ACTA UNIVERSITATIS LODZIENSIS
FOLIA CHIMICA 1, 1982

Stefania Taniewska-Osińska, Marian Woldan

VISCOSIMETRIC INVESTIGATIONS OF H_2O-$AcNH_2$-NaI TERNARY SYSTEM WITHIN THE TEMPERATURE RANGE 25-85°C*

The viscosity of NaI solutions in mixed water-acetamide solvents over the temperature range 25-85°C has been measured. The dependence of viscosity, relative viscosity and the thermodynamic functions of activation for fluid flow of investigated solutions on the concentration and temperature has been discussed. The conclusions about the effect of NaI and acetamide on the structure of investigated systems have been drawn.

The literature data on viscosity of electrolyte solutions indicate that ions can increase or decrease the viscosity of solvent relatively to their solvation and influence on the solvent structure. Weakly solvated ions decrease the viscosity of solvent, while strongly solvated ones increase the above mentioned quantity.

The conclusion about the effect of electrolyte on solvent in case of diluted solutions can be drawn from the analysis of value of B coefficient from Jones-Dole's equation and its change with temperature [1, 2].

As for the more concentrated solution the conclusion about the effect of electrolyte on solvent can be drawn from the dependence of relative viscosity of the solution on its concentration and temperature [3].

---

* The present work has been carried out and supported within the framework of research on Interdepartment Problem MR-I-11.

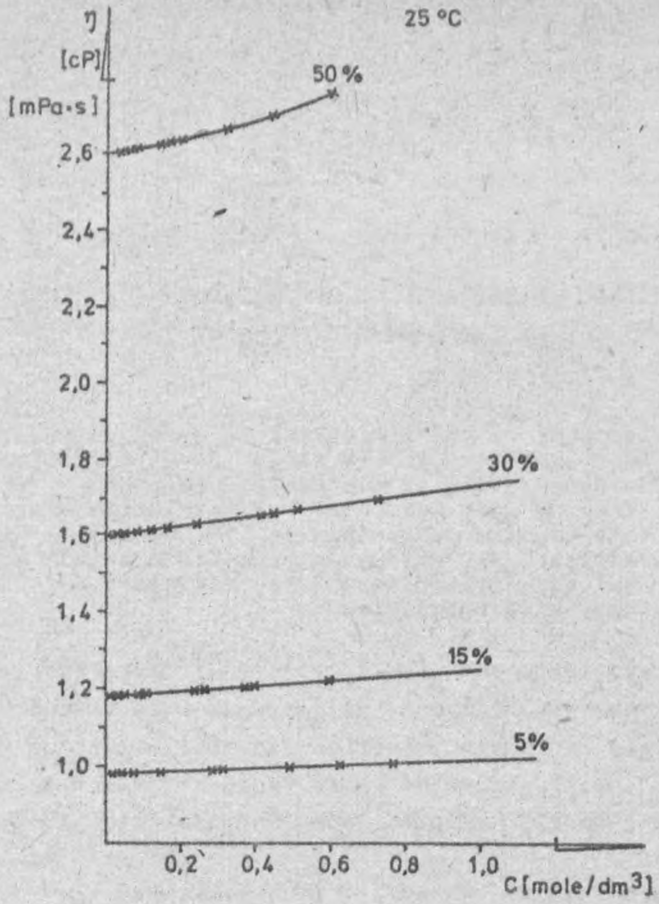

Fig. 1. Dependence of viscosity of NaI-solutions in water-acetamide solvents vs. concentrations of electrolyte at 25°C (wt % $AcNH_2$)

From recent works [4, 5] it follows that structural changes taking place in the solution illustrate the temperature coefficient $\Delta\eta_r/\Delta T$ of relative viscosity better than relative viscosity. In case of electrolyte ordering solvent structure $\Delta\eta_r/\Delta T$ coefficient is negative and positive for structure breaking electrolytes.

The analysis of thermodynamical properties of electrolyte solutions in molten acetamide [6] allowed to observe a certin similarity of the above mentioned solutions to aqueous solutions. Thus it seemed interesting to carry out the viscosimetric investigations of NaI solutions in mixed water-acetamide solvents. Such investigations could supply certain information on interaction among water and acetamide molecules.

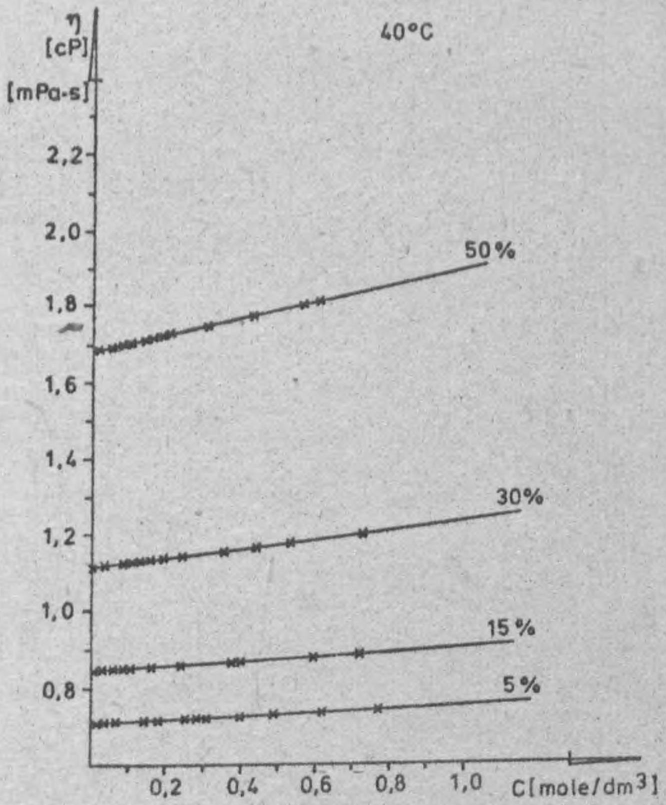

Fig. 2. Dependence of viscosity of NaI solutions in water-acetamide solvents vs. concentrations of electrolyte at 40°C (wt % $AcNH_2$)

Experimental

The mixed water-acetamide solvents were prepared from twice distilled water and acetamide p. a. by "Xenon" - Łódź. The way of purifying acetamide and NaI was described earlier [7]. For the measurements of viscosity of NaI solutions in water

