tested; that is, the jellies are at the same temperature as the room and close to 40° F. Standard glues of various grades are always run at the same time, so temperature or other changes affecting the strength will act on the standards and jellies being tested in like manner. Enough water is put into the thistle tube and capillary so that when a flat glass plate is held firmly against the mouth of the thistle tube (covered with the rubber diaphragm) the water in the capillary will stand exactly at the upper mark A, the three-way stopcock C being opened to the air. Stopcock C is now closed to the air and opened to the rubber bulb D and scale tube E, the water in which was set to the zero mark. Pressure is now applied through the bulb (a screw clamp between the bulb and stopcock allowing only a steady, slow, and even pressure to be applied to the system) until the water in the capillary falls from the point A to the point B. The height of the water in the scale tube is now read off, and this measures the force required to deform the rubber diaphragm alone, and this force must be deducted from the tests on the jellies for the proper grading of the glues. If all joints of the instrument are tight, the stopcock C may be closed as soon as the water reaches the point B, and the height of the water in the scale tube read off at leisure, but this cannot be done unless everything is absolutely tight.

To test a jelly in a tumbler, as illustrated, the stopcock is opened to the air and it is ascertained that the water in the scale tube stands at the zero mark. The tumbler is placed on the movable support shown (by coarse screw adjustment) and brought in contact with the rubber diaphragm and forced against this diaphragm until the water in the capillary stands at the point A. The stopcock C is then quickly closed and immediately the rubber bulb is squeezed steadily and the water in the capillary forced down to the point B. The height of the water in the scale tube is now quickly read and measures the force required to deform the jelly by a definite volume, namely, the volume between points A and B on the capillary tube. It also includes the force required to deform the rubber alone, so for the force required by the jelly itself, the figure previously found for the rubber must be deducted. It is necessary to operate with moderate speed in adjusting the jelly surface to the rubber diaphragm and in forcing down the water from A to B. This should be done by a steady, even pressure, not by jerky or quick application of pressure on the bulb.

Used correctly this instrument is very sensitive and gives concordant results. Used incorrectly it is still sensitive, but will not give concordant results. The water in the capillary *must* stand at the point A when a flat glass or metal plate is held firmly against the mouth of the thistle tube covered with the rubber, as only in this way can we start with the jelly and rubber forming an approximately flat surface. It is assumed generally that if the mouth of the thistle tube is forced against the jelly surface until the water in the capillary stands at point A we are starting under like pressures each time. But this is not so. It

makes a difference whether we press into the jelly so that it forms a convex surface upwards into the rubber and then force down to a flat surface at the end, or whether we start with a level surface on the jelly and force the rubber downward into the jelly. In the first case the jelly itself tends to return to its original position and acts with the rubber, in the other case it continually works against the rubber.

An attempt was made to use an artificial jelly surface by stretching a rubber diaphragm over the mouth of the tumbler through the side of which we made a hole and attached a long pressure measuring tube. The tumbler was then completely filled with water and pressures through the thistle tube applied to the rubber surface. This did not work at all, for the rubber of the tumbler not only was deformed through the thistle tube, but bulged up between the center and sides and the pressures recorded were not at all proportional to the pressures applied. This same thing undoubtedly occurs to some extent in testing a glue jelly and occasions errors, but to no such extent as with a liquid like water acting on an elastic diaphragm. Working against a mercury surface was also unsatisfactory for several reasons. In short, nothing has been found to replace running a set of standard grades with each set of tests.

DETERMINATION OF THE TENSILE STRENGTH OF GLUE¹

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At the present time the testing of glue consists for the most part in the determination of the viscosity and jelly strength, as compared to a standard glue. This standard glue is usually one which has been selected because of the satisfaction it has given through years of practice. In the purchasing of glue, manufacturers hesitate considerably in departing from a particular standard, because of their lack of knowledge of how another glue will act. As six to ten months may elapse before the manufacturer knows the results, it is quite obvious that considerable risks may be run. The question also arises as to whether the standard adopted is what it should be for a particular type of work, whether it has the requisite strength or elasticity, is brittle or the reverse.

Various methods of measuring the tensile strength have been tried, such as gluing together wood or biscuit ware, or soaking paper in glue and determining the strength of the glues. These have been unsuccessful, due to the presence of so many variables, such as humidity, temperature, viscosity and temperature of glue, pressure at which it is applied at the joints, and condition of the joints, such as the amount of moisture, smoothness of surface, etc. Recognizing the fact that the most important test of a glue should be a knowledge of its actual strength and stretch or elasticity, and that equipped with such knowledge, standards could then be scientifically established for every phase of work, a new method has been evolved.

¹ Presented at the 58th Meeting of the American Chemical Society, Philadelphia, Pa., September 2 to 6, 1919.

This work was originally done in 1913-1914, but owing to the fact that there were no suitable tensile machines at hand, the completion of the work was put off till this time.

METHOD

The method consists in melting the glue, pouring into molds, drying, cutting into strips of definite size, and obtaining the strength and stretch by pulling on a tensile machine.

