THE STUDY OF THE CONSISTENT PROPERTIES OF GLYCEROGEL CONTAINING ST. JOHN'S WORT

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A study of consistent properties of glycerogel based on St. John's wort tincture has been performed using «Rheotest-2» rotational viscosimeter. It has been revealed that the analyzed properties of glycerogel characterize the system as being thixotropic providing recovery of glycerogel after stress. Values of mechanical stability equal to 2,6 and coefficient of dynamic flow (Kd_1 = 34,64 %; Kd_2 = 72,58 %) is an evidence of quantitative confirmation of satisfactory degree of system distribution on application on skin and mucosal surfaces as well as during technological stage of preparation. The revealed hysteresis loops are an evidence of thixotropy of studied glycerogel. This characterizes good spreading and extrusion properties. It also confirms prevalence of reversible thixotropic bonds capable of restoration after system destruction. It is revealed that increase in temperature leads to appropriate reduction of all the consistent properties of the analyzed glycerogel. The obtained information allows make a prognosis of storage conditions of elaborated glycerogel based on St. John's wort tincture.

Keywords: St. John's wort tincture, consistent properties of gel, thixotropy, dynamic viscosity, hysteresis loops, mechanical stability

Rheological properties directly affect quality, stability, as well as therapeutical and consumer properties such as release of drug substance from ointment base, comfort and easiness of application, packagability and extrusion from tube. The process of application and distribution of ointment on the skin and mucosal surfaces is analogous to the process occurring during the shear of visco-plastic material in rotational viscosimeter, whereas spent effort is consistent to tension of shear characterizing resistance of a material to shear deformation on certain speed measured with instrumental methods [1, 2].

Considering the aforementioned, evaluation of consistent properties is important and necessary part of research on creation of soft pharmaceutical forms [3, 4, 5].

The faculty of pharmaceutical form technology of the Tashkent Pharmaceutical Institute lead a study on creation of glycerogel based on St. John's wort tincture. The aim of the research is evaluation of consistent properties of the developed gel composition.

Materials and methods of research

For evaluation of the consistent features a gel of St.John's wort tincture on hydrophilic base (sodium carboxymethylcellulose glycerogel) was used. This properties were studied with a «Rheotest-2» rotational viscosimeter using a cell consisting of coaxial cylinders S/S2 with a constant Z = 8,06. For this a batch of glycerogel was placed into measuring device and was kept in thermostat for 30 min keeping temperature constant. Considering hot climate of the republic, three temperature levels were used during the study – 25, 40, 55 °C. Then the cylinder in the measuring device was rotated using twelve increasing speed of shear levels and each reading of indicator device was noted. Destruction of glycerogel structure was achieved with rotation of the cylinder on the maximal speed for 10 min. Then the rotation was stopped for 10 min and readings at each of twelve speed of shear level was noted on its reduction. On the basis of obtained results maximal tension of shear and effective viscosity was calculated and the rheograms of glycerogel flow were composed.

Tension of shear (τ) was calculated as follows:

$$\tau = Z \cdot \alpha,$$

where τ – tension of shear, Pa; Z – cylinder constant equal to 8,06 Pa; α – reading of measuring device.

Effective viscosity was calculated as follows:

$$\eta = \frac{\tau}{\gamma},$$

where η – effective viscosity, Pa·s; τ – tension of shear, Pa; γ – gradient of shear flow velocity, s^{-1}.

Mechanical stability (MS) was calculated as follows:

$$MS = \frac{\tau_1}{\tau_2},$$

where τ_1 – limit of durability of intact structure; τ_2 – limit of durability of destructed structure.

A separate series of experiments performed quantitative evaluation of glycerogel flow containing St.John's wort tincture. During the experiments the aforementioned «Rheotest-2» rotational viscosimeter with cylindrical device was used and viscosity of glycerogel was determined using the speed consistent to the speed of spread of pharmaceutical form on the skin surface and mucosa (shear velocity 3,0 and 5,4 s^{-1}). Also, velocity of technological processing (shear velocity 27,0 and 145,8 s^{-1}) was estimated with subsequent calculation of coefficient of dynamic flow of glycerogel [6]. In addition, a dynamic viscosity and its dependence on temperature was determined.

Results of research and their discussion

The relation of effective viscosity to shear velocity for glycerogel on 25, 40, 55 °C temperature levels is demonstrated in Table.

The results show the increase of maximal tension of shear and decrease of effective viscosity with increasing deformational forces. This suggests presence of structure in the studied sample of glycerogel.