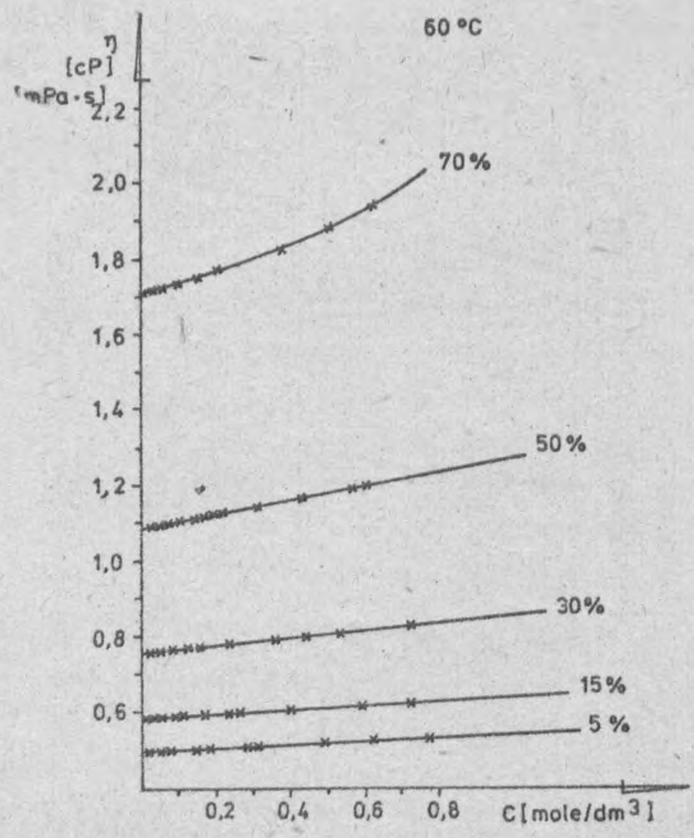

Fig. 3. Dependence of viscosity of NaI solutions in water-acetamide solvents vs. concentrations of electrolyte at 60°C (wt % $AcNH_2$)

acetamide solvents the Ubbelohde's viscometer by Schott - Gen Mainz (Jena Glass) was used.

The viscometer was placed in liquid ther mostate allowing to keep the required temperature with the precision to ±0.05°C. The error of viscosity measurements was ±0.5%. The results of viscosity measurements of NaI solutions in water-acetamide solvents at the temp. 25°, 40°, 60°, 75° and 85°C are presented on Fig. 1-5.

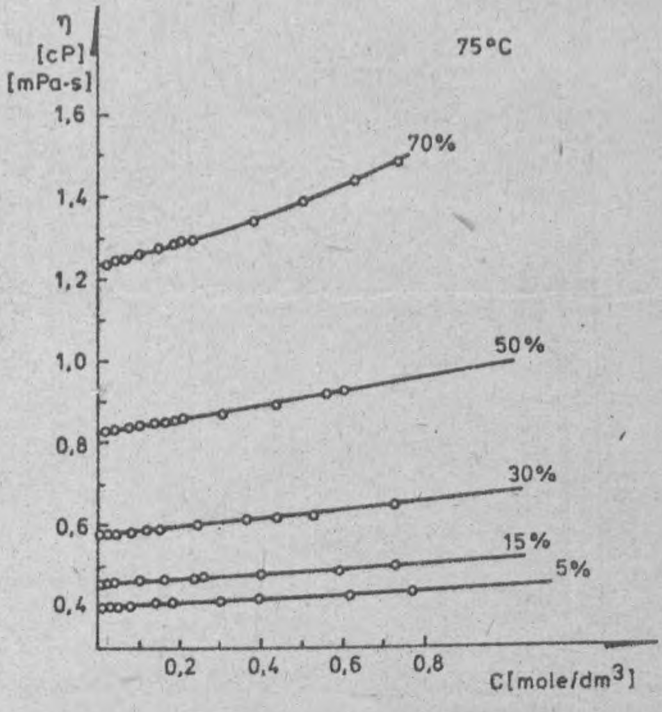

Fig. 4. Dependence of viscosity of NaI solutions in water-acetamide solvents vs. concentration of electrolyte at 75°C (wt % $AcNH_2$)

The discussion of results

As it seen from Fig. 1-5 the viscosity of the investigated H_2O-$AcNH_2$-NaI ternary system grows with the increase of electrolyte concentration in the solution. The increase of viscosity of the solution is the least in solvents with small acetamide contents and it grows gradually with the increase of nonelectrolyte contents in the solution. It seems probable that the observed increase of viscosity of the investigated ternary system with the increasing acetamide contents in the solution

