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Birmingham Section.

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DR. T. SLATER PRICE IN THE CHAIR.

THE INTERPRETATION OF COLOUR VALUES OBTAINED BY LOVIBOND'S TINTOMETER.

BY ARTHUR W. KNAPP, B.Sc., F.I.C.

The Lovibond Tintometer is being more and more used as a convenient instrument for the measurement and recording of colours. The theory of the tintometer is that any colour can be matched with a suitable combination of red, yellow and blue standard glasses.

In using the Lovibond Tintometer I found that it was possible to make glasses of different values match the same colour or match one another, for example :

3.0 Red	5.0 Yellow	1.0 Blue
gave the same colour as		
2.2 Red	4.2 Yellow	0.2 Blue

In examining a body with this colour, two experimenters with perfect eyesight might correctly record different results. This is an obvious objection to the use of the instrument, and therefore I thought it worth while to find the cause, in order that this possibility of obtaining inconsistent results might be eliminated.

The following experiments revealed the cause: the standard glasses are not perfectly transparent to white light; and hence a little white light is lost for each glass that is passed through. This is what one would naturally expect, for perfectly transparent bodies are unknown, but I have not seen it mentioned anywhere that the amount of light so lost must be considered in recording the colour. Of a large number of comparisons of combinations of glasses, the following are selected to illustrate this point.

(1) (It will be remembered that the standard glasses are intended to be so arranged that equal amounts of red, yellow and blue give a neutral tint. Actually, such combinations do give greys almost free from colour.) A combination of 12 glasses :

2, 2, 2, 2 Red 2, 2, 2, 2 Yellow 2, 2, 2, 2 Blue
does not give the same depth of grey as

8 Red 8 Yellow 8 Blue

but give the same grey as the three glasses :

4.0 Red 4.0 Yellow 4.0 Blue

This apparent error in the standards is produced by ignoring the white light which each glass absorbs and scatters. Theoretically, white light passing through an ideal yellow glass would retain the whole of its yellow component and would only be diminished in its red and blue components. Practically, when light passes through one of the standard yellow glasses, marked 0.2, there are actually absorbed red and blue rays corresponding to 0.2 of yellow, and also, as the calculation below shows, about 0.36 of white light (i.e., 0.36 each of yellow, red and blue). If we assume that the glasses are correct so far as their primary colours are concerned, then the average amount of white light absorbed in the above comparison by each glass is calculated thus: the first combination contains nine more glasses than the second, and these nine glasses are responsible for $4.0 - 0.8 = 3.2$ of grey. Or one glass absorbs as an average $3.2 \div 9 = 0.36$ of white light.

(2) Comparing glasses of one colour, it might be expected that the five glasses 0.1, 0.2, 0.4, 0.5, 0.8 ($= 2.0$) of yellow would match the one glass, 2.0 of yellow. We find that they look, in a sense, equally yellow, but that the screen seen through the one glass appears by comparison flooded with sunlight. And to make it match the five glasses, it is necessary to add .2 each of red, yellow and blue. One glass thus absorbs in this case 0.2 of white light.

These two examples must not be taken as indicating that the standard glasses, supplied with the tintometer, are not true as far as their primary colour is concerned, but simply that their property of stopping white light has been ignored. Thus 0.1 of yellow is 0.1 of yellow, but also about 0.3 of grey. That the glasses are correctly standardised was shown by having the same number of glasses in any two combinations compared, so as to cancel out the greyness. Examples :

(1) 2.0, 0.5, 0.2, 0.1 ($= 2.8$) of any colour match 1.0, 0.8, 0.6, 0.4 ($= 2.8$) of the same colour.

(2) The six glasses 2.0 of Red and .1, .2, .4, .5, .8 of Yellow match the six glasses .1, .2, .4, .5, .8 of Red and 2.0 of Yellow.

