the council. This "finger-signature" indicates that the act, to which it is attached in attestation, has been discussed and definitively approved by those whose mark has thus been put upon it. It is usual in Cathay [China], when any contract is entered into, for the outline of the fingers of the parties to be traced upon the document. For experience shows that no two individuals have fingers precisely alike. The hand of the contracting party is set upon the back of the paper containing the deed, and lines are then traced round his fingers up to the knuckles, in order that if ever one of them should deny his obligation this tracing may be compared with his fingers and he may thus be convicted.[1]

Professor Henri Cordier of Paris, the editor of Yule's famous work, adds to this passage a footnote relative to the history of finger-prints, and commenting on the claim of Sir W. Herschel, tersely remarks:

> Sir W. Herschel was entirely wrong; Mr. Faulds protested against the claim of Sir W. Herschel, and finally a Japanese gentlemen, Kumagusu Minakata, proved the case for the Japanese and the Chinese. None of these writers quoted the passage of Rashid-eddin which is a peremptory proof of the antiquity of the use of finger-prints by the Chinese.

Indeed it is, and the observation that no two individuals have finger-marks precisely alike is thoroughly Galtonian. There is the earlier testimony of the Arabic merchant Soleiman, who wrote in A.D. 851, and who states that in China creditor's bills were marked by the debtor with his middle finger and index united (see my History, p. 643). But we have more. E. Chavannes, in reviewing my article in the *T'oung Pao* (1913, p. 490), has pointed out three contracts of the T'ang period, dated A.D. 782 and 786 and discovered in Turkestan (two by Sir Aurel Stein), which were provided with the finger-marks of both parties, and contain at the end the typical formula:

> The two parties have found this just and clear, and have affixed the impressions of their fingers as a distinctive mark.[2]

A clay seal for which no later date than the third century B.C. can be assumed, and which bears on its reverse a very deeply and clearly cut impression of the owner's thumb-mark, has been brought back by me from China, and is illustrated and described in the above paper. I have also shown how the system was developed in ancient China from magical beliefs in the power of bodily parts, the individual, as it were, sacrificing his finger in good faith of his promises; in its origin, the finger-print had a magical and ritualistic character.

Sir W. Herschel states that he fails to see the definite force of the word "identification" in the Chinese finger-print system. In his opinion, there must be two impressions at least, that will bear comparison, to constitute "identification." He thinks, of course, one-sidedly of the detection of criminals to which the process has been applied by us, but never in the East (for what reason, I have stated elsewhere). Most certainly, the idea underlying Chinese finger-prints was principally that of identification, as expressly stated by Rashid-eddin and all Chinese informants. If a doubt or litigation arose, all that was necessary was to repeat the finger impression of the contractor who had formerly signed the deed.

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SPECIAL ARTICLES

ON THE COLLOID CHEMISTRY OF FEHLING'S TEST

I

As familiarly known, when Fehling's solution is treated with a reducing substance, it is generally expected that a bright red precipitate will be obtained. Frequently, however, an orange or yellow precipitate is obtained and in certain instances nothing but a yellowish-green or bluish-green discoloration results. The attempts to account for these differences are, for the most part, chemical in nature; it is held that the red reaction represents a precipitate of cuprous oxide, the orange or yellow ones more doubtful suboxides or hydrated forms of the oxide, while the character of the greenish discolorations is left doubtful. It is often be-

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[1] See H. Yule, "Cathay," new ed., Vol. III., p. 123, London, 1914, Hakluyt Society.

[2] See A. Stein, "Ancient Khotan," Vol. I., pp. 525–529, Oxford, 1907, where the three documents are published and translated by Chavannes.

lieved that these latter represent but questionable evidence for the presence of any true reducing substances, or if conceded to be positive evidence for such, it is held that the reducing substances can not be present in great amounts.

An investigation of this series of changes from a colloid-chemical point of view reveals the fact that these color changes are coincident, not with differences in the nature of the reduction products, but only with differences in the size attained by the particles of reduced substance. If the copper oxide particles are brought down in very fine (subcolloid or colloid) form, the greenish discolorations are produced; as the copper oxide particles grow in size they become yellow, then orange, and when very coarse they are red. The series shows, in other words, what has been observed by different colloid-chemical workers: that one and the same material may, in the colloid state, show different colors, the color order following Wolfgang Ostwald's color law, according to which the most highly dispersed particles of a given substance are likely to be yellow, turning, as the size of the particles increases, to orange or red, and finally to violet, blue or black.

As to which of these possible colors will be obtained from a Fehling's solution undergoing reduction depends upon the conditions surrounding the reduction, the greenish discolorations being obtained whenever the conditions are such as will keep the cuprous oxide, as produced, in its finely divided state; while the red will result when opposite conditions obtain.

Three factors are chiefly concerned in the process:

1. Contrary to the generally accepted notion, the presence of too much reducing substance (as too much dextrose) is more likely to yield a greenish result than the presence of too little. This is because with much reducing substance the reduction starts from many points at once, but with exhaustion of the available copper salt the process comes to a halt before the cuprous oxide particles have attained any great size.

