POLIAKRILAMID VA OLTINGUGURT SUSPENZIYALARINING SILJISH OQIMIDAGI REOLOGIK TAVSIFLARI

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Annotation

In this work, the results of the research conducted on the results of the research carried out in the shear field in the cell rheometer of the "cylinder-cylinder" type of the structural and phase changes of suspension gels formed by sulfur microparticles (S) of anionic polyacrylamide (aPAA) samples are discussed. The transition of the "suspension gel" into a "suspension solution" in a continuous manner, i.e., according to the mechanism of type II phase transitions, in which the change in viscosity is explained due to the continuous deformation changes of macromolecules together with microparticles in the shear flow, without separating from each other, due to the flow's rotational and forward movement. . Viscous flow activity energy Ea = αR =α8.31 was analyzed about the indicator of energetic changes.

Key words: anionic polyacrylamide, suspension gels, effective viscosity, hysteresis effect, type II phase transitions, limit shift, fluidity.

Introduction

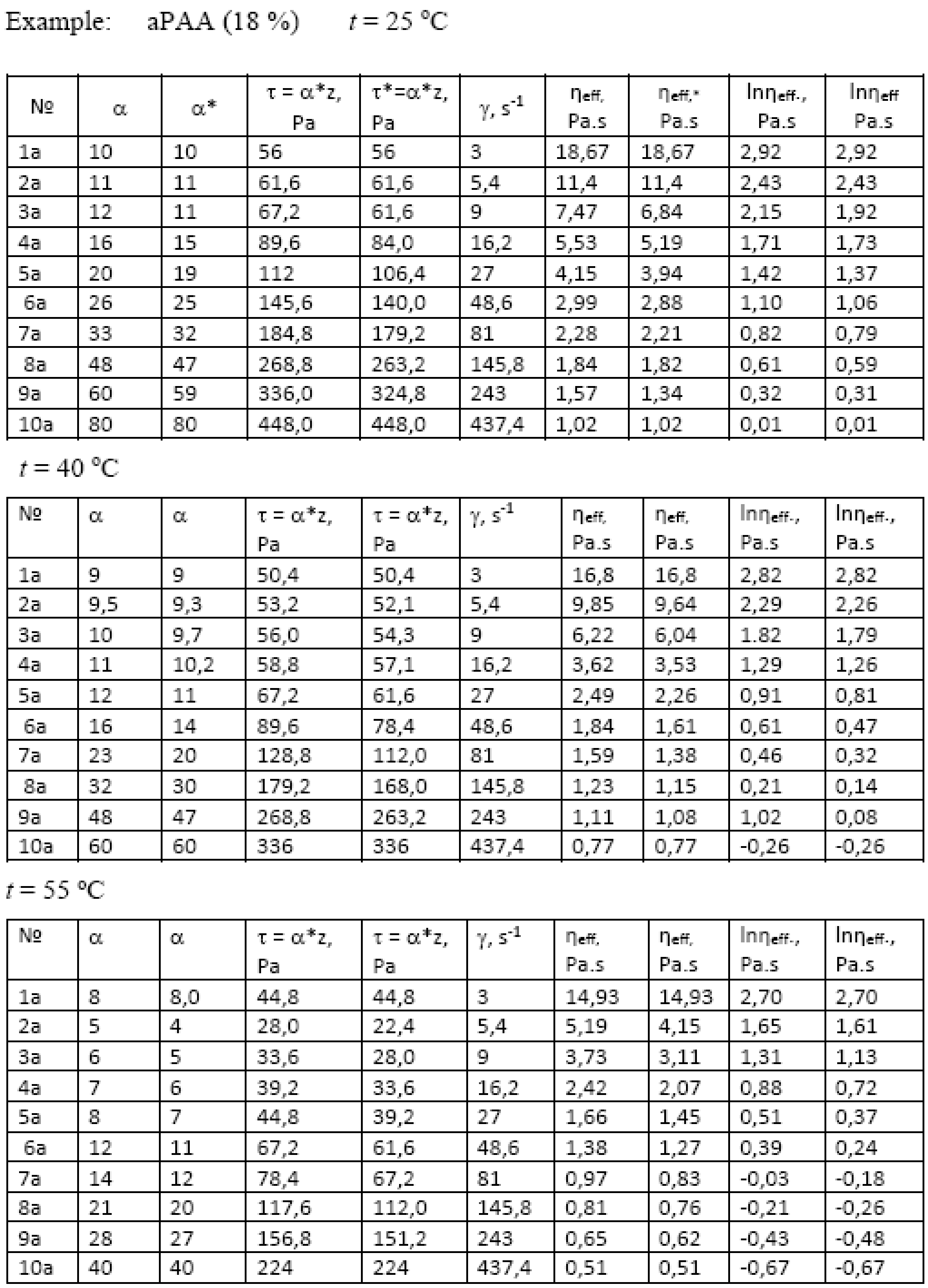
For the research, anionic polyacrylamide aPAA(18%) and aPAA (30%) samples were added in equal proportions to semi-dilute C[⍰]>1 solutions dissolved in water with a concentration of C = 1 g/dl in sulfur microparticles (2-5 μm) to form "suspension gels". " was prepared. In order to consistently study the properties of their constituent elements interacting and exhibiting structural organization, research was conducted in the shear field, where macromolecular fluids perform rotational and forward movements under the influence of constant shear stress and carry out deformational structural changes.