In all such combinations the matches were perfect or almost perfect; which shows that the glasses are carefully standardised and that their greyness is not markedly variable. It will now be seen that in using the Lovibond Tintometer the colour values represented by figures on paper do not vary proportionally with the actual colour values; they make, however, a very useful record, for one can, provided one knows the number of glasses used, always obtain the same colour again. The note above shows that we should be more nearly expressing the truth if we added, to the values for the red, yellow and blue, from 0.2 to 0.4 of grey for each glass used. And further, if this were done, disagreements, due to the use of different numbers of glasses, would be avoided. This will be seen from the following examples :

(a) 3.0 Red	5.0 Yellow	1.0 Blue
gave the same colour as		

(b) 2.2 Red	4.2 Yellow	0.2 Blue
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They are here recorded in the usual way. In (a) three glasses are used, and in (b) five glasses. Accurately to record the grey introduced by the glasses we should need to know the exact amount of white light that each particular glass absorbs. It will be sufficiently near for our purpose to consider each one as introducing the average 0.3 of grey found above. Adding 0.3 grey ($= 0.3$ red, 0.3 yellow, 0.3 blue) for each glass used, we get, since $3 \times 0.3 = 0.9$ and $5 \times 0.3 = 1.5$:-

(a) 3.0 Red	5.0 Yellow	1.0 Blue
0.9	0.9	0.9

3.9	5.9	1.9
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(b) 2.2 Red	4.2 Yellow	0.2 Blue
1.5	1.5	1.5

3.7	5.7	1.7
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which agree as well as can be expected under ordinary working conditions. If we prefer to express (a) and (b) in terms of their visual composition, as suggested by Mr. Lovibond, we see that the error occurs in the black :

(a) Black 1.0	Orange 2.0	Yellow 2.0
(b) Black 0.2	Orange 2.0	Yellow 2.0

To apply the suggested correction when the colours are so expressed we have merely to add 0.9 to the black in (a), and 1.5 to the black in (b).

As a final example :

(c) 1.9 Red	1.9 Yellow	0 Blue
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was very different from 2.0 red and 2.0 yellow, but was almost identical with

(d) 3.0 Red	3.0 Yellow	1.0 Blue
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Each 1.9 was made up of 1.0, 0.5, 0.4, so that (c) was made up of six glasses and (d) of three glasses. Applying the suggested correction, we obtain :

(c) 3.7 Red	3.7 Yellow	1.8 Blue
(d) 3.9 Red	3.9 Yellow	1.9 Blue

The same result could be obtained, more tediously, experimentally, if one had some pieces of uncoloured glass, each of which had the same greyness (probably about 0.3) as the coloured glasses. The experimenter would arrange to have, on the object side of the match, the same number of such uncoloured glasses as there were

coloured glasses in the combination which matched. I believe Mr. Lovibond has suggested the use of such glasses for special substances, like water-white oils, glycerine, etc.

DISCUSSION.

Mr. J. F. LIVERSEEGE said that the colour of the Welsh water in Birmingham had been regularly determined with the tintometer, and notable seasonable variations had been found. The amount of colour was smallest in the middle of the year. About September there was a decided increase, the maximum being attained about November. The colour then gradually fell till about May. The colour was determined at several stations, and it was, of course, advisable that different workers should get the same results. A sample of water was examined in Wales and the colour given as 2.4 of red, 10.6 of yellow and 0.5 of blue. Mr. Knapp and himself had examined the sample the next day and found the colour to be: red 3.0, yellow 11.2, blue 1.0. With the glasses then in use the first colour could be produced by either using five or eight glasses. The latter was a fair match of the water. They used six glasses in their match, and if, for the two extra glasses, 0.6 was added to the figures of the observer in Wales, the result was very similar to what they obtained. To avoid this cause of disagreement, rules previously drawn up for tintometer observations were amended as follows:—The white reflector must be placed so that the surface is uniformly illuminated. The sun must not shine on it. The right and left fields must have the same appearance. The equality of the fields should be tested occasionally by transferring the trough from one side of the instrument to the other. This reversal should make no difference to the colour of the water as determined by the glasses. The reflector, the glasses, and the trough must be kept clean. The bottle of water should be shaken thoroughly before the trough is filled. If the water is turbid, the contents of the trough should be stirred periodically. Welsh water should be matched if possible with yellow and red glasses only, not less than 0.2 of a colour being added at once. With dark waters the addition may be 0.4 or 1.0. If red and yellow glasses alone give a colour brighter than the water, add blue, and increase the red and yellow proportionately. (The Triple "neutral" glasses may be used as a guide to the amount of increase.) In cases of doubt, record the smaller amount of blue. For instance, if between 0 and 0.2, put down 0; if between 0.2 and 0.4, put down 0.2. Use the smallest possible number of glasses, that is, replace 0.2 and 0.4 of the same colour by 0.6; or replace 0.4 and 0.6 by 1.0. When a match is apparently obtained, give the eyes a little rest, stir the water if turbid, then test the accuracy of the match by adding 0.2 of red (or 0.4 if the water is dark) to the right and left of the instrument, and if the change effects an improvement, modify the glasses accordingly. Then try 0.2 of yellow in the same way, then red and yellow together, and finally 0.2 each of red, yellow, and blue together. If none of these changes make an improvement in the match, the result is recorded. No "neutral" glasses must be present in the final match, and all glasses must be on one side. *Glasses used.*—Red, yellow, and blue, 0.2, 0.4, 0.6, 0.8, 1.0, 2.0, 3.0, 4.0, 5.0, 10.0, 15.0, 20.0; neutral (for trial matches only) 0.2, 0.5, 1.0.