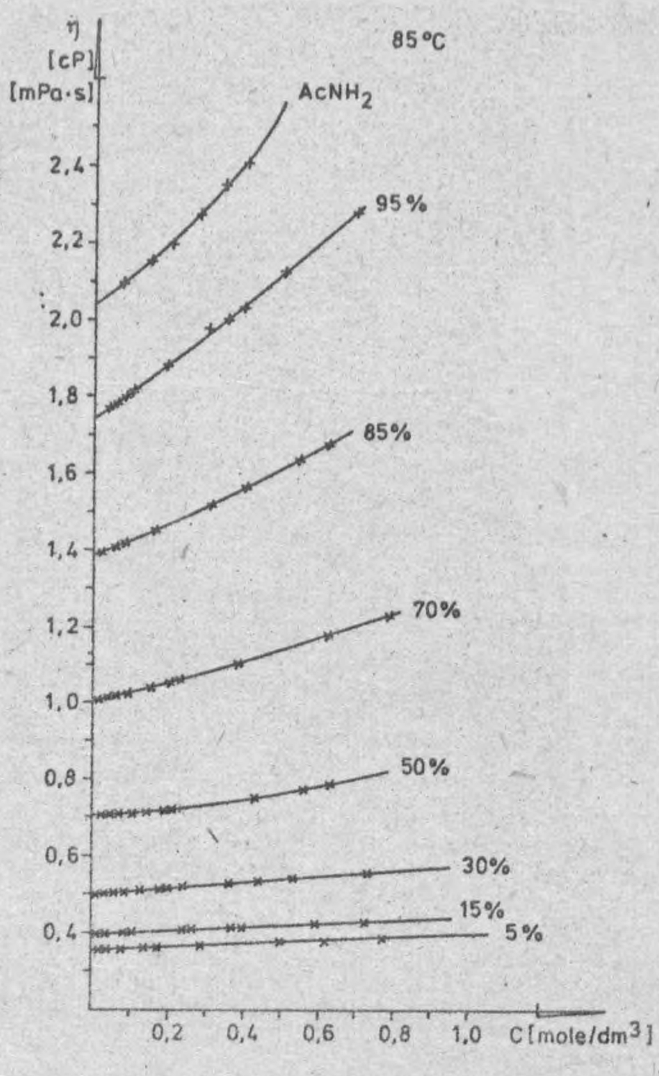

Fig. 5. Dependence of viscosity of NaI solutions in water-acetamide solvents vs. concentration of electrolyte at 85°C (wt % AcNH$_2$)

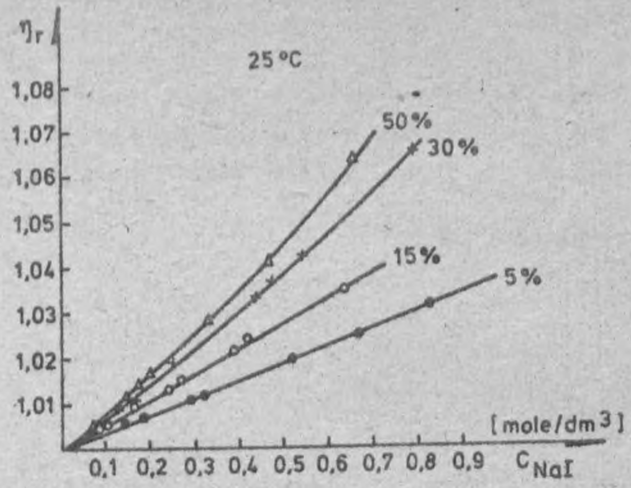

Fig. 6. Dependence of relative viscosity of NaI solutions in water-acetamide solvents vs. concentration and acetamide contents at 25°C (wt % $AcNH_2$)

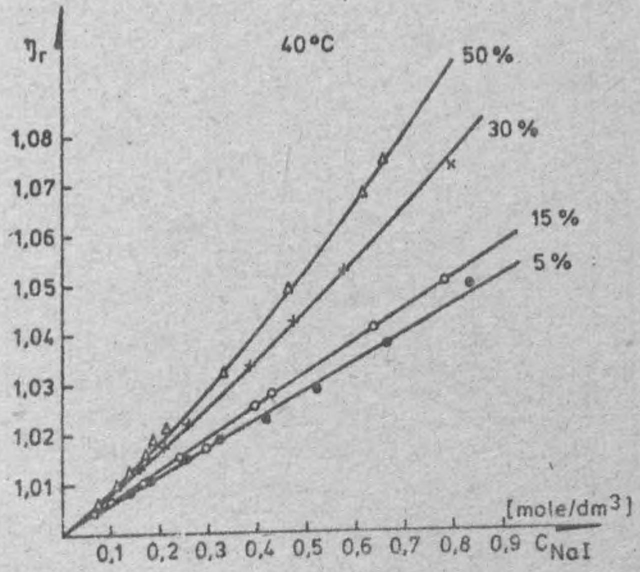

Fig. 7. Dependence of relative viscosity of NaI solutions in water-acetamide solvents vs. concentration and acetamide contents at 40°C (wt % $AcNH_2$)

is caused by the presence of greater acetamide molecules and by the formation of mixed associates composed of water and acetamide molecules with the contribution of hydrogen bonds.

From the dielectric investigations [8-10] it follows that hydrogen bonds among water and acetamide molecules are slightly weaker than hydrogen bonds in pure water. It can be thus ex-

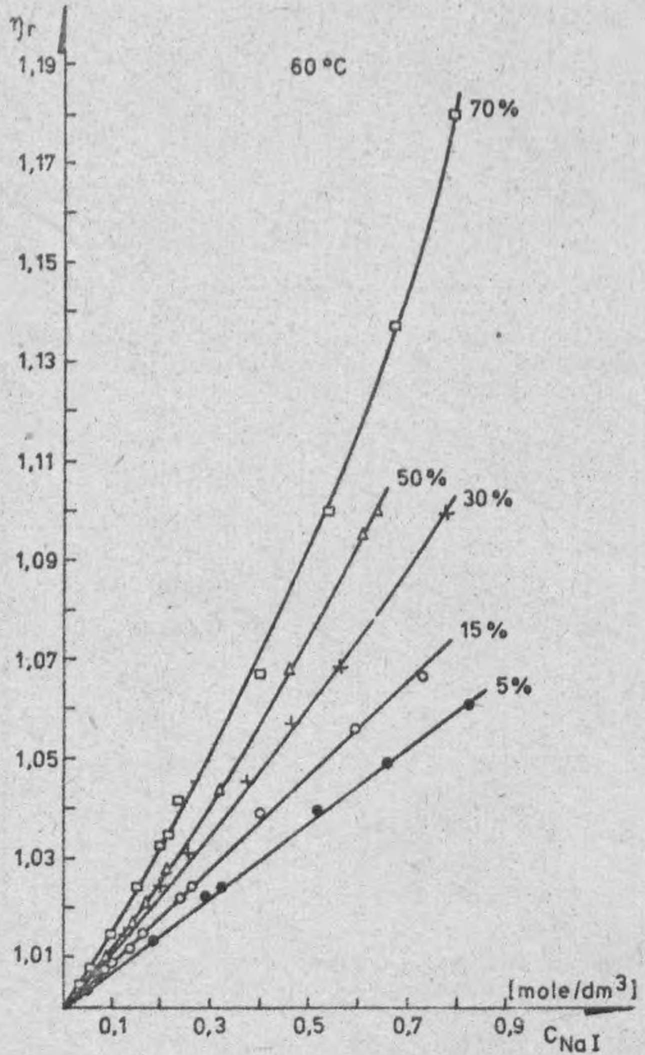

Fig. 8. Dependence of relative viscosity of NaI solutions in water-acetamide solvents vs. concentration and acetamide contents at 60°C (wt % $AcNH_2$)

pected that the observed greater effect of temperature changes on the viscosity of H_2O-$AcNH_2$-NaI system in comparison with H_2O-NaI binary system is caused by a partial disintegration of mixed water-acetamide asociates present in the solution.