Fig. 1 and 2 characterize change of effective viscosity logarithm ($\ln\eta_{eff}$) in relation to gradient of shear flow velocity (γ) and dependence of gradient of shear flow velocity on tension of shear (τ) for studied glycerogel on 25, 40, 55 °C temperature levels.

The results of determination of maximal tension of shear and effective viscosity for glycerogel containing St. John's wort tincture

Velocity gradient, s^{-1}	Tension of shear, Pa	Effective viscosity, Pa·s	Tension of shear, Pa	Effective viscosity, Pa·s	Tension of shear, Pa	Effective viscosity, Pa·s
	Temperature 25 °C		Temperature 40 °C		Temperature 55 °C	
1	88,66	88,66	64,48	64,48	48,36	48,36
1,8	112,84	62,69	80,60	44,78	64,48	35,82
3	137,02	45,67	88,66	29,55	72,54	24,18
5,4	161,20	29,85	104,78	19,40	88,66	16,42
9	185,38	20,60	120,90	13,43	104,78	11,64
16,2	201,50	12,44	137,02	8,46	112,84	6,97
27	217,62	8,06	161,20	5,97	128.96	4,78
48,6	249,86	5,14	193,44	3,98	161,20	3,32
81	282,10	3,48	225,68	2,79	185,38	2,29
145,8	322,40	2,21	265,98	1,83	233,74	1,60
243	370,76	1,53	306,28	1,26	274,04	1,13
437,4	403,00	0,92	354,64	0,81	330,46	0,76

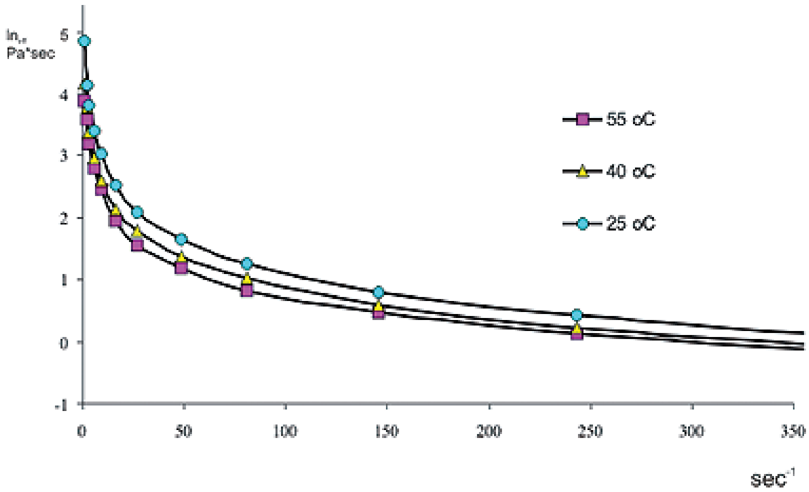

Fig. 1. Relation of effective viscosity logarithm to velocity gradient of shear flow for glycerogel containing St. John's wort tincture

Fig. 1 demonstrates that increase of gradient of shear flow velocity, i.e. velocity of deformation leads to reduction of viscosity of solutions till a certain point: γ~250 s^{-1}. Further, the graphs practically do not change. The increase in temperature shifts the graphs to the area of smaller readings of viscosity.

The change of viscosity to γ~250 s^{-1} characterize destruction of primary structure of glycerogel in result of disruption of intermolecular (intercomponent) bonds (nonchemical, i.e. hydrogen, ionic bonds, etc.). Stabilization of fluidity (1/viscosity) at $\gamma > 300$ s^{-1} indicate establishment of intermolecular bonds of the level at which they do not influence system viscosity.

Fig. 2 allows estimation of hysteresis taking place in direct and indirect change of velocity gradient in relation to tension of shear. The width of hysteresis loops is a relative estimate of degree of structureforming processes which increase its stability [7]. The area of hysteresis loops narrows down with increase of temperature. This is determined by increased thermal motion of the components, i.e. diminished interaction of the components in the sample. Meanwhile, the shift of hysteresis loops to the smaller values of velocity gradient and tension of shear determined by reduction of viscosity of glycerogel samples with increasing temperature.

Presence of hysteresis loops is an evidence of thixotropy in a studied glycerogel which characterizes good spreading and extrusion properties. Moreover, it can be concluded that reversible thixotropic bonds, which can reestablish after destruction of system, are prevailed in the studied glycerogel.