Mr. F. H. ALCOCK said it appeared to him that the author's suggestion presented some difficulty. He did not think that it was a question of multiplication, addition, subtraction, or division. They had to look for the difficulty in the reflection, diffusion, refraction and polarisation of light. When he was dealing with turbid waters such considerations, which were constantly cropping up, in the subject of light, were concerned in the variation.

Mr. KNAPP, in reply, observed that Mr. Liversedge had recommended that 0.1 should no longer be used in matching the colour of Birmingham water. He thought that was wise, since a 0.1 glass added 0.1 of colour, and 0.3 of grey to the light passed through; so that, for example, the addition of a 0.1 yellow glass caused a reduction of brightness which was more marked than the increase in yellow. Personally, he had found that where there were more than 5 units of a colour already present, his eye was not always sensitive even to an addition of 0.2 of that

colour. In his own experiments the possibility of refraction, etc., having an influence was eliminated, for he had used no medium, but had compared the standard glasses with one another.

Manchester Section.

Meeting held at the Grand Hotel, Manchester, on Friday, November 4th, 1910.

DR. G. J. FOWLER IN THE CHAIR.

CONTRIBUTION TO THE STUDY OF CHEMICAL DISINFECTANTS.

BY PROFESSOR SHERIDAN DELEPINE, M.B., C.M., M.S.C.

I propose to approach this subject from the bacteriological and hygienic point of view only. I cannot attempt to deal fully with all the facts bearing upon the biological and hygienic aspect of disinfection by chemical disinfectants, all I can hope to do is to indicate by means of records of experiments and observations some of the factors which have to be considered. For this purpose I propose to utilise chiefly the work which has been carried out in my laboratory either by myself or by several workers who have employed under my supervision the same methods as those I have used. During this period I have gradually improved many technical details, but most of my older work has been controlled by more extended experiments conducted in my laboratory in the course of the last ten years by a number of research workers.

As I am not at liberty to refer in detail to the investigations I have carried out on behalf of a number of firms, I will not refer to any patent disinfectant by name (except when published statements are available). I propose, however, as soon as I have been able to complete independent and strictly comparable series of tests with all the most important disinfectants at present on the market, to publish my results. In the time at my disposal it is impossible to refer to the work done by other observers, but as I have given elsewhere* a general account of the subject I may perhaps be excused for this omission.

The problem of disinfection is more complicated than is generally supposed. In principle it is simple enough; we know that infectious diseases and fermentations are due to living microbes, and that by killing or rendering these microbes inactive we may stop the spread of infection. We may therefore say that chemical disinfectants are substances which prevent the spread of infection by bringing about the death of the living organisms causing infection. It is not always easy to distinguish between the results brought about by the death of the infecting microbes and those caused by a suspension or inhibition of their activities. Certain products have the power even in very minute doses to arrest the multiplication and other activities of bacteria so completely that perfect sterilisation is simulated. Substances acting in this way are generally termed antiseptics; they are only inhibitory agents. The same product may in small doses act as an antiseptic and in larger doses as a disinfectant, in fact this is usually the case.

Inhibitory action is very different in its effects from lethal action, for microbes which have been kept in a state of suspended activity by the action of an antiseptic may begin to multiply again when the material containing them is mixed with other products or simply diluted.

The mode of action of antiseptics is understood in very few cases only.

Goppert showed in 1889 that mercuric chloride may be fixed by the living bacteria and inhibit their growth and multiplication without killing them. This is easily proved by transferring the bacteria which have been exposed for a certain length of time to the action of certain

*Standardizing of Disinfectants, J. Royal Inst. of Public Health, 1908.