Objects and methods

Such a displacement field was created (generated) in the cell of coaxial cylinders of the type "cylinder-cylinder" (S\S1') of the rheometer "Reotest-2" (Germany) in mode Ia, in the range of 12-step speed gradient g γ ⍰⍰0 ÷ 1320 s^{-1} . Rheometric measurements in this velocity gradient field, 25 °C; 40 °C; It was carried out at a temperature of 55 °C, the results of measurements and calculations are included in Table 1.

Results and its Discussion

Table 1. Results of measurement and calculation of rheological parameters Example: aPAA (18 %)



Example: aPAA (18 %) $t = 25\ ^{o}C$

№	α	$\alpha*$	$\tau = \alpha*z$, Pa	$\tau*=\alpha*z$, Pa	γ, s^{-1}	$\eta_{eff,}$ Pa.s	$\eta_{eff,*}$ Pa.s	$ln\eta_{eff.}$, Pa.s	$ln\eta_{eff}$ Pa.s
1a	10	10	56	56	3	18,67	18,67	2,92	2,92
2a	11	11	61,6	61,6	5,4	11,4	11,4	2,43	2,43
3a	12	11	67,2	61,6	9	7,47	6,84	2,15	1,92
4a	16	15	89,6	84,0	16,2	5,53	5,19	1,71	1,73
5a	20	19	112	106,4	27	4,15	3,94	1,42	1,37
6a	26	25	145,6	140,0	48,6	2,99	2,88	1,10	1,06
7a	33	32	184,8	179,2	81	2,28	2,21	0,82	0,79
8a	48	47	268,8	263,2	145,8	1,84	1,82	0,61	0,59
9a	60	59	336,0	324,8	243	1,57	1,34	0,32	0,31
10a	80	80	448,0	448,0	437,4	1,02	1,02	0,01	0,01

$t = 40\ ^{o}C$

№	α	α	$\tau = \alpha*z$, Pa	$\tau = \alpha*z$, Pa	γ, s^{-1}	$\eta_{eff,}$ Pa.s	$\eta_{eff,}$ Pa.s	$ln\eta_{eff.}$, Pa.s	$ln\eta_{eff.}$, Pa.s
1a	9	9	50,4	50,4	3	16,8	16,8	2,82	2,82
2a	9,5	9,3	53,2	52,1	5,4	9,85	9,64	2,29	2,26
3a	10	9,7	56,0	54,3	9	6,22	6,04	1.82	1,79
4a	11	10,2	58,8	57,1	16,2	3,62	3,53	1,29	1,26
5a	12	11	67,2	61,6	27	2,49	2,26	0,91	0,81
6a	16	14	89,6	78,4	48,6	1,84	1,61	0,61	0,47
7a	23	20	128,8	112,0	81	1,59	1,38	0,46	0,32
8a	32	30	179,2	168,0	145,8	1,23	1,15	0,21	0,14
9a	48	47	268,8	263,2	243	1,11	1,08	1,02	0,08
10a	60	60	336	336	437,4	0,77	0,77	-0,26	-0,26