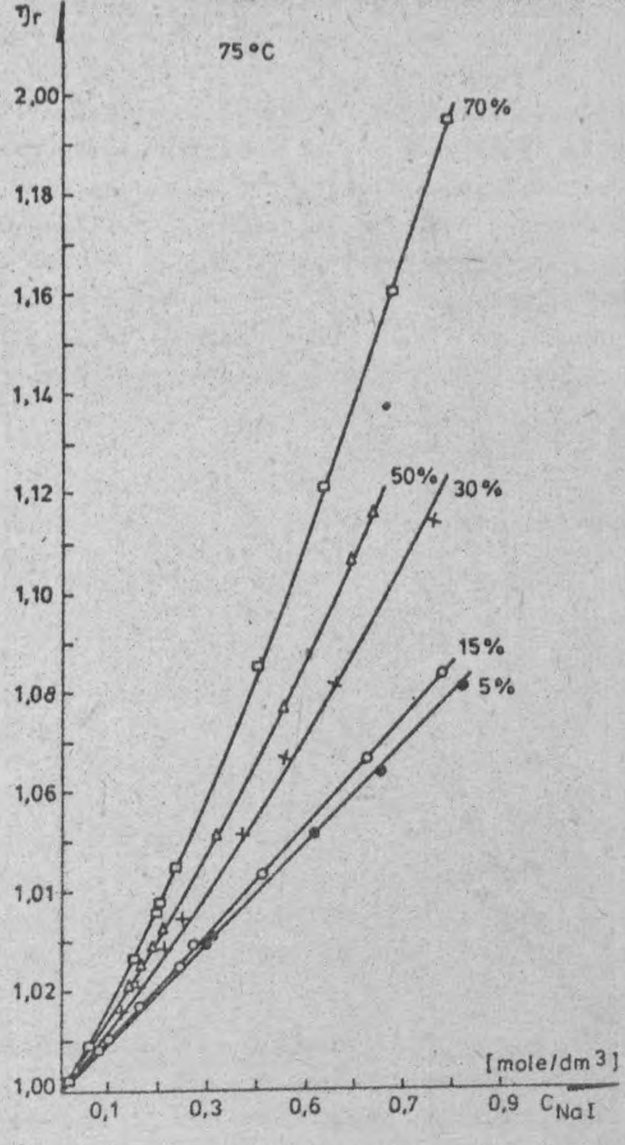

Fig. 9. Dependence of relative viscosity of NaI solutions in water-acetamide solvents vs. concentration and acetamide contents at 75°C (wt % $AcNH_2$)

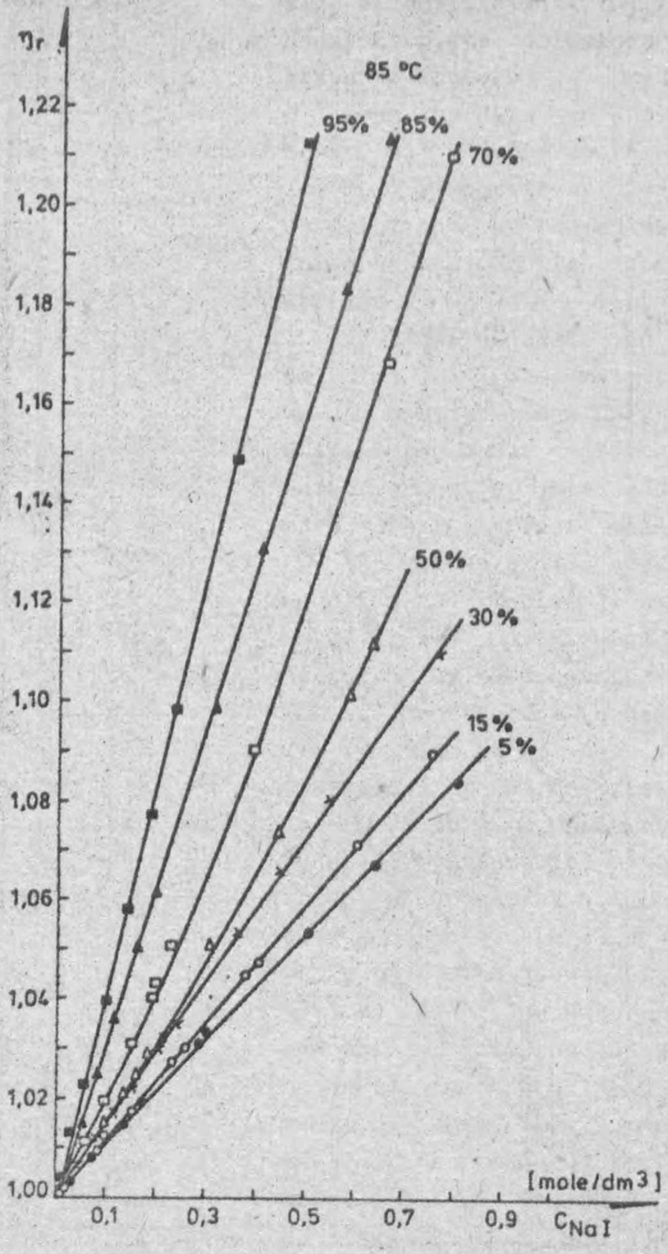

Fig. 10. Dependence of relative viscosity of NaI solutions in water-acetamide solvents vs. concentration and acetamide contents at 85°C (wt % $AcNH_2$)

The discussed above changes of viscosity of H_2O-$AcNH_2$-NaI ternary system as a function of concentration and temperature are more visible in case of relative viscosity of the investigated systems. The dependence of relative viscosity η_r of NaI solutions in water acetamide solvents on the salt concentration, nonelectrolyte contents and temperature is presented on Fig. 6-10.

