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DETERMINATION OF RHEOLOGICAL CHARACTERISTICS OF SALIVA

Nurmatova F.B.
Head of department of "Biophysics and IT technologies in medicine"
Tashkent State Dental Institute

ABSTRACT:

Liquid media make up the largest part of the body, their movement ensures metabolism and oxygen supply to cells, therefore, mechanical and rheological properties, the flow of liquids are of particular interest to physicians and biologists. The article discusses methods for determining the viscosity and surface tension of saliva.

Keywords: viscosity, saliva, Stokes method, viscometer, surface tension.

Introduction:

Viscosity determines the nature of fluid movement in the vessels, therefore, in medical practice, much attention is paid to the viscosity of biological fluids (blood, saliva, urine, etc.).

Saliva is one of the most important secretory fluids produced by the body. In humans, saliva is 98% water plus electrolytes, mucus, white blood cells, epithelial cells (from which DNA can be extracted), enzymes (such as amylase and lipase), antimicrobial agents such as secretory IgA, and lysozymes.

Enzymes contained in saliva are necessary to start the process of digestion of dietary starches and fats. These enzymes also play a role in breaking down food particles trapped in the crevices, thus protecting the teeth from bacterial decay. Saliva also has a lubricating function, moistening food and allowing initiation of swallowing, as well as protecting the oral mucosa from drying out.

A healthy person produces up to 2 liters of saliva per day. In the presence of health problems, an increase in the degree of viscosity of saliva can be observed: it becomes thick and sticky, in some cases foam and white mucus appear.

Such symptoms require careful attention. It is necessary to find out the causes of their appearance as early as possible and begin treatment.

Viscosity is one of the properties of saliva, a change in which can cause a pathological process. In particular, the high viscosity of saliva contributes to the development of salivary stone disease.

A significant increase in viscosity is also accompanied by intense damage to the teeth by caries.

At a normal viscosity index, saliva has only a slightly higher viscosity (1 cP = $1 \cdot 10^{-3}$ Pa s) than water ($0{,}89 \cdot 10^{-3}$ Pa s). However, saliva is a non-Newtonian fluid, does not have a constant viscosity coefficient, depends on the shear rate (velocity gradient).

Often, increased saliva viscosity is a signal of health problems and is accompanied by other suspicious signs. By analyzing the whole complex of symptoms, you can determine the disease. The salivary glands of an adult healthy person produce from one to two liters of secretion daily. The purpose of this liquid is to lubricate the oral cavity in order to facilitate the processes of chewing and speaking. Thanks to the secret, the digestion of food begins already at the moment of chewing it, since saliva contains active enzymes. The perception of the taste qualities of products also depends on the degree of their processing with salivary fluid.

Saliva is the first available natural antiseptic. That is why small wounds in the mouth heal much faster than on the skin.

In order for all these processes to proceed exactly as they should, salivation must be sufficient, and the discharge itself must be transparent or slightly cloudy, liquid and imperceptible to humans. Violation of the usual consistency of saliva cannot be overlooked, since an obsessive feeling of discomfort is created, speech and the usual rhythm of life are disturbed, problems with digestion, teeth and oral mucosa are possible.

Dental problems can also be the "culprits" of the appearance of thick, viscous saliva. Periodontitis, periodontal disease (inflammatory lesions of the soft tissues of the oral cavity) lead to pathological changes in the structure of the gums, the amount of saliva produced decreases. In addition, the elements of the epithelial tissue are mixed with the secret, making it viscous, thick.

At its core, biophysics, like physics, is an experimental science - its laws are based on facts established by experience. As a result of the generalization of experimental facts, physical laws are established - stable repeating objective patterns that exist in nature, establishing a connection between physical quantities.

To establish quantitative relationships between physical quantities, they must be measured, that is, compared with the corresponding standards.

MATERIALS AND METHODS.:

There are several methods for determining the viscosity coefficient. In biophysics, a set of methods for determining the viscosity of a liquid is called viscometry.

STOKES METHOD:

The viscosity of a liquid can be determined by measuring the speed at which a ball falls through the liquid.