$t = 55\ ^{o}C$

№	α	α	$\tau = \alpha*z$, Pa	$\tau = \alpha*z$, Pa	γ, s^{-1}	$\eta_{eff,}$ Pa.s	$\eta_{eff,}$ Pa.s	$ln\eta_{eff.}$, Pa.s	$ln\eta_{eff.}$, Pa.s
1a	8	8,0	44,8	44,8	3	14,93	14,93	2,70	2,70
2a	5	4	28,0	22,4	5,4	5,19	4,15	1,65	1,61
3a	6	5	33,6	28,0	9	3,73	3,11	1,31	1,13
4a	7	6	39,2	33,6	16,2	2,42	2,07	0,88	0,72
5a	8	7	44,8	39,2	27	1,66	1,45	0,51	0,37
6a	12	11	67,2	61,6	48,6	1,38	1,27	0,39	0,24
7a	14	12	78,4	67,2	81	0,97	0,83	-0,03	-0,18
8a	21	20	117,6	112,0	145,8	0,81	0,76	-0,21	-0,26
9a	28	27	156,8	151,2	243	0,65	0,62	-0,43	-0,48
10a	40	40	224	224	437,4	0,51	0,51	-0,67	-0,67

Based on the measurement results, the logarithmic effective viscosity ($ln\eta_{eff}$) and velocity gradient (γ) connection rheograms were made for different temperatures (25 ^{o}C; 40 ^{o}C; 55 ^{o}C) and these rheograms are presented in Fig. 1.

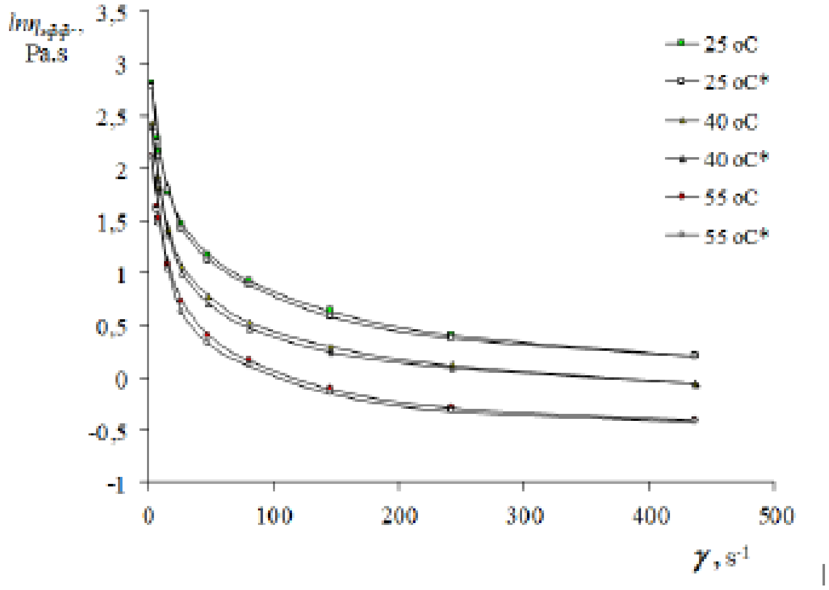


Fig. 1. Relation rheograms of the effective viscosity (ln▯$_{eff}$) of the aPAA(18 %):water (2:100) solution at different temperatures to the velocity gradient (γ) in shear flow: 25 ^{o}C, 40 ^{o}C, 55 ^{o}C graphs with increasing γ , 25 ^{o}C*, 40 ^{o}C*, 55 ^{o}C* graphs measured as γ decreases.

The appearance of rheograms is characteristic of non-Newtonian flow, and a discrete increase in temperature caused a discrete shift of viscosity towards lower values. Such descriptions indicate that the "suspension gel" transitions to a "suspension solution" in a continuous manner, that is, by the mechanism of type II phase transitions, in which the viscosity decreases due to the continuous deformation changes of the macromolecules together with the microparticles in the shear flow, without separating from each other, due to the flow's rotational and forward movement. indicates. When the measurements were carried out in 12 steps of the speed gradient in order of successive increase and decrease, the differences between the effective viscosity values determined in these two directions were minimal, and the graphs did not show a bright hysteresis effect. So, when the suspension gel changes to the state of suspension solution in the displacement field, it indicates that macromolecules and microparticles are not separated from each other, and their flocs are stable in the flow. Because there was no drastic change in the effective viscosity due to flocculon disintegration in the shear flow.