2. Irrespective of the amount of reducing substance present, the greenish discoloration will be obtained whenever materials are present in the reaction mixture which tend to stabilize the cuprous oxide in its finely divided form. Such materials are of the group of the lyophilic (hydrophilic) colloids and whenever present, either because added experimentally to reaction mixtures prepared in the laboratory or brought in with the mixtures being tested for reducing bodies (like diabetic urine) they incline to stabilize the cuprous oxide when this is still in a finely divided state.

3. With certain reducing substances (like dextrose) such "protective" hydrophilic colloids may be produced in the course of the reactions incident to the Fehling's test itself. In the action of the alkali of Fehling's solution upon dextrose, for example, there are produced, from a chemical point of view, not only the various degradation products which are responsible for the reduction of the copper salt, but, from a colloid point of view, many of these are colloid in nature and so tend to inhibit a precipitation of the cuprous oxide in coarse form.

Consideration of these various facts not only renders intelligible many of the excellent empiric instructions which different chemists have long found useful when Fehling's test for the qualitative or quantitative determination of various reducing bodies is employed, but they indicate also what schemes should be followed if it is desired to get the copper oxide precipitated in its coarse red form.

To allow adequate time for the growth of the cuprous oxide particles, it is better to make reductions at low temperatures than at higher ones. A Fehling's test carried out at room temperature by mixing the Fehling's solution with the suspected material and setting this aside for twenty-four hours is therefore more likely to yield a red precipitate than if the test is made by boiling the two together in the ordinary way.

Care should also be taken not to use excessive quantities of the material containing the reducing bodies. This not only avoids the possibility of using more reducing substance than there is available copper salt that may be reduced, but it minimizes the possibilities of adding excessive quantities of protective colloids which might stabilize the cuprous oxide in its finely divided form. Finally, in doubtful cases, a dilution of the reaction mixture is always to be tried. By this method there is avoided not only excessive concentration of the reducing body itself, but through adequate dilution, both those protective colloids which may be added from without, or those which may be formed in the reaction mixture itself are likely to be diluted to a point where their effect in stabilizing the cuprous oxide in its finely divided form is largely lost.

II

While working on the reduction of Fehling's solution by formaldehyde, we encountered a series of reactions which, while largely familiar to the physical chemists since Bredig's classical studies on the inorganic ferments, are somewhat new in their sum total; and since the reactions are strikingly like those observed in biological material, we have used them to elucidate the nature of such biological reactions for our students.

Formaldehyde reduces a Fehling's solution not only to the ordinary cuprous oxide, but to the metallic copper. The copper comes down in colloid form, but as this happens, a second reaction ensues in which the metallic copper acts upon the formaldehyde and decomposes it with the liberation of hydrogen. The liberation of hydrogen continues for hours, until either all the formaldehyde has been decomposed or all the copper salt has been reduced.

We use this reaction as a biological analogue illustrating the formation of an enzyme (the reduced copper) from a series of simple "dead" materials (alkali, salts, carbohydrate). From another point of view we may say that the formaldehyde poisons or acts as a toxin upon the Fehling's solution. Against this the reaction mixture produces an antitoxin (the metallic copper).

The reaction may also be used to illustrate the action of different enzymatic poisons. Potassium cyanide, for example, when added to the Fehling's solution will not only prevent its reduction by the formaldehyde but, added after the reduction has been initiated, will inhibit or stop further reduction and liberation of hydrogen.

As emphasized by Hoppe-Seyler, the production of nascent hydrogen is held to be essential in the chemistry of respiration. But depending upon whether this production of hydrogen in a biological oxidation mixture occurs in the presence or in the absence of oxygen, totally different effects (as an oxidation in the one case or a reduction in the other) may be brought about. The same is true of the chemistry of a Fehling's solution when reduced by formaldehyde.

If a substance like methylene blue or phenolsulphonephthalein is added to the reaction mixture, these dyes are left untouched or are deoxidized, depending upon whether the reaction mixture is kept in a flat dish exposed to oxygen or in a tall tube from which oxygen is largely excluded. In other words, the first dye behaves just as in the classical experiments of Paul Ehrlich upon tissue oxidations; the phenolsulphonephthalein acts as in the experiments of E. C. Kendall. Phenolsulphonephthalein suffers reduction in the body whenever oxygen is absent while it is left untouched when this is not the case.

A detailed account of these experiments has been sent to the *Kolloid-Zeitschrift* for publication.

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THE OIL CONTENT OF COTTON SEED AN ACCURATE BASIS FOR COMMERCIAL STANDARDIZATION

As a result of four years' work by the author, three of which are shown in the table below, and based on more than 500 determinations in the cotton industry laboratory of the Georgia State College of Agriculture, it was found that the oil content of cotton seed is an inherent characteristic of the variety, and that the percentage of oil in any variety can be increased by selection with no corresponding loss of other desirable qualities. Al-