It can be easily noticed that relative viscosity of the investigated solutions grows with the increase of electrolyte concentration and acetamide contents in the mixed solvents. It can be supposed that the increase of relative viscosity of the discussed systems is caused by growing volume of solvations shells around ions. In order to verify this hypothesis the values of limiting effective flowing volume of NaI in water-acetamide solvents were calculated over the temperature range 25-85°C (Table 1).

Table 1

The values of the limiting effective flowing volume (cm^3/mole) of NaI in water acetamide solvents within the temperature range 25-85°C

T(°C)	5 wt % $AcNH_2$	15 wt % $AcNH_2$	30 wt % $AcNH_2$	50 wt % $AcNH_2$	70 wt % $AcNH_2$	85 wt % $AcNH_2$	95 wt % $AcNH_2$
25	16	24	32	36	-	-	-
40	24	28	40	44	-	-	-
60	28	36	48	56	76	-	-
75	36	44	56	64	84	-	-
85	40	48	60	68	92	132	168

The limiting effective flowing volume of NaI in the investigated solutions was obtained by extrapolation to $c = 0$ of effective flowing volumes calculated from Einstein's equations concerning relative viscosity of the solutions

$$\eta / \eta_0 = 1 + 2.5cV_e \qquad (1)$$

where:

c - molar concentration of the solution

V_e - effective flowing volume of electrolyte i. e. the volume of 1 mole of ions together with solvations shells.

As it is seen from Table 1 the limiting effective flowing volume V_e^o of NaI in water-acetamide solutions increases with the growth of acetamide contents and temperature. Greater V_e^o values of NaI in solutions with greater acetamide contents can be explained by growing contribution of acetamide molecules in solvation of ions and the decrease of V_e^o value of NaI with growing temperature can be caused by breaking effect of thermal motions of molecules on mixed solvent structure. In higher temperature the mixed water-acetamide associates with weaker hydrogen bonds are more susceptible to disruption than water associates. More free molecules which can take part in ionic solvation appear then in the solution.

Using the Fig. 6-10 the values of temperature coefficient of relative viscosity $\Delta\eta_r/\Delta T$ of the investigated solutions were determined. The obtained values are given in Table 2.

Table 2

The values of temperature coefficient of relative viscosity $\Delta\eta_r/\Delta T$ of NaI solutions in water-acetamide solvents within the temperature range 25-85°C

m (mole/kg)	25-40°C	40-60°C	60-75°C	75-85°C
1	2	3	4	5.
	5 wt % $AcNH_2$ (1.58 mole % $AcNH_2$)			
0.1	0.1	0.1	0.1	0.1
0.2	0.3	0.2	0.2	0.1
0.3	0.4	0.3	0.4	0.1
0.4	0.5	0.5	0.5	0.1
0.5	0.7	0.6	0.6	0.2
0.6	0.8	0.7	0.8	0.3

Table 2 (contd.)

1	2	3	4	5
	15 wt % $AcNH_2$ (5.1 mole % $AcNH_2$)			
0.1	0.1	0.1	0.1	0.1
0.2	0.2	0.2	0.2	0.2
0.3	0.3	0.3	0.3	0.3
0.4	0.5	0.4	0.4	0.3
0.5	0.6	0.6	0.5	0.4
0.6	0.7	0.7	0.7	0.5
	30 wt % $AcNH_2$ (11.55 mole % $AcNH_2$)			
0.1	0.1	0.1	0.1	0.1
0.2	0.2	0.2	0.2	0.2
0.3	0.4	0.4	0.3	0.3
0.4	0.6	0.5	0.5	0.3
0.5	0.7	0.6	0.6	0.2
0.6	1.0	0.7	0.7	0.3
	50 wt % $AcNH_2$ (23.36 mole % $AcNH_2$)			
0.1	0.2	0.1	0.1	0.1
0.2	0.3	0.3	0.2	0.2
0.3	0.5	0.4	0.2	0.4
0.4	0.7	0.6	0.3	0.5
0.5	0.9	0.8	0.4	0.7
0.6	1.1	1.0	0.6	1.0
	70 wt % $AcNH_2$ (41 mole % $AcNH_2$)			
0.1	-	-	0.1	0.2
0.2	-	-	0.3	0.4
0.3	-	-	0.6	0.5
0.4	-	-	0.9	0.7
0.5	-	-	1.1	0.9
0.6	-	-	1.3	1.1

The temperature coefficient $\Delta\eta_r/\Delta T$ of water-acetamide NaI solutions is positive and it increases with the growing salt concentration in the solution alike in water. According to literature [4, 11] it can substantiate the breaking effect of dissolved NaI on the structure of water-acetamide solvents.

In order to compare acetamide with other solvents the dependences of $\Delta\eta_r/\Delta T$ coefficient of 0.5 m NaI solutions in several water-organic solvents on the mixture composition are presented on Fig. 11.

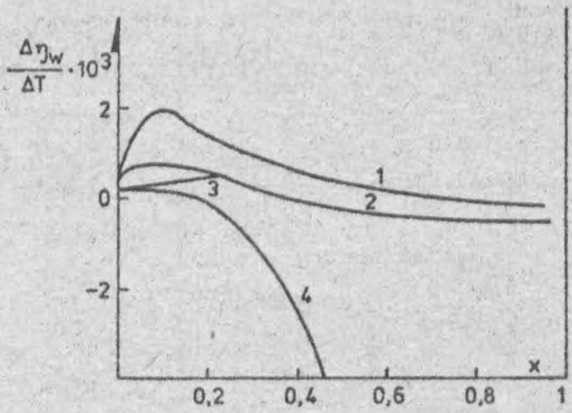

Fig. 11. Dependence of $\Delta\eta_r/\Delta T$ coefficient of 0.5 m NaI solutions is several water-organic solvents on the mixture composition within the temperature range 25-35°C. 1 - water-isopropanol [12]; 2 - water-DMF [13]; 3 - water-acetamide; 4 - water-formamide [13]