The problem of flow around a ball was solved by Stokes. He also found a formula that relates the resistance force in the steady motion of a ball in a medium with the viscosity coefficient – η

$$F_c=6\pi r\eta\upsilon \text{ (I)}$$

where r is the radius of the ball, υ *is* the speed of its movement.

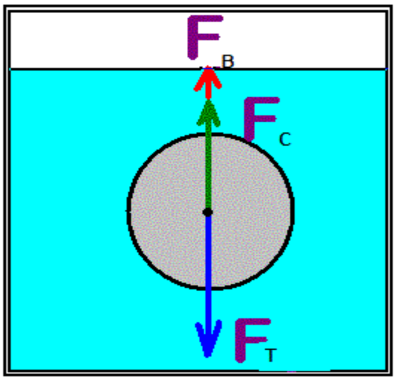
The Stokes method allows you to determine the viscosity coefficient of a liquid **η** when a small ball is moving, falling vertically in a liquid. Three forces act on the ball when moving in a liquid

Ball weight $\mathbf{P=4/3\ r^3\ \rho g}$, (2)

where **ρ** is the density of the substance of the ball, the buoyancy force

$$\mathbf{F_B=4/3\pi r^3\rho_0 g}, \text{ (h)}$$

where $\boldsymbol{\rho_0}$ - fluid density and drag force (I).



The first and second forces are constant in magnitude, the third is proportional to the speed. When a ball moves in a liquid, there comes a moment when all three forces are balanced, and the ball begins to move uniformly.

THE CONDITION FOR UNIFORM MOTION OF THE BALL:

$$\mathbf{P=F_{to}+F_c}$$

$$\mathbf{4/3\ r^3\ \rho g=4/3\pi r^3\ \rho_0 g+6\pi r\eta\upsilon}$$

$$\mathbf{4/3\ pr^3\ g\ (\rho-\rho_0) = 6\ pr\eta\upsilon}$$

After making the transformations, we get the following formula

$$\mathbf{\eta=2r_{cf}^2\ g(\rho-\rho_0)\ /\ 9\upsilon}$$

The speed of the ball is found by the formula: $\mathbf{\upsilon=\ell/t}$, where ℓ is the path of uniform motion, **t** is the time of motion. Because ρ, ρ_0, g are constant values , then $2/9(\rho-\rho_0)g$ will be denoted by "C" i.e. $C=2(\rho-\rho_0)g/9$. The working formula will look like:

$$\eta = C\, r_{av.}^2 / \upsilon$$

Thus, in the work it is necessary to measure the radii of the balls and the time of their movement in the liquid.

To determine the viscosity coefficient , a tall cylinder with the test liquid is taken , the cylinder has an annular mark at the top. This mark corresponds to
the height where the forces acting on the ball balance each other. In addition, at a distance ℓ **from the** top mark , there is the same mark at the bottom . Throwing the ball into the cylinder, mark with a stopwatch the time of its passage ℓ **between** the ring marks, from which the falling speed **υ is determined** .
The diameter of the ball is determined using a micrometer.

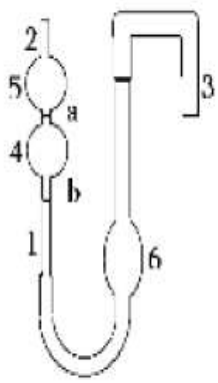
The Stokes method is used in medicine. According to the reaction of erythrocyte sedimentation (ROE) in blood plasma, the viscosity of the plasma is judged: the greater the viscosity of the plasma, the smaller the column of erythrocytes settled for a certain time.

