THE PHYSICAL PROPERTIES OF HUMAN SEBUM*†

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Previous articles by Butcher and Parnell (1), (2), confirm the theory of Emanuel (3), who suggested that the accumulation of sebum on the skin surface was largely controlled by the state of viscosity of the sebaceous layer. The experiments of Miescher and Schoenberg (4) also lead them to conclude that the quantity of sebum is determined by an interplay of physical factors. A review of the literature, however, provides only the scantiest information concerning the physical properties of sebum. It, therefore, seemed worth investigating the physical properties of sebum and their variation under the influence of exogenous conditions.

The method of collecting the sebum was that developed by Emanuel (3), and subsequently used by Butcher and Parnell (1). Ether was placed in the Emanuel cup for one minute and samples were taken from the foreheads of a large number of individuals all of whom habitually used no hair dressing. The composite quantity of the sebum thus acquired amounted to approximately 0.04 cc. This was utilized in the succeeding determinations. To recover the sebum after a determination the apparatus was first washed with absolute alcohol and then with ether. These solvents were then distilled off.

SPECIFIC GRAVITY

A pycnometer was improvised from a short length of narrow glass tubing. A quantity of sebum was introduced therein to a mark and weighed on an analytical balance. This weight was then compared with the weight of an equal volume of water and corrected to 20°C. referred to water at 4°C. The values obtained were derived by dividing the weight of the quantity of sebum by the weight of the quantity of water. This gave the apparent density. Temperature and buoyancy corrections, when applied, did not influence the fourth decimal place and so were disregarded. The apparent density was then multiplied by the density of water at 20°C., i.e. 0.9982. The resulting value was then divided by the density of water at 4°C. which is unity.

Three determinations were made. The values obtained, as corrected to 20°/4° were: a) 0.9135; b) 0.9049; c) 0.9130.

The mean of these is 0.9105 and the value 0.911 20°/4° was used as the working value in the subsequent computations.

SURFACE TENSION

The method used was that described by Harkins and Brown (5), modified to accommodate the small amount of sebum. Short lengths of glass tubing,

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having an inside diameter of about $\frac{3}{8}$ of an inch, were sealed at one end. Benzene was placed in one, carbon disulphide in another, and the sebum in a third.

Capillary tubes of various diameters and having approximately uniform bore throughout were drawn from stock laboratory glass tubing, cleaned with bichromate-sulfuric acid solution and washed with several organic solvents. They were dried with a water aspirator and introduced into the benzene and carbon disulphide. The height of rise in the capillary tubes was then noted with a cathetometer. These liquids, having known surface tensions and specific gravities,

TABLE 1

The surface tension of sebum

DETERMINATION	HT. OF RISE IN CAP.	RADIUS OF CAP.	SURFACE TENSION	TEMP.
	cm.	*cm.*	*dynes/cm.*	*deg. C.*
1	4.28	0.012	22.90	30
2	5.11	0.011	25.09	31
3	3.11	0.020	27.74	26.5
4	2.87	0.019	24.34	27.5
5	2.40	0.025	26.76	29
6	3.02	0.018	24.25	29.5
7	3.64	0.018	29.29	29
8	2.71	0.020	24.17	30
9	4.11	0.011	20.18	30.5
10	2.86	0.019	24.22	29

were used to determine the bores of the capillary tubes by employing their respective values in the following formula:

$$r = \frac{2S}{hdg}$$

r—radius of capillary tube (cm)
h—height of rise in capillary tube (cm.)
d—density of the liquid
g—gravity constant (980.28)
S—surface tension of the liquid (dynes/cm.)

The capillary tubes whose radii had just been determined were carefully cleaned and dried. They were then introduced into the sebum and the height of rise in the tubes was again noted with the cathetometer.

Table 1 indicates the values, observed and computed, used in determining the surface tension of the same sebum at different temperatures. The formula used in the computations was the same as that used in determining the bore of the capillary tubes, S now being the unknown value. The angle of contact between the sebum and the walls of the capillary tube was taken to be zero and hence the cosine of the angle, which ordinarily enters into this formula, was equal to unity.

The surface tension values range from a low of 20.18 dynes per centimeter to a high of 29.29 dynes/cm. with the mean surface tension being 24.89 dynes/cm. These values, however, are of little significance unless the following is considered.

It was noted that a flaky precipitate separated and floated in the substance of the sebum in many of the determinations. The speed with which the sebum rose and came to rest in the capillary tube varied inversely with the apparent density of the precipitate. In addition, there seemed to be more viscous and less viscous components in the sebum. The former would cling to the sides of the glass tube even on heating, whereas the latter would flow readily, especially with a rise in temperature.

Although the range of values obtained for the surface tension might be explained on the basis of aberrations in the wall surface of the capillary tube or technic procedure, it is believed that the separations just alluded to are primarily responsible.

The method of recovery of the sebum from the apparatus might, possibly, have resulted in an alteration of its properties either by contamination or by loss of some of the separable components and also explain the variations in surface tension.

An attempt was made to check the surface tension of the sebum at a higher temperature, viz. 41 to 42 degrees C. Three determinations were possible with the amount of sebum then available. The values obtained are in dynes/cm.: a) 26.68; b)25.19; c)25.04.

It can, therefore, be concluded that sebum, within the temperature range of 26.5° to 31°C., possesses an average of 24.89 dynes/cm. of surface tension determinable by the method employed. The greater regularity of the values at the higher temperature can be interpreted as being due to the more homogeneous nature of sebum at that temperature. It would also seem to indicate that, should it be possible to obtain a "true" value for the surface tension between 26° and 31°C., it would probably fall within the range of values indicated in table 1.