From the enclosed data it follows that $\Delta\eta_r/\Delta T$ coefficient of aqueous NaI solutions containing small amounts of DMF (up to ~ 5 mole %) and isopropanol (up to ~ 10 mole %) grows with the increacing organic component contents. It substantiates the growing breaking effect of NaI on the structure of these mixtures. Thus a conclusion can be drawn that the mixtures are more ordered than pure water. This conclusion is in agreement with the results of works of Kessler et. al. [14, 15]. The greater contents of DMF and isopropanol in the mixture causes the decrease of value of the discussed coefficient which changes its sign into negative. Similarly, in water-formamide system the value of $\Delta\eta_r/\Delta T$ coefficient decreases with growing amide contents. The negative sign of the coefficient $\Delta\eta_r/\Delta T$ of NaI solutions substantiates the ordering effect of the dissolved electrolyte on the structure of the discussed mixtures. It can be easily observed that from all the discussed substances formamide breaks water structure most. In case of water-acetamide system the coefficient $\Delta\eta_r/\Delta T$ points weakly to the disturbing effect of NaI on the structure of water-acetamide mixtures alike in case of pure water nad molten acetamide [4]. The breaking effect of NaI slightly increases with the growing contents of acetamide in the solution. From the carried out comparison it follows that acetamide with three dimentional hydrogen bond lattice in solid state [16-18] probably forms with water the associates with spacial structure while flat formamide molecules [19] form chain associates with water [20, 21].

Using Jones-Dole's equation we have determined the values of A and B coefficients of NaI solutions in water-acetamide mixtures. The coefficient A substantiating the electrostatic interactions among ions in the solutions is close to zero and almost doesn't change with the growing temperature. The values of B coefficient (Table 3) being the measure of interactions among ions and molecules of the solvent are positive in case of the solutions investigated by us. The values of this coefficient increase with the growing contents of acetamide in the mixed

Table 3

The values of B (l/mole) coefficient of Jones-Dole's equation of NaI in water-acetamide solvents

T(°C)	5 wt % $AcNH_2$	15 wt % $AcNH_2$	30 wt % $AcNH_2$	50 wt % $AcNH_2$	70 wt % $AcNH_2$	85 wt % $AcNH_2$	95 wt % $AcNH_2$
25	0.04	0.06	0.08	0.09	-	-	-
40	0.06	0.07	0.10	0.11	-	-	-
60	0.07	0.09	0.12	0.14	0.19	-	-
75	0.09	0.11	0.14	0.16	0.21	-	-
85	0.10	0.12	0.15	0.17	0.23	0.33	0.42

solvent and with the temperature growth. From this it follows that the effect of the addition of acetamide on electrolyte-water interactions is similar to the effect of temperature. It is known that temperature growth has breaking effect on the solvent structure, so acetamide molecules also cause the disturbance of structure of aqueous NaI solutions. It seems probable that this fact is connected with the affinity of acetamide molecules (hydrophilic character) to water. The formation of mixed associates from water and acetamide molecules bound by hydrogen bonds disturbs the structure of aqueous NaI solution. A similar course of relation of B coefficient of Na_2SO_4 and $MgSO_4$ to acetamide contents in mixed H_2O-$AcNH_2$ solvent was observed by D. Singh, N. P. Singh and L. Bahadur [22].

The investigations of viscosity of H_2O-$AcNH_2$-NaI system in five temperatures carried out by us allowed to calculate the values of thermodynamic functions of activation for fluid flow from Eyring's equation:

$$\eta = \frac{h\,N}{V} \exp\frac{\Delta G^{\ddagger}}{RT} = \frac{h\,N}{V} \exp\frac{\Delta H^{\ddagger}}{RT} \exp\frac{-\Delta S^{\ddagger}}{R} \qquad (2)$$

where:

h - Planck's constant
N - Avogardo's number
V - molar volume of solvent
R - gass constant

$\Delta G^{\ddagger}$, $\Delta H^{\ddagger}$ and $\Delta S^{\ddagger}$ - free energy, enthalpy and entropy of activation for fluid flow.

It follows from the literature [23-25] that in case of water structure ordering electrolytes both $\Delta H^{\ddagger}$ and $\Delta S^{\ddagger}$ increase with the growing salt concentration, while solvent structure breaking electrolyte causes the decrease of the values of these functions. Discussing the values from Tables 4-7 it can be notived that enthalpy of activation for fluid flow of NaI solution in water-acetamide mixtures decreases with the growth of salt concentration and temperature, similarly to water [24]. The growth of acetamide contents in mixed solvent on the other hand, causes the increase of the value enthalpy of activation.

Table 4

The values of enthalpy, free energy and entropy of activation for fluid flow of NaI solutions in water-acetamide mixture (5 wt. % $AcNH_2$ = 1.58 mole % $AcNH_2$)

m	25°			40°			60°			75°			85°		
	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$
$\frac{mole}{kg}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$
0.02	16.86	9.47	24.8	15.76	9.13	21.2	14.46	8.79	17.0	13.58	8.57	14.4	13.04	8.45	12.8
0.05	16.85	9.47	24.8	15.75	9.13	21.1	14.42	8.79	16.9	13.53	8.58	14.2	12.98	8.46	12.6
0.08	16.85	9.48	24.7	15.73	9.14	21.0	14.39	8.80	16.8	13.48	8.59	14.0	12.92	8.47	12.4
0.10	16.85	9.48	24.7	15.71	9.14	21.0	14.36	8.80	16.7	13.45	8.60	13.9	12.88	8.48	12.3
0.15	16.83	9.48	24.7	15.68	9.15	20.9	14.30	8.81	16.5	13.37	8.61	13.7	12.80	8.49	12.0
0.20	16.81	9.49	24.6	15.64	9.16	20.7	14.25	8.82	16.3	13.30	8.63	13.4	12.72	8.51	11.8
0.30	16.76	9.50	24.4	15.57	9.17	20.4	14.14	8.83	16.0	13.19	8.66	13.0	12.59	8.54	11.3
0.40	16.68	9.51	24.1	15.48	9.19	20.1	14.05	8.85	15.6	13.09	8.68	12.7	12.49	8.56	11.0
0.50	16.57	9.52	23.7	15.39	9.20	19.8	13.97	8.87	15.3	13.02	8.71	12.4	12.43	8.59	10.7
0.60	16.45	9.52	23.2	15.29	9.22	19.4	13.90	8.90	15.0	12.97	8.74	12.2	12.39	8.62	10.5