Even when the velocity gradient (▯) was plotted against the shear stress (▯), the hysteresis effect was not evident (Fig. 2).

Fig. 2. Dependence of velocity gradient (g) on shear stress (γ) of aPAA (18%):S (2:2:100) suspension in shear flow at different temperatures

From these rheograms, the limiting shear stress (⍰$_{pr}$) and the limiting yield stress (⍰$_{pr}$) and the mechanical stability of the suspension gel in the flow were determined from the ratio MC= ⍰$_{k}$ /⍰$_{pr}$ (Table 2).

Table 2. Quantities of rheometric parameters at different temperatures

t, ^{o}C	τ_{pr}, Pa	τ_{k}, Pa	MC
25	64	125	1,95
40	39	69	1,77
55	24	40	1,67

As can be seen from the rheograms and the data in the table, as the temperature increases, the limit shear (τ_{pr}) and yield (τ_{pr}) stresses also increase, and this situation causes a partial decrease in the amount of mechanical stability (MC).

1–rasmdagi reogrammalardan $\gamma \to 0$ ga ekstrapolyatsiya qilinganda, $ln\eta_{eff} \to ln\eta$ sharti bajarilishidan kelib chiqib, dinamik qovushqoqlik (η) miqdorlari aniqlandi, ya'ni va buning grafik ko‘rinishi quyidagicha bo‘ldi (3 –rasm).

When extrapolating to $\gamma \to 0$ from the rheograms in Fig. 1, the dynamic viscosity (η) was determined based on the fulfillment of the condition $ln\eta_{eff} \to ln\eta$ i.e., its graphical appearance was as follows (Fig. 3).

25 ^{o}C da $ln\eta$ = 2,95 Pa.s. η = 19,11 Pa.s.

40 ^{o}C da $ln\eta$ = 2,65 Pa.s. η = 14,15 Pa.s.

55 ^{o}C da $ln\eta$ = 2,20 Pa.s. η = 9,03 Pa.s.

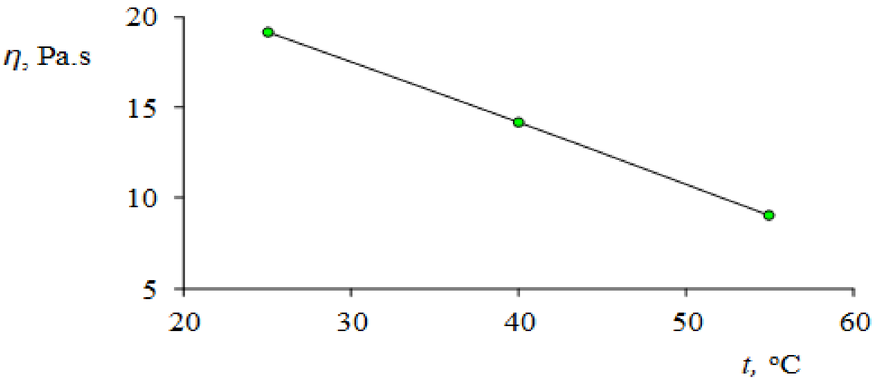


Figure 3. Dependence of dynamic viscosity (η) on temperature (t) for aPAA (18%):S (2:2:100) suspension gel solution in shear flow

Grafikdan haroratning oshishi bilan dinamik qovushqoqlikni to‘g‘ri chiziqli pasayishi ko‘rinib turibdi. Bunday bo‘lishi issiqlikni oshishi bilan flokulalararo ta’sirlanishlarni susayib borishi, ammo flokulalar o‘zlarining fizik holatlarini saqlab qolishidan dalolat beradi. Chunki, issiqlik ta’sirida flokulalarning parchalanib ketib, qovushqoqligining keskin o‘zgarishi grafikda aks etmagan.

Tadqiqot natijalari asosida Frenkel –Eyring formulasi bo‘yicha $\ln\eta_{eff}$ ni 1/T ga bog‘lanish grafigi tuzildi (4–rasm).

The graph shows a linear decrease in dynamic viscosity with increasing temperature. This indicates that interfloccular interactions weaken with increasing temperature, but floccles retain their physical state. Because the flocculates disintegrated under the influence of heat and the sudden change in viscosity was not reflected in the graph.