In the result of research a value of mechanical stability is calculated to be 2,6. This also indicates that the studied glycerogel possesses high thixotropic properties and allows complete restoration of the structure after applied tensions occurring during the technological process of production of current pharmaceutical form.

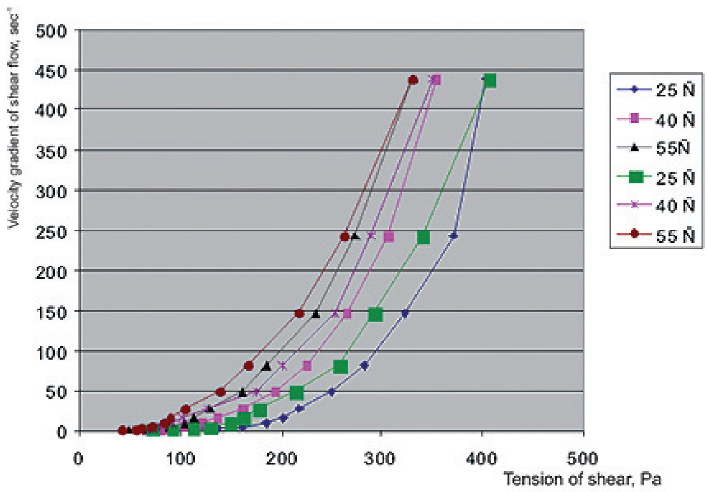

Fig. 2. Relation of velocity gradient of shear to tension of shear

The estimated coefficient of dynamic flow of glycerogel at temperature 25 °C (Kd_1 = 34,64 %; Kd_2 = 72,58 %) is an evidence of quantitative confirmation of satisfactory degree of system distribution on application on skin and mucosal surfaces as well as during technological stage of preparation.

To estimate dynamic viscosity values extrapolation of velocity gradient to zero was performed in a separate series of experiments taking into account available data on temperature influence on consistent properties of ointments.

Fig. 3 demonstrates that increase of temperature leads to decrease of all rheological properties of glycerogel. For example, reduction of temperature 1,6 and 2,2 times entails decrease of dynamic viscosity values 1,78 and 2,39 times respectively. The data obtained allows to make a prognosis on storage conditions of elaborated pharmaceutical form containing St. John's wort tincture.

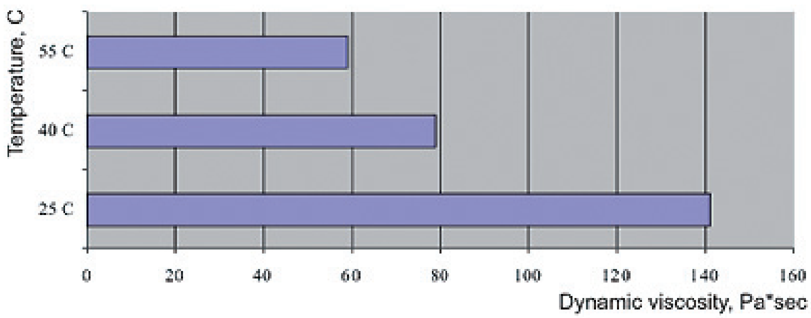

Fig. 3. Relation of dynamic viscosity of glycerogel containing St. John's wort to temperature

Bibliography

1. Tentsova A.I., Gretsky V.M. Contamporary aspects of research and production of ointments, Meditsina. – M., 1980. – P. 96–141.

2. Arkusha A.A. The study of structural and mechanical properties of ointments to determine optimal consistency: autoref. disc. ... doctor of pharmaceutical science. – Harkov. – 1982. – P. 22.

3. Maksudova F.H. and Karieva E.S. Investigations of rheological properties of diclofenac sodium gel preparation // Medical and Health Sciences Journal. – 2013. – Vol. 14 (1). – P. 91–94.

4. Karieva E.S., Yunusova H.M. The study of rheological properties of Meloxycam ointment // Pharmaceutica bulletin of Uzbekistan. – 2009. – № 3. – P. 17–19.

5. Nazarova Z.A., Ziyamuhamedova M.M., Rahmanova K.J. The study of rheological properties of gel containing liquid extract of Handel // Pharmaceutical journal. – 2008. – № 2. – P. 57–59.

6. Gritsenko V.I. Elaboration of composition and technology of soft pharmaceutical form of heparin and methyluracil: disc. doctor of pharmaceutical science. – Harkov. – 2005. – P. 129.

7. Shram G. Basis of practical rheology and rheometry. – M., 2003. – P. 312.