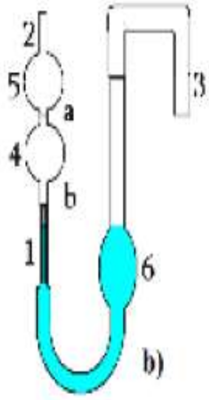
DETERMINATION OF THE VISCOSITY COEFFICIENT USING A CAPILLARY VISCOMETER:

Although the Stokes method provides the easiest way to determine the viscosity of a liquid, it has a number of significant drawbacks. Firstly, the measurement of Stokes viscosity requires a rather large amount of the test liquid, which is absolutely unacceptable in biomedical research. Secondly, the Stokes method determines the coefficient of dynamic viscosity, and the nature of the movement of fluid through the vessels depends mainly on the coefficient of kinematic viscosity ν.

Thirdly, it is difficult to eliminate the temperature dependence of the viscosity coefficient using the Stokes method, since it is impossible to achieve temperature constancy in a large volume of the liquid under study. In connection with the listed shortcomings, at present, in laboratory practice, the viscosity coefficient is determined using a capillary viscometer. Usually, the Ostwald-Pinkevich viscometer is used to determine the viscosity of saliva.

The Ostwald-Pinkevich viscometer is a U-shaped glass tube with a capillary I, balls 4, 5 and a tank 6. Through the end of the tube 2, the test liquid with a volume of 3-4 cm^3 is poured into the viscometer (so that the tank 6 is filled). Then the pear is inserted into the rubber tube 3 and the liquid is sucked in so that it rises above the mark "a" and partially fills the ball 5. The pear is removed; the liquid begins to flow out of the balls. The time of the liquid outflow from the ball 4 is determined, i. e. from mark "a" to mark "b".





This method is based on the Poiseuille formula, which establishes the relationship between the volume V of a liquid of viscosity η flowing through a capillary with radius R and length L in time **t** at a pressure drop **Δp** at the ends of the capillary:
To do this, we use the Poiseuille to which the volume of liquid flowing out V from a long capillary tube is equal to:

$$\mathbf{V} = \frac{\pi r^4 t \Delta p}{8\eta\ell} \quad (I)$$

where **Δp** is the pressure difference at the ends of the tube in dynes/cm2 , **r** is the radius of the capillary in cm, t **is** *the* outflow time in s, *ℓ* **is** *the length* of the capillary in cm, and
η is the viscosity of the liquid.

From formula (I): $\eta = \frac{\pi r^4 t\Delta p}{8V\ell}$

If the liquid flows out under the influence of its own weight, then the pressure difference is equal to the hydrostatic pressure, i.e.

$$\Delta p = \rho g h,$$

where ***g*** *is* the acceleration of gravity, **ρ** *is* the density of the liquid, **h** *is* the height of the liquid column, then

$$\eta = \frac{\pi r^4 t \rho g h}{8V\ell} \quad (2)$$

If the experiment is done with distilled water, the viscosity of which η_0 is known from the tables, and then with the liquid under study, the viscosity of which is denoted by η_x, then the viscosity of distilled water will be equal to

$$\eta_0 = \pi r^4 t_0 \rho_0 g h / 8V_0\ell \quad (3)$$

and the viscosity of the liquid under study (at the same temperature as water)

$$\eta_x = \pi r^4 t_x \rho_x g h / 8V_x\ell \quad (4)$$

Dividing term by term equality (4) by (3) and reducing the radius **r** , length ***ℓ*** , height **h** , volumes V_0 and V_x ,because they are the same, we get:

$$\eta_x / \eta_0 = \rho_x t_x / \rho_0 t_0$$

From here we get the working formula:

$$\eta_x = \eta_0 \frac{\rho_x t_x}{\rho_0 t_0} \quad (5)$$

In formula (5) η_0 and η_x are the viscosity coefficients, respectively, of distilled water and the investigated liquid in Poise;
ρ_0 and ρ_x - density, respectively, of distilled water and the investigated liquid in g/cm ^{3};
t_0 and t_x - the time of the expiration of distilled water and the test liquid, respectively, in seconds.

Results.<u>Work order</u>

1. Pour distilled water into the viscometer through tube 2, filling reservoir 6.
2. Through the rubber tube 3, suck in water with a pear above the mark"a"into the ball 5.
3. Remove the bulb from tube 3 and measure the time of distilled water outflow (t_0) from ball 4 (between marks "a" and "b"). Measurements t_0 repeat 5 times and record in the table.

