experimental data	*Calculated value*	
303.15	0.00250	0.988	0.00979	2.10	2.01	0.45
303.15	0.00313	0.985	0.0122	2.15	2.10	0.48
303.15	0.00375	0.982	0.0146	2.21	2.20	−1.70
303.15	0.00433	0.979	0.0170	2.28	2.29	−2.39
303.15	0.00510	0.976	0.0193	2.35	2.39	−4.56
303.15	0.00624	0.970	0.0240	2.51	2.57	−5.40
303.15	0.00736	0.964	0.0287	2.63	2.75	−6.14
303.15	0.00848	0.958	0.0332	2.78	2.93	−7.14
303.15	0.0110	0.947	0.0422	3.08	3.30	−6.74
303.15	0.0132	0.936	0.0510	3.41	3.64	−6.74
303.15	0.0229	0.905	0.0718	4.41	4.66	−5.71
303.15	0.0243	0.900	0.0758	4.66	4.83	−3.65
303.15	0.0255	0.895	0.0798	5.05	5.01	0.79
303.15	0.0268	0.889	0.0837	5.39	5.18	3.90
303.15	0.0281	0.884	0.0876	5.73	5.35	6.63
308.15	0.00192	0.989	0.00948	1.90	1.80	5.26
308.15	0.00241	0.986	0.0118	1.98	1.89	4.55
308.15	0.00286	0.983	0.0141	2.02	1.97	2.48
308.15	0.00335	0.980	0.0165	2.09	2.06	1.44
308.15	0.00386	0.977	0.0188	2.15	2.14	0.47
308.15	0.00489	0.972	0.0233	2.29	2.32	−1.31
308.15	0.00556	0.967	0.0278	2.41	2.47	−2.49
308.15	0.00656	0.961	0.0323	2.54	2.64	−3.94
308.15	0.00756	0.956	0.0367	2.68	2.81	−4.85
308.15	0.00820	0.951	0.0410	2.84	2.97	−4.85
308.15	0.00917	0.945	0.0454	3.00	3.13	−4.33
308.15	0.0101	0.940	0.0496	3.13	3.29	−5.11
308.15	0.0111	0.935	0.0538	3.32	3.46	−4.22
308.15	0.0117	0.930	0.0580	3.51	3.60	−2.56
308.15	0.0139	0.924	0.0620	3.71	3.82	−2.96
308.15	0.0149	0.919	0.0661	3.90	3.97	−1.79
308.15	0.0158	0.914	0.0701	4.15	4.13	0.48
308.15	0.0167	0.909	0.0741	4.31	4.29	0.46
308.15	0.01755	0.904	0.0781	4.49	4.44	1.11
308.15	0.0184	0.899	0.0820	4.75	4.59	3.37
308.15	0.0196	0.895	0.0858	5.09	4.75	6.68
313.15	0.00122	0.989	0.00922	1.73	1.63	5.78
313.15	0.00153	0.987	0.0115	1.78	1.71	3.93
313.15	0.00182	0.984	0.0138	1.83	1.78	2.73
313.15	0.00213	0.982	0.0160	1.89	1.86	1.59
313.15	0.00244	0.979	0.0183	1.94	1.94	0.00
313.15	0.00314	0.974	0.0227	2.07	2.09	−0.97
313.15	0.00369	0.969	0.0271	2.20	2.24	−1.82
313.15	0.00424	0.964	0.0315	2.34	2.39	−2.14
313.15	0.00478	0.959	0.0358	2.48	2.54	−2.42
313.15	0.00532	0.955	0.0400	2.60	2.68	−3.08
313.15	0.00585	0.950	0.0443	2.70	2.83	−4.81
313.15	0.00637	0.9452	0.0485	2.83	2.97	−4.95
313.15	0.00717	0.940	0.0526	2.99	3.12	−4.35
313.15	0.00741	0.936	0.0567	3.16	3.25	−2.85
313.15	0.00819	0.9311	0.0607	3.37	3.40	−0.89
313.15	0.00869	0.927	0.0648	3.58	3.51	1.12
313.15	0.00919	0.922	0.0688	3.78	3.68	2.65
313.15	0.0108	0.917	0.0726	3.99	3.86	3.26
313.15	0.0115	0.912	0.0765	4.21	4.00	4.99
313.15	0.0120	0.908	0.0804	4.41	4.14	6.12

3. CONCLUSION

The electrical conductivity and viscosity of absorbent for DMSO and DMSO + Mn^{2+} were measured at different temperatures and different SO_2 partial pressures in this article according to the need of industrial design.

The model of electrical conductivity with solubility was proposed according to the group statistical theory, and the electrical conductivities calculated by the model are in good agreement with the experimental data.

The model of viscosity with solubility was developed, and the calculated viscosity using the model is in good agreement with the experimental values.

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