Table 5

The values of enthalpy, free energy and entropy of activation for fluid flow of NaI solutions in water-acetamide mixture (15 wt. % $AcNH_2$ = 5.10 mole % $AcNH_2$)

m	25°			40°			60°			75°			85°		
$\frac{mole}{kg}$	$\Delta H^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta G^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta S^{\ddagger}$ $\frac{J}{mole \cdot K}$	$\Delta H^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta G^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta S^{\ddagger}$ $\frac{J}{mole \cdot K}$	$\Delta H^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta G^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta S^{\ddagger}$ $\frac{J}{mole \cdot K}$	$\Delta H^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta G^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta S^{\ddagger}$ $\frac{J}{mole \cdot K}$	$\Delta H^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta G^{\ddagger}$ $\frac{kJ}{mole}$	$\Delta S^{\ddagger}$ $\frac{J}{mole \cdot K}$
0.02	17.38	10.12	24.4	16.63	9.77	21.9	15.73	9.42	18.9	15.12	9.16	17.1	14.74	9.01	16.0
0.05	17.35	10.12	24.3	16.60	9.78	21.8	15.70	9.43	18.8	15.09	9.17	17.0	14.72	9.02	15.9
0.08	17.32	10.13	24.2	16.57	9.78	21.7	15.67	9.43	18.7	15.06	9.18	16.9	14.69	9.03	15.8
0.10	17.30	10.13	24.1	16.55	9.79	21.6	15.65	9.44	18.6	15.05	9.18	16.8	14.67	9.04	15.7
0.15	17.25	10.14	23.9	16.50	9.79	21.4	15.61	9.45	18.5	15.00	9.20	16.7	14.63	9.06	15.6
0.20	17.21	10.14	23.7	16.46	9.80	21.3	15.56	9.47	18.3	14.95	9.21	16.5	14.58	9.07	15.4
0.30	17.14	10.16	23.4	16.37	9.82	20.9	15.46	9.49	17.9	14.85	9.25	16.1	14.47	9.11	15.0
0.40	17.08	10.17	23.2	16.30	9.84	20.6	15.36	9.51	17.6	14.73	9.28	15.7	14.34	9.14	14.5
0.50	17.04	10.18	23.0	16.23	9.85	20.4	15.26	9.54	17.2	14.60	9.31	15.2	14.20	9.18	14.0
0.60	17.02	10.20	22.9	16.17	9.87	20.1	15.15	9.56	16.8	14.47	9.34	14.7	14.04	9.21	13.5

Table 6

The values of enthalpy, free energy and entropy of activation for fluid flow of NaI solutions in water-acetamide mixture (30 wt. % $AcNH_2$ = 11.55 mole % $AcNH_2$)

m	25°			40°			60°			75°			85°		
	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$	$\Delta H^{\ddagger}$	$\Delta G^{\ddagger}$	$\Delta S^{\ddagger}$
$\frac{mole}{kg}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$	$\frac{kJ}{mole}$	$\frac{kJ}{mole}$	$\frac{J}{mole \cdot K}$
0.02	19.00	11.16	26.3	18.03	10.80	23.1	16.87	10.44	19.3	16.09	10.16	17.0	15.61	10.04	15.6
0.05	18.96	11.17	26.1	18.00	10.81	23.0	16.84	10.45	19.2	16.06	10.17	16.9	15.58	10.05	15.4
0.08	18.93	11.17	26.0	17.96	10.81	22.8	16.81	10.46	19.1	16.03	10.18	16.8	15.55	10.07	15.3
0.10	18.91	11.18	25.9	17.94	10.82	22.7	16.79	10.47	19.0	16.01	10.19	16.7	15.53	10.07	15.2
0.15	18.85	11.19	25.7	17.89	10.83	22.5	16.74	10.48	18.8	15.96	10.21	16.5	15.48	10.10	15.0
0.20	18.79	11.20	25.5	17.83	10.84	22.3	16.68	10.50	18.6	15.91	10.23	16.3	15.43	10.12	14.8
0.30	18.68	11.22	25.1	17.72	10.87	21.9	16.58	10.53	18.2	15.81	10.27	15.9	15.33	10.16	14.4
0.40	18.58	11.24	24.6	17.62	10.89	21.5	16.48	10.57	17.8	15.71	10.31	15.4	15.24	10.20	14.1
0.50	18.47	11.26	24.2	17.52	10.91	21.1	16.39	10.60	17.4	15.62	10.36	15.1	15.15	10.24	13.7
0.60	18.37	11.28	23.8	17.42	10.93	20.7	16.29	10.63	17.0	15.53	10.40	14.7	15.05	10.28	13.3

Table 7

The values of enthalpy, free energy and entropy of activation for fluid flow of NaI solutions in water-acetamide mixture (50 wt. % $AcNH_2$ = 23.36 mole % $AcNH_2$)

m · mole/kg	25°			40°			60°			75°			85°		
	$\Delta H^{\ddagger}$ kJ/mole	$\Delta G^{\ddagger}$ kJ/mole	$\Delta S^{\ddagger}$ J/mole·K	$\Delta H^{\ddagger}$ kJ/mole	$\Delta G^{\ddagger}$ kJ/mole	$\Delta S^{\ddagger}$ J/mole·K	$\Delta H^{\ddagger}$ kJ/mole	$\Delta G^{\ddagger}$ kJ/mole	$\Delta S^{\ddagger}$ J/mole·K	$\Delta H^{\ddagger}$ kJ/mole	$\Delta G^{\ddagger}$ kJ/mole	$\Delta S^{\ddagger}$ J/mole·K	$\Delta H^{\ddagger}$ kJ/mole	$\Delta G^{\ddagger}$ kJ/mole	$\Delta S^{\ddagger}$ J/mole·K
0.02	22.57	12.80	32.8	20.65	12.35	26.5	18.37	11.97	19.2	16.83	11.75	14.6	15.87	11.61	11.9
0.05	22.54	12.80	32.7	20.62	12.36	26.4	18.33	11.98	19.1	16.79	11.76	14.5	15.83	11.62	11.7
0.08	22.52	12.81	32.6	20.59	12.36	26.3	18.30	11.99	19.0	16.75	11.77	14.3	15.79	11.64	11.6
0.10	22.50	12.81	32.5	20.57	12.37	26.2	18.28	11.99	18.9	16.73	11.78	14.2	15.77	11.65	11.5
0.15	22.44	12.82	32.3	20.52	12.38	26.0	18.22	12.01	18.6	16.67	11.80	14.0	15.71	11.67	11.3
0.20	22.37	12.84	32.0	20.45	12.39	25.8	18.16	12.03	18.4	16.62	11.83	13.8	15.66	11.69	11.1
0.30	22.22	12.86	31.4	20.31	12.42	25.2	18.05	12.07	17.9	16.52	11.87	13.3	15.57	11.74	10.7
0.40	22.02	12.88	30.7	20.16	12.45	24.6	17.94	12.12	17.5	16.43	11.93	12.9	15.50	11.79	10.4
0.50	21.80	12.90	29.8	19.99	12.48	24.0	17.82	12.16	17.0	16.37	11.98	12.6	15.46	11.84	10.1
0.60	21.55	12.93	28.9	19.80	12.52	23.3	17.71	12.21	16.5	16.31	12.04	12.3	15.44	11.90	9.9