Table 1

No.	t_0 (s)	t_x (s)	η_x (P)	$\Delta\eta_x$ (P)
one				
2				
3				
4				
5				

4. Carefully remove the viscometer from the tripod and pour water through tube 2, then fill reservoir 6 with the test liquid and determine, in the same way as with water, the outflow time t_x of the test liquid from ball 4 (between "a" and "c").

Repeat the measurements 5 times and record in the table.
η_0=0.01 P; ρ_0=1 g/cm^3. ρ_x=1,26 g/cm^3
Find $\bar{\eta}$; $\overline{\Delta\eta}$; D_η .

Record the result η = ($\bar{\eta}$ ± $\overline{\Delta\eta}$) P
With a simplified method of determination, a 1.0 ml micropipette can be used.

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First, the pipette must be calibrated with distilled water. To do this, draw water into the pipette to the zero mark (V = 1.0 ml), placing and holding the pipette with your hand in a strictly vertical position. Further on the stopwatch, V (H_2O) is noted, flowing out in 10 seconds. Repeat the definition 3-5 times. The results are recorded in table 2, similarly conducting an experiment with saliva.

Table 2. The results of determining the relative viscosity of saliva

№	Water volume, ml	Saliva volume, ml	η, rel. units	V(H_2O)
1				
2				
3				
4				
5				

$$\overline{V}_{H_2O} = \frac{\Sigma V_c}{n_{л.}} \quad \overline{V}_{сл.} = \frac{\Sigma V}{n}$$

According to the average values of V (H_2O) and $V_{sl.}$ calculate the relative viscosity of saliva, assuming the viscosity of water is 1: .

$$\eta_{сл.} = \eta_{H_2O} \cdot \frac{\overline{V}_{H_2O}}{\overline{V}_{сл.}}$$

Compare the obtained viscosity value with the norm, draw a conclusion.

What does viscosity depend on? In what units is it measured?

DETERMINATION OF THE SURFACE TENSION OF SALIVA:

Surface-active properties of saliva provide its wetting ability in relation to the teeth, oral mucosa.

Normal σ_{saliva} = 40-60 Erg/cm^2. When saliva σ falls below the physiological norm, saliva foams, and its washing and cleansing properties decrease. With caries, an increase in σ of saliva is noted due to the relative increase in mucins in it.

DEFINITION PROGRESS:

Using a personal (individual**!)** eye dropper, take 3-4 drops of saliva from the bottom of the mouth. Apply 1 drop of saliva to filter paper from a height of 1 cm from its surface. After 1 minute, circle the outline of the stain with a pencil. Calculate the spot area using the formula:

$S = A \cdot B \cdot \pi$,

where A is half of the largest diameter, mm;

B - half of the smallest diameter, mm; π is the number π (3.14).

For comparison, experiment with distilled water. Repeat the experiment 2-3 times. Enter the data in table 3.

Table 3 The result of determining the surface tension of saliva

experience number	Water	Saliva	σ_{Saliva}, Erg / cm ^{2}	

The surface tension of saliva is calculated by the formula:

$$\sigma_{сл.} = \sigma_{H_2O} \cdot \frac{\overline{S}_{сл} \cdot \rho_{сл}}{\overline{S}_{H_2O} \cdot \rho_{H_2O}}$$

.

saliva ρ can be taken equal to 1 g / ml, because according to numerous literature data, ρ_{sl} = 1.001-1.008 g/ml, or, if necessary, perform an additional experiment to determine the density of saliva.

Estimate the obtained value of σ of $_{saliva}$, compare with σ $_{of\ water.}$

CONCLUSION:

Make a conclusion. The presence of what substances in saliva changes the surface tension and how?

Thus, it follows that all of the above, being related to the oral mucosa, is of interest to future dentists and is reflected in the work program as questions for course profiling. [6]
Such facts, on the one hand, testify to the importance of biophysics in understanding the biological processes that accompany the vital activity of an organism, and, on the other hand, increase interest in the subject.

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