Based on the results of the research, a graph of the connection of $\ln\eta_{eff}$ to 1/T was created according to the Frenkel-Eyring formula (Fig. 4).

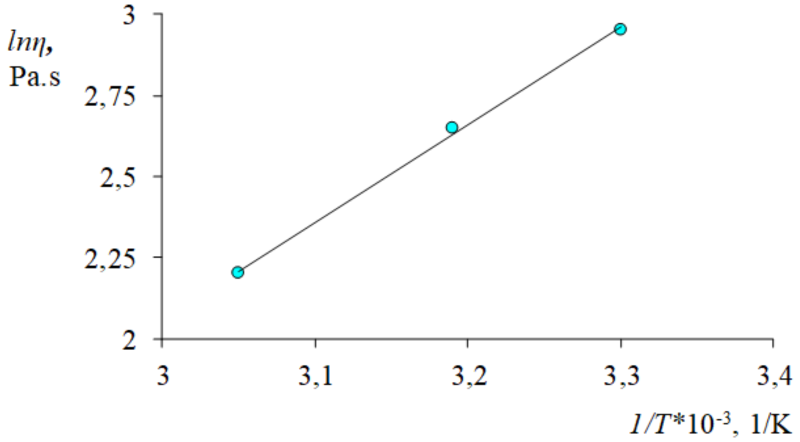


Figure 4. Dynamic viscosity (η) versus temperature (1/T) graph for aPAA (18%):S (2:2:100) suspension gel - solution

Since the deviation angle of the graph is a ⍰ $[(\ln\eta_{eff})_1 - (\ln\eta_{eff})_2]/[(1/T)_1 - (1/T)_2]$ ⍰⍰⍰ E_a/R , the viscous flow activity energy E_a ⍰ aR ⍰ a8,31, i.e., the indicator of energy changes due to the friction and impact of the components in the flow due to the rotational-advance movement in the flow was determined, i.e.:

$E_a = a \times R = 3{,}0 \times 10^{3*} \times 8{,}31^{*} = 24930\ J/mol = 24{,}93\ kJ/mol$

Bunga binoan suspenziyadagi komponentlar siljish oqimida kuchsiz kimyoviy bog‘lar energiyasi, masalan, vodorod bog‘lar energiyasi (3 – 50 kJ/mol) darajasida o‘zaro ta’sirlashar ekan deb xulosa qilish mumkin. Bunday energetik ko‘rsatgichlar suv:aPAA (30%):S (100:2:2) uchun E_a = 27,6 kJ/mol ekanligi ham parallel o‘tkazilgan tadqiqotlar asosida aniqlangan. Bunga muvofiq PAA namunalarning gidrolizlanish darajasini 18 % dan 30 % gacha o‘zgarishi qovushqoq oqim faollik energiyasini E_a = 24,93 kJ/mol dan E_a = 27,6 kJ/mol gacha o‘zgarishini ko‘rsatdi.

kattaligi jihatidan vodorod energiyasini miqdori diapazonida. Bu mohiyatan suspenziyadagi oltingugurt mikrozarrachalari va polakrilamid namunasining o‘zaro ta’sirlashish energiyalari gel tugunlarini fizik gellarga xosligini va ularni siljish maydonida parchalanishi poliakriamid molekulalarining mexanik va termik destruksiyalarisiz amalga oshishini hamda ularning mikrozarrachalar bilan flokulyatsion ta’sirlashlar hosil qilganligidan dalolat beradi.

Accordingly, it can be concluded that the components in the suspension interact at the level of weak chemical bond energy, for example, hydrogen bond energy (3 - 50 kJ/mol) in the shear flow. Based on parallel studies, such energy indicators were determined to be E_a = 27.6 kJ/mol for water:αPAA (30%):S (100:2:2). Accordingly, changing the degree of hydrolysis of PAA samples from 18% to 30% showed a change in the viscous flow activation energy from E_a = 24.93 kJ/mol to E_a = 27.6 kJ/mol in the range of the amount of hydrogen energy in terms of magnitude. In fact, the energy of interaction between sulfur microparticles in suspension and polyacrylamide sample indicates that the gel knots are characteristic of physical gels and that their disintegration in the shear field takes place without mechanical and thermal destruction of polyacrylamide molecules and that they form flocculation interactions with microparticles.

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