Solutions of glue, 60 to 80 per cent by volume, are soaked for 12 hrs. and melted up at a temperature of 160° F. Great care is necessary at this point to avoid the formation of bubbles and foam.

The molds are of irons, 12 in. square and $\frac{1}{4}$ in. deep. The surface of the iron is carefully polished, so that no impression of any kind will be left on the glue. It should be noted that the slightest imprint becomes strongly emphasized on the dried glue surface. The mold is just warm enough to prevent chilling of the glue, approximately 130° F. The glue solution is poured into the leveled molds and permitted to jell. Under summer conditions, approximately 5 hrs. are allowed. This sheet is then removed and permitted to dry on fine-meshed galvanized or tinned wire, raised so as to permit circulation of the air around the under surface of the glue. The glue sheet is continually reversed in order to obtain a flat surface without too much curling. As soon as the edges show signs of complete drying, they are cut to prevent curling and the formation of uneven spots and strains. This cutting consists merely of making a slit about $\frac{1}{4}$ in. deep into the glue. By drying under slight pressure as soon as the glue appears partially dried, a perfect flat surface is obtained. It should be noted that the jellying and drying should take place undisturbed by air currents of any kind. The flat sheet is next cut into strips of definite size, preferably using a hot knife, as this is considerably quicker than using a very sharp cutter. They are then ground exactly on a grinding wheel or other suitable device. The center portion of the strip is then ground in, to insure breaking at center. The thickness of the strips and the widths were varied in order to check up the results. A suitable thickness averaged 0.1 in. and a suitable width 0.33 in. The overall length of the strip was about 7 in. and the ground portion at center about 2.5 in. A strip is illustrated in the accompanying photograph.

The tensile machine was an electrically driven Schopper with a capacity of 500 kg. The jaws on this machine are more nearly in alignment than on any other machine used. This is of vital importance, as the slightest deviation of the jaws will give poor results, due to the torsion and shear set up.

RESULTS

Using a hide glue, designated D-400, the following tests covering several parts of a shipment were made:

Thickness	Width	Kg. Break	Per cent Stretch	Tensile Strength Lbs. per Sq. In.
0.091	0.337	174	3	12,510
0.077	0.352	168	3	13,690
0.088	0.352	185	3.0	13,200
0.144	0.411	362	3.5	13,500
0.096	0.382	216	3.5	13,000
0.099	0.398	235	5	13,200
0.094	0.399	226	4.5	13,270
0.091	0.446	249	5	13,500
0.097	0.379	218	...	13,100
0.103	0.425	262	5.5	13,180
0.147	0.403	368	6	13,710
0.102	0.426	259	5.5	13,150
0.139	0.433	358	5	13,270
0.095	0.345	198	4.5	13,350
0.130	0.322	248	...	13,100
0.102	0.444	269	6	13,100
0.098	0.459	271	6.5	13,300
				Av., 13,240

The following are the results obtained with a glue designated D-300:

Thickness	Width	Kg. Break	Per cent Stretch	Tensile Strength Lbs. per Sq. In.
0.057	0.352	75	2	8,250
0.054	0.355	76	2	8,750
0.055	0.350	71	2	8,150
0.057	0.336	73	1.9	8,400
0.061	0.346	83	2	8,690
0.095	0.351	137	2.8	9,050
0.095	0.349	123	2.2	8,200
0.055	0.314	68	2	8,700
				Av., 8,523

A glue designated A-500 and taken from various portions of a shipment averaged 7,600 lbs. per sq. in. and 2 per cent stretch. A glue designated G-“Special” averaged 11,573 lbs. per sq. in. and 3.5 per cent stretch.

These glues were kept under standard conditions but pulled at room temperatures. They represent glues in commercial use of 3 different factories, and were selected because of the ease with which they could be obtained.

DISCUSSION

It will be noted that the results check very closely. Using varying widths and thicknesses, the tensile strength was always about the same. The stretch showed slight variation, due largely to the inaccuracy of the scale readings.

CONCLUSIONS

This method gives a feasible way of determining the exact strength and stretch of a glue, its elastic limit and other physical properties. It will permit manufacturers to determine exactly the physical character and properties of their glues, also to vary their processes and raw materials and determine the effect on the finished product.

This method will also permit the establishment of scientifically selected standard expressed in absolute units. At present it is not possible to compare the results of tests made by one laboratory with those of another, as the strength of solution, temperature, and manipulation are different. There are often exceptions to the fact that a glue with a high viscosity or jelly strength is stronger than a low viscosity glue

Certain factories can often meet viscosity and jelly requirements of a sample, but their glues will lack the strength and flexibility of glues from other factories having exactly the same jelly and viscosity.

At the present time work is being done to determine the following:

- 1—The relationship between the viscosity, jelly strength, tensile strength, and stretch.
- 2—The relationship between gelatin, chondrin, keratin, mucin, etc., and their effect on the strength and stretch of a glue.
- 3—Effect of heating and the length of time of heating on the strength and stretch of glues, both in liquid form and dried form.
- 4—Effect of the soaking of glues on their strength and stretch.
- 5—Effect of the age of glues on their strength and stretch.
- 6—Effect of dissolving a glue, drying, redissolving, etc., on the strength and stretch.
- 7—Effect of the addition of other substances to glue.
- 8—Effect of humidity and temperature on glue.

