CHEMISTRY SECTION

A Photo-Electric Apparatus for Determination of Color and Turbidity in Refined Sugar

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The presence of color, turbidity, or any impurity in refined sugar is objectionable- Several types of equipment have been developed for testing sugar in the granulated form, but believing that turbidity or color would be more readily detected in solution, we attempted some years ago to develop apparatus for grading in the solution form.

In developing this system, numerous samples of supposedly the highest-quality sugars were obtained from which sugar solutions were made and color determined by use of a colorimeter. The solution showing the least color was classified as A+, or a numerical grade of 0.5. Using this as a standard, we had colored glass made to match the color of that particular sugar solution. Similar standards were made to represent grades of A or 1.0 and B+ or 1.5.

After using this system for a number of years we found that results were not sufficiently accurate for the close control we desired, therefore we began investigation to develop a more accurate method of grading. This resulted in the building of an experimental photo-electric apparatus which was used at one laboratory for a year. It was found to be a decided improvement over our old system of grading, but it was still not sufficiently accurate. A number of changes and improvements were made resulting in the equipment we are using at the present time, which, we feel, provides a rapid and reasonably accurate method for grading refined sugar. Pure distilled water is the standard used against which to compare the sugar solution.

The equipment consists of a hardwood instrument case with a bakelite top. Mounted in the top is a momentary contact push button, a potentiometer, and an indicating meter with an arbitrary scale graduated from 0 to 100. A metal housing with hinged door and centering screws is provided for enclosing the glass sample cylinder. An electric lamp and lens system is located in the top of the housing. At the bottom of the housing is mounted a photo-electric cell. A means is provided for focusing the lamp, through a lens system, on the sensitive surface of the photo-electric cell.

The test cylinders are of special make with cut polished bottoms and graduated to contain a 12-inch depth of solution. The lamp is a G. E. 6.5 volt, 1.7 ampere, No. G8DCB, microscope illuminator bulb.

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A Lucite block is placed under the test cylinder and a Lucite plunger is inserted in the top of the cylinder. These are to eliminate error caused by light refraction, since Lucite has the peculiar property of carrying light rays straight through it and not permitting them to be dispersed through the sides.

Only a 6-volt wet battery should be used and no attempt should be made to use AC current and a transformer, since all sources of AC current are subject to voltage fluctuation which will destroy the accuracy of the instrument. Dry cells should not be used.

Method of Using the Apparatus

The following procedure should be followed closely in standardizing the instrument and in making the tests on sugar:

All beakers, special Nessler tubes, and other apparatus used in making the tests must be perfectly clean, otherwise incorrect readings will result.

1. Dissolve 100 grams of the sugar to be tested in a beaker in 100 ml. of hot distilled water. Do not filter the sugar solution. Cool and de-air in the mixing beaker, then fill one of the special Nessler tubes 1/16 inch above the graduation line (which represents 12 inches depth) with the sugar solution. Insert the Lucite plunger in the top of the tube making sure there are no air bubbles in the solution or under the plunger.

2. Fill a similar Nessler tube to 1/16 inch above the graduation line with pure cool distilled water and insert a Lucite plunger.

3. Place the tube of distilled water on the Lucite block in the metal case of the instrument and close the door of the case.

4. Depress the push button and adjust the potentiometer until the instrument reads 100. The apparatus is now standardized at 100 on pure distilled water.

Note: It is almost impossible to compensate for so-called cell fatigue, but errors which might result from this may be almost entirely eliminated by care on the part of the operator. Depress the push button and let the indicating instrument swing to its maximum reading after which it will move slowly and slightly down scale. Keep the button in the depressed position until the down-scale movement of the pointer is imperceptible and then read the instrument at that point.

5. Remove the distilled water tube and insert the one containing the sugar solution.

6. Depress the push button and observe the reading of the indicating instrument. This reading is the solution grade of the sugar and represents color, turbidity, or a combination of both. After the reading is made the instrument should be re-standardized on distilled water, then a check sugar reading made. With correct procedure the two readings on the sugar solution should be the same.

In any case where the solution appears turbid, the notation " T " should follow the grade number.

7. Any color, turbidity or other impurities in the sugar lower the reading of the instrument. It is therefore necessary that every precaution be taken to avoid outside contamination of the sugar or the sugar solution.

8. The special Nessler tubes should be cleaned once per shift with chromate-cleaning solution. This will prevent formation of a film that lowers readings and causes variation in readings when using different tubes.

9. The Lucite plungers and blocks should not be washed in hot water. Care also should be taken to avoid scratching the Lucite parts as well as the bottom of the Nessler tubes.

It is usually possible to see with the naked eye, by looking up through a tube of solution, whether turbidity or color is the cause of a low grade. Where turbidity is present, it is a simple matter by filtration of the solution through an asbestos mat, to determine about what extent of turbidity there is. For example, the original unfiltered solution has a grade of 80 and appears quite turbid. It is then filtered, and the grade is 95. Of the 20 points difference between 100 and 80, 15 points are due to turbidity and 5 points to color.

The instrument is very sensitive. In many cases visual grading of the crystallized sugar gives a result of A+, while the grades obtained by use of the photo-electric apparatus may range from 60 to 98. It is more sensitive to turbidity than to color, either of which is, of course, objectionable in sugar. The presence of even a small amount of bag lint in the sugar solution will obstruct the passage of light and lower the reading.

The effect of even slight turbidity is demonstrated by the following table, showing the relationship of turbidity to the photo-electric reading.

Turbidity, parts per 100,000 Calcium carbonate	Photo-electric reading
1.0	77
0.9	80
0.8	84
0.7	86
0.6	87
0.5	80
0.4	90
0.3	92
0.2	94
0.1	96
0.0	100

The above relationship was established by using very finely divided, chemically pure, precipitated calcium carbonate in pure distilled water.

So far, we have not made a practice of trying to differentiate between color and turbidity, only in the case of rather low grades.

We specify that the sugar solutions tested are not to be filtered, as we want to know the grade of the sugar which is actually sacked. It is therefore very important that extreme care be exercised in the procedure of sampling and testing to avoid contamination and erroneous grades.

Because of its sensitivity, the instrument is a good detector. With normal and good operation there is not much fluctuation in grades, but when there is a decided drop, it usually indicates some sub-normal operation such as improper filtration, poor centrifugal work, etc.

Results obtained from the use of this apparatus are closely watched by factory operators and we feel it to be of considerable value in our control work.

Other Uses of Apparatus

We feel there are other uses to which the apparatus is applicable, although these have not been tried extensively :

1. Color determinations on juices at various stages of the process by dilution to a uniform density, such as a brix of 10.

2. Detection of caramel by lead-acetate treatment of juices diluted to a uniform brix of 10.

3. Determining contamination in white centrifugal wash water caused by broken or unclean water filters.

4. Determination of magnesium in limerock analysis and phosphates and sulfates in boiler waters by establishing the relationship between actual results and the photo-electric reading.

5. Colorimetric determinations in soil testing.

Conclusion

In our opinion, this is a quick and accurate method for determining color and turbidity in sugar. While it may not be the final answer to the problem, at least, we feel it is a marked improvement over anything we have used for this purpose before.