

substances separately (*Compt. rend.*, 1836, 2, 543; see also *Ann. Chim. Phys.*, 1852 [iii.], 36, 430). Now the accuracy with which Biot could carry out his observations was very much less than that possible at the present time, which may perhaps be illustrated by the fact that whereas Biot thought that quartz conformed to his simplest law of rotation dispersion, Prof. Lowry himself has shown that a Drude expression of no less than three terms is necessary to represent its behaviour. Further, it has not been shown with modern accuracy, either that the rotation dispersions of terebenthenes and oil of lemon conform to Prof. Lowry's definition of simple dispersion, or that when mixed together they conform accurately to his definition of anomalous dispersion. Practically all modern work has demonstrated very clearly the fact, of which Biot was aware, that only in exceedingly few cases, if indeed in any, can one obtain, by mixing together two optically active liquids, purely additive results. It is doubtful, therefore, whether it is even worth while to repeat Biot's experiment.

Again, Prof. Lowry seems to be unduly partial towards the evidence which he adduces in favour of his views. Thus, for example, he says: "Tschugaeff has shown that anomalous rotatory dispersion can be produced by superposing the opposite partial rotations of two radicals in the same molecule, as in *l*-menthyl *d*-camphorsulphonate." This statement is utterly misleading. Tschugaeff found the dispersion of *l*-menthyl *d*-camphorsulphonate to be anomalous, and he suggested that this might be due to the superposition of two opposite partial rotations, but he certainly did not show that this is actually the case. It suits Prof. Lowry's view, however, to regard Tschugaeff's assumption as equivalent to a demonstration, but he makes no reference to the fact that in *l*-menthyl *d*-camphorsulphonate there are not two asymmetric centres in the molecule, but actually five—and even six if Prof. Lowry's idea of the asymmetry of the carbonyl group be adopted—so that the rotation dispersion of menthyl camphorsulphonate should be a very complex affair if superposition of asymmetric centres in the molecule plays a part in it.

It would easily be possible to extend these remarks.

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Organic Chemistry Department,
University of Glasgow,
April 26.

I FIND it difficult to discover what reply Prof. Patterson expects to his courteous letter of April 26. From the two experiments which he cites I gather that he wishes to call in question the general proposition that *anomalous rotatory dispersion in transparent media is due to the superposition of two normal rotations¹ of opposite sign*. He has, however, described these two experiments in such a way that it is difficult to believe that either Biot's or Tschugaeff's paper was before him when he wrote his letter. In particular, Biot's synthesis of an anomalous rotatory dispersion, by superposing two normal dispersions of opposite sign (*C.R.*, 1836, 2, 540), does not depend, as he suggests, on the existence of an additive law of optical rotatory power in mixed liquids, since in the first instance the liquids were not mixed but were contained in two separate tubes, the superposition of rotations being purely optical. A precisely similar result was obtained when the two liquids were mixed, but there are no numerical data in the paper which

¹ A 'normal' rotatory dispersion is defined as one in which α , $d\alpha/d\lambda$, and $d^2\alpha/d\lambda^2$ remain constant in sign throughout the region of transparency. In an 'anomalous' dispersion, changes of sign may occur in all these quantities, giving rise respectively to a reversal of sign, a maximum and an inflexion in the dispersion curve.

would justify the assertion that Biot "found that the rotation dispersion of a mixed solution . . . was identical with the sum of the dispersions of the same substances separately"; nor does my acceptance of the general proposition set out above depend on any such assumption.

In the same way, Tschugaeff's experiment (*Ber.*, 1911, 44, 2023) was not a mere numerical exercise in the summation of optical rotations, but a definite test to find out whether anomalous rotatory dispersion could be produced by "intramolecular superposition" as well as by Biot's process of "extramolecular" superposition. His experiment showed that an alcohol and acid, the opposite rotations of which would have given rise to anomalous dispersion if superposed by either of Biot's methods, also gave rise to anomalous rotatory dispersion when united into a single molecule by the elimination of a molecule of water. This successful synthesis has been generally accepted as evidence of the continued existence of the opposite partial rotations of the two radicals after esterification; and its success does not depend, as Prof. Patterson appears to think, on the accuracy of the law of optical superposition, which Tschugaeff himself regarded as only a "first approximation." Nor is it necessary that the component "normal" rotations in any of these syntheses should conform to the law of "simple rotatory dispersion."

Since, as I have shown (*J.C.S.*, 1925, 127, 606), there are at least six different ways (mathematical, physical or chemical) in which normal rotatory dispersions may be superposed to produce anomalous rotatory dispersion, there is plenty of room for diverse opinions as to the particular form of superposition which gives rise to this effect in any given case; but I do not think that any useful purpose would be served by a discussion in the columns of NATURE of these applications of a general principle which was established once for all by Biot in 1836.

T. M. LOWRY.

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Cambridge, May 1.

Hardness of Copper-Tin Alloys.

IN NATURE of January 23 I described some experiments on the hardness of various materials, the hardness being measured by the pressure which the material can withstand.

Since that time the same test has been applied to many of the metallic elements, and it is intended to form as complete a table as possible of the hardness of those to which this method is applicable.

Some experiments have also been made on the hardness of alloys, and its variation with the relative proportions of the constituent metals.

An example for copper-tin alloys is given in the accompanying diagram (Fig. 1). These alloys exhibit an extraordinary range of hardness passing from 48 tons/inch² (pure copper) to about 6 tons/inch² (pure tin), but rising to 220 tons/inch² when one-third of the volume is tin (speculum metal). The hardness of the latter is about that of rather a low temper spring steel, though the other physical properties of the two are very different.

I found that small quantities (a gram or less) of the required alloys could be conveniently made by melting the proper proportions of the constituents under borax in the closed end of a hard glass tube, using a

² The statement which Patterson describes as "utterly misleading" is a close paraphrase of the words used by Tschugaeff himself in describing his experiments in the Faraday Society's general discussion on "Optical Rotatory Power," when he claimed that he had shown "that anomalous dispersion may be produced by the superposition of the partial rotations produced by two asymmetric complexes within the molecule of an active body" (*Trans. Faraday Soc.*, 1914, 10, p. 73).