VISCOSITY

Viscosity determinations were made for the temperature range between 26.5° and 38°C., this being the range of physiological interest. The method employed was an adaptation of that described by Cannon and Fenske (6). The microviscometer used as designed by these authors had a capillary bore of 0.40 mm. and the reference marks were spaced to accommodate the small amount of sebum available. The column of sebum was further subjected to the downward pressure of a column of water 7 cm. long introduced into the viscometer above the sebum. This was to assure sufficient pressure for an even flow. Olive oil of known viscosity was used as the reference liquid. The following formula was employed in determining the viscosity of sebum:

$$n_1 = \frac{d_1 t_1}{d_2 t_2} n_2$$

n_1—viscosity of sebum at T°C.
n_2—viscosity of olive oil at T°C.
d_1—density of sebum
d_2—density of olive oil
t_1—time of flow of sebum column at T°C.
t_2—time of flow of olive oil column at T°C.

The results obtained are summarized in the graph and table 2. The values were seen to vary from 551.9 millipoises at 38°C. to 997.5 millipoises at 26.5°C.

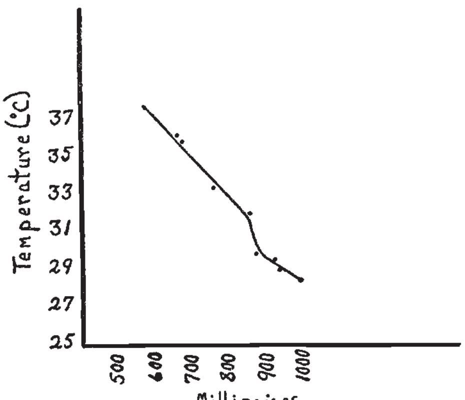
An attempt to duplicate the curve yielded values slightly lower, but both curves were approximately parallel.

Both curves showed an irregularity between 29°C. and 32°C. The significance of this is, perhaps, more clearly brought out by noting the values of t_1 as it varies with the temperature (table 2).

TABLE 2

The viscosity of sebum

TEMPERATURE	TIME OF FLOW	TIME OF FLOW PER °C. BETWEEN TWO READINGS	VISCOSITY OF SEBUM
°C.	*seconds*	*seconds*	*millipoises*
38	140.2		551.9
36.5	159.3	12.7	651.8
36	160.6	2.6	664.0
33.5	173.1	5.0	748.2
32	201.8	19.1	855.0
30	218.7	8.5	859.7
29.5	232.0	26.6	904.28
29.2	243.0	36.7	926.3
28.5	268.8	36.8	984.3
26.5	301.7	16.4	997.5



Viscosity of Sebum at T°C

In studying the figures in table 2 it will be seen that the time of flow per degree centigrade is relatively small up to 30° C. and much greater beyond that point. The average overall time of flow between 38° and 30° is seen to be 9.8 seconds/°C., and from 30° to 26.5° it is 23.7 seconds/°C.

It is believed that the temperature around 30°C. is critical for one or more of the sebum fractions, and at this temperature or slightly below the fraction or fractions suddenly assume either a solid or highly viscous character. With continued decrease in temperature so strongly would the more viscous component cling to the walls of the tube that the validity of viscosity readings below 29°C. must be questioned.

FREEZING POINT

It would seem that the value of 33° to 36°C. for the melting point of sebum, which was ascribed to Linser by Miescher and Schoenberg (4), must be modified since one of the fractions in the sample used in these determinations was seen to be fluid at room temperature and below. Obliteration and return of movement in the capillary of the viscometer (with a pressure of 7 cm. of water above) was found to occur between 15° and 17°C.

DISCUSSION

The physical properties of sebum have been investigated and the viscosity has been found to increase considerably as the sebum is cooled. An abrupt increase in viscosity was noted as the sebum was cooled to 29°–30°C. As the temperature was lowered to this level, resinous-like material was observed to adhere to the sides of the capillary tube, indicating a separation of the sebum into its components.

It is interesting that this separation into components occurs at the temperature which so closely correlates with the frequent 30°C. temperature of the surface of the forehead (7). The sebum cools as it reaches the skin surface and the increased viscosity provides resistance to further exudation of sebum from the orifice of the gland. This viscosity controls the level of the sebaceous layer. Warming the skin (2) reduced the viscosity, thus removing the resistance and allowing more sebum to exude from the orifice of the gland.

In evaluating these results the following must be remembered. Sebum, being a physiological product, may show variation in properties between different individuals and even in the same individual under varying conditions. Since our sample was taken from a large number of individuals it would seem that our values should be capable of reduplication with a fair degree of closeness. The greatest value of these results, however, is that they show quite definite qualitative trends which tend to support the existing theory of the control of sebum secretion.

CONCLUSIONS

1. The specific gravity of sebum collected from the foreheads of a number of individuals has been found to be 0.911.

2. The surface tension at temperatures varying from 26.5°C. to 31°C. has been found to average 24.89 dynes/cm.

3. The viscosity at 38°C. was found to be 551.9 millipoises, at 30°C.—859.7 millipoises and at 28.5°C.—984.3 millipoises. The sebum separated into various components when the temperature was lowered to 29°–30°C. and ceased to flow at 15°–17°C.

4. It is believed that viscosity is altered by temperature to the extent that

the viscosity largely affords the resistance to further exudation of sebum from the gland orifice, thereby regulating the accumulation of the sebum on the skin surface.

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