From this it follows that NaI introduced to water-acetamide solvent acts similarly to the growth of temperature i. e. breaks solvent structure. Fluid flow of the solvent with disturbed structure requires smaller input of energy. The addition of acetamide causes opposite effect. The increase of acetamide contents in aqueous NaI solution cause, as it was mentioned above, the formation of greater and greater ammounts of mixed associates, which makes the fluid flow of the solution more difficult. Thus the enthalpy of activation for fluid flow grows with the increasing acetamide contents in the solution. Similar conclusions about the effect of NaI and acetamide on the structure of investigated systems can be drawn from the analysis the dependence of activation entropy for fluid flow of the discussed systems on the solution concentration, acetamide contents in the mixed solvent and on temperature.

REFERENCES

[1] Kaminsky M., Z. Phys. Chem., 5, 154 (1955); 8, 173 (1956); 12, 206 (1957).

[2] Kaminsky M., Disc. Faraday Soc., 24, 171 (1957).

[3] Pienkina N. W., Zhur. Fiz. Khim. ("Winiti" No 2612, 2613, 2614, 2615) (1971).

[4] Woldan M., Doctoral Dissertation, University Łódź, (1973).

[5] Taniewska-Osińska S., Woldan M., Acta Univ. Lodz. ZNUŁ, S. II, 24, 33 (1978).

[6] Taniewska-Osińska S., Woldan M., Rocz. Chem., 48, 1753 (1974).

[7] Taniewska-Osińska S., Woldan M., Rocz. Chem., 51, 1933 (1977).

[8] Rohdewald P., Moldner M., J. Phys. Chem., 77, 373 (1973).

[9] Gonczarow W. S., Ljaszczenko A. K., Jastremskij P. S., Zhur. Strukt. Khim., 17, 4, 662 (1976).

[10] Gonczarow W. S., Jastremskij P. S., Izv. Vyssh. Ucheb. Zaved. Khim. Khim. Tekhn., 4, 602 (1976).

[11] Stokes R. H., Mills R., Viscosity of Electrolytes and Related Properties, New York (1965).

[12] Taniewska-Osińska S., Kacperska A., Pol. J. Chem., 53, 1351 (1979).

[13] Piekarska A., Doctoral Dissertation, University Łódź (1975).

[14] Mishustin A. J., Kessler Yu. M., Zhur. Strukt. Khim., 15, 205 (1974).

[15] Verstakov E. S., Yastremskij P. S., Kessler Yu. M., Mishustin A. J., Emelin V. P., Zhur. Fiz. Khim., 49, 1604 (1975).

[16] Senti F., Harker D., J. Am. Chem. Soc., 62, 2008 (1940).

[17] Hamilton W. C., Acta Cryst., 18, 866 (1965).

[18] Denne W. A., Small R. W. H., Acta Cryst., B27, 1094 (1971).

[19] Ladell J., Post B., Acta Cryst., 7, 559 (1954).

[20] Kessler Yu. M., Emelin V. P., Toluleev Yu. S., Truskov O. V., Lapshin R. M., Zhur. Strukt. Khim., 13, 2, 210 (1972).

[21] Yastremskij P. S., Verstakov E. S., Kessler Yu. M., Mishustin A. J., Emelin V. P., Bobriner Yu. M., Zhur. Fiz. Khim., 49, 2950 (1975).

[22] Singh D., Singh N. P., Bahadur L., Indian J. Chem., 13, 1177 (1975).

[23] Good W., Electrochimica Acta, 10, 1 (1965); 11, 759, 767, (1966); 12, 1031 (1967).

[24] Good W., Electrochimica Acta, 9, 203 (1964).

[25] Nightingale E. R., Benck R. F., J. Phys. Chem., 63, 1777 (1959).

Department of Physical Chemistry
University of Łódź

Stefania Taniewska-Osińska, Marian Woldan

BADANIA WISKOZYMETRYCZNE UKŁADU TRÓJSKŁADNIKOWEGO H_2O-$AcNH_2$-NaI W ZAKRESIE TEMPERATURY 25-85°C

Zmierzono lepkość roztworów NaI w mieszanych rozpuszczalnikach wodnoacetamidowych w zakresie temperatury 25-85°C. Przedyskutowano zależność lepkości, lepkości względnej oraz funkcji termodynamicznych aktywacji lepkiego przepływu badanych roztworów w zależności od stężenia roztworu i temperatury. Wyśnuto wnioski dotyczące wpływu NaI i acetamidu na strukturę badanych układów.

Стефания Тфневска-Осиньска, Марян Вольдан

ВИССКОЗИМЕТРИЧЕСКИЕ ИССЛЕДОВАНИЯ СИСТЕМЫ H_2O-$AcNH_2$-NaI В ИНТЕРВАЛЕ ТЕМПЕРАТУРЫ 25-85°C

Определена вязкость системы H_2O-$AcNH_2$-NaI в интервале температуры 25-85°C. Рассчитано относительную вязкость, температурный коэффицент $\Delta\eta_r/\Delta T$ и термодинамические функции активации вязкого течения. Анализ полученных данных в зависимости от концентрации и температуры позволил сделать вывод, что NaI разрушает структуру растворителя вода-ацетамид.