THE DETERMINATION OF IODIDE AND BROMIDE IN MINERAL WATERS AND BRINES¹

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In a former paper² the authors recommended the permanganate method for the determination of iodide in mineral waters and brines. By the use of this method the iodide is oxidized to iodate by potassium permanganate in slightly alkaline solution and the iodate determined iodometrically by adding potassium iodide, acidifying with hydrochloric acid and titrating the liberated iodine with thiosulfate. This method gives very satisfactory results for the iodide content, but it does not leave the solution in a condition suitable for the determination of the bromide content.

In that paper the authors also showed that iodide may be quantitatively separated from large amounts of chlorides (up to 10 g. NaCl) and from amounts of bromide equivalent to not more than 0.3 to 0.4 g. bromine by liberating the iodine with ferric sulfate and removing it by distillation with steam. The iodine is absorbed in a potassium iodide solution and titrated with thiosulfate.

In a second paper³ a method was proposed for the estimation of bromide in the presence of large amounts of chloride (10 g. NaCl). This method takes advantage of the selective oxidizing action of chromic acid, and the liberated bromine is removed by aspiration.

In the present paper some results are reported of determinations of the iodide and bromide content of mixtures of iodide, bromide, and chloride. These

results were obtained by combining the ferric sulfate method for iodide with the chromic acid method for bromide.

PROCEDURE

The procedure for the determination of iodide and bromide in the presence of chloride is as follows: The iodide should first be determined by the permanganate method, since more accurate results can be obtained by its use than by the use of the ferric sulfate method. Another sample is then taken which should contain not more than 0.1 g. of bromine as bromide or more than 10 g. of total salts. The iodine is removed from this sample by oxidizing with ferric sulfate and distilling the liberated iodine with steam according to the method described in the first paper. The iodine is absorbed in a potassium iodide solution and may be titrated with thiosulfate and the results used to check those obtained by the permanganate method. The residue in the distilling flask is emptied into a beaker, heated to boiling, and the iron precipitated with ammonia or sodium hydroxide. If sodium hydroxide is used, care must be taken not to add a great excess, though a slight excess will be taken care of later by the chromic acid. Any excess of ammonia will be removed during the subsequent evaporation. Filter off the iron hydroxide, wash with hot water, and evaporate to dryness or nearly so. The bromide is determined in the residue by the chromic acid method, the details of which were given in the second paper.

Calcium chloride does not interfere with either determination, but care should be taken when precipitating the iron not to precipitate too much calcium hydroxide by the addition of an excess of alkali, as otherwise the precipitate will be bulky and difficult to wash. This applies also to magnesium chloride if sodium hydroxide is used for precipitating the iron. If much magnesium chloride is present the solution may become acid during evaporation, due to hydrolysis. This may be guarded against by coloring the solution with methyl orange and adding a drop of sodium hydroxide solution if it becomes acid.

Expt. No.	NaCl Taken G.	I as KI Taken G.	Br as KBr		I Found G.	Br Found G.	Error in I Det. G.	Error in Br Det. G.
			Taken G.	Found G.				
1	..		0.0600		0.0598		—0.0002	—0.0002
2	..		0.0800		0.0798		—0.0002	—0.0002
3	10		0.0800		0.0790		—0.0010	—0.0010
4	..	0.0803	0.0800	0.0794	0.0798	—0.0009	—0.0002	—0.0002
5	10	0.0803	0.0200	0.0792	0.0191	—0.0011	—0.0009	—0.0009
6	10	0.0803	0.0400	0.0794	0.0385	—0.0009	—0.0015	—0.0015
7	10	0.0402	0.0800	0.0397	0.0784	—0.0005	—0.0016	—0.0016
8	10	0.0803	0.0800	0.0792	0.0790	—0.0011	—0.0010	—0.0010
9	10	0.0803	0.0200	0.0795	0.0188	—0.0008	—0.0012	—0.0012
10	10	0.0803	0.0400	0.0798	0.0385	—0.0005	—0.0015	—0.0015
11	10	0.0803	0.0020	0.0805	0.0015	+0.0002	—0.0005	—0.0005
12	10	0.0803	0.0040	0.0798	0.0033	—0.0005	—0.0007	—0.0007
13	10	0.0803	0.0010	0.0792	0.0006	—0.0011	—0.0004	—0.0004
14	10	0.0402	0.1000	0.0396	0.0984	—0.0006	—0.0016	—0.0016

An inspection of the table will show that the results for iodide are all low with the exception of Expt. 11, which is probably due to an error of manipulation. Much better results can be obtained by the use of the permanganate method. The results for bromide are also low, but it is believed that this method will give more accurate results for the bromide content of such mixtures than any other method.

¹ Read before the Division of Water, Sewage and Sanitation, at the 58th Meeting of the American Chemical Society, Philadelphia, Pa., September 5, 1919.

² THIS JOURNAL, 11 (1919), 563.

³ *Ibid.*, 11 (1919), 954.