"Experiments on the Flame Spectrum of Carbon Monoxide."

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In the investigation of flame spectra at high temperatures, 'Phil. Trans.,' A, vol. 185, p. 676, Part I, 1895, it was found that carbon monoxide when burnt with oxygen gave faint lines or bands in its spectrum coincident with edges of some of the carbon bands which have been observed in the flame of coal-gas. The experiments were made simply with the view of ascertaining what might be usually seen in a carbon monoxide flame, and looked for in a flame from a Bessemer converter. The spectrum was photographed with a fairly wide slit, and the exposure was of one hour's duration. It was composed almost entirely of a continuous band of rays, but there were very feeble indications of lines or the edges of bands which, after careful inspection, being barely visible, were just capable of being measured. Their positions lay between wave-lengths 5945 and 4249. Other faint bands were seen at 6337, 6172, 4224, and 4183. These all lie within the region of coloured rays and apparently belong to carbon, but they were by no means considered an important feature in the spectrum.

The exact nature of the carbon monoxide spectrum bears upon the researches of Professor Smithells ('Trans. Chem. Soc.,' 1894, p. 603), so that it seemed desirable to decide whether the lines observed were really due to carbon monoxide gas, or to some impurity which gained admission to the material burned, or to the flame produced by its combustion. A little consideration showed that possibly carbonaceous dust, in other terms, organic matter floating in the air, might be concerned in the production of the feeble carbon bands, as the exposure was a long one. Again, as the gas was conveyed from the gas-holders and also from the oxygen cylinders through tubes of india-rubber, there was some amount of uncertainty as to whether the tubes had not contributed to the gases some minute quantity of a volatile hydrocarbon. To obviate any such complication, a further series of photographs was taken with a spectroscope slit of narrower dimensions to obtain better definition.

The gases were conveyed through patent flexible steel tubing which had not been used for any other purpose. The flame was produced by burning the carbon monoxide by means of a Deville blowpipe fitted with a polished platinum nozzle. Oxygen was conveyed into its interior by a polished platinum jet. The image of the flame was projected on to the slit, and the photographic plates were exposed from thirty-five to forty minutes. One part of the spectrum

was photographed more strongly than the rest, the slit being wider, so that any feeble lines not easily seen under the usual conditions might be made apparent. Two spectra were photographed, but one was rather too weak to justify conclusions drawn from its appearance.

Presence of the Water-vapour Spectrum.

The second spectrum was sufficiently dense, and its examination disclosed the curious fact that it contained two groups of the water-vapour lines (Liveing and Dewar, 'Phil. Trans.,' vol. 179, p. 27). The strongest group in the carbon monoxide spectrum belonged to Section VI, wave-lengths 3428, 2472, 3548, and 3933, the last line corresponds in position with the solar line K. It is stated that the lines in this section are weaker than those in Section V of the oxy-hydrogen flame, which lie between 3063 and 3203·5. Now, although these latter lines were photographed in the carbon monoxide they were of much feebler intensity than those in Section VI.

The lines were identified by comparing them with those from the flame of the oxyhydrogen blow-pipe photographed with the same instrument, with which they were found to coincide. That both are obtained by the same process of combustion, but by gases from different sources and with groups of lines with different relative intensities, was thus established.

There were no other lines visible, only a continuous band of rays.

Possible Origin of the Water-vapour Lines in the Carbon Monoxide Spectrum.

As to the possible origin of these two groups of lines, it was at once conceivable that the water-vapour present in the carbon monoxide was the cause of their appearance.

Another spectrum was then photographed, using on this occasion a four-prism instrument, but there is, unfortunately, no means of obtaining on one plate both groups of lines including those more refrangible than 3502.

The gas was dried by passing it through pumice soaked in oil of vitriol. A continuous spectrum was visible, with very slight indications of some of the less refrangible of the water-vapour lines. A further trial was made of the dried gas, which in this case was burnt from the interior or oxygen jet of the Deville blow-pipe, the oxygen passing through the platinum nozzle of the outer tube. A steady brilliant flame burnt for fifty minutes. In this instance the two groups of the water-vapour lines were as distinct as before, with a continuous band of diffused rays, but no other lines or bands were seen. It may be remarked that damp weather prevailed during these

experiments, and though dry oxygen surrounded the dry carbon monoxide gas, yet the moisture of the atmosphere may have contributed the water-vapour.

In the original photograph of the carbon monoxide there were no water-vapour lines apparent in the spectrum. Their invisibility may be accounted for by a want of definition, owing to their being photographed with a more widely open slit. That the relative intensities of the two groups of lines are not the same as in groups V and VI of Messrs. Liveing and Dewar's photographs, furnishes grounds for believing that they belong to the spectra of two different substances. It is not improbable that one of these substances is an oxide of nitrogen, for it has long been known that nitric acid is produced in minute quantity by burning hydrogen, and there is reason to believe that it is also formed on the outside of a carbon monoxide flame, where a greenish-yellow tinge is observed.

It has been suggested to me by Professor Smithells that the existence of the water-vapour spectrum, in the circumstances just described, may be a confirmation of the observation made by Dixon, that carbon monoxide when dry will not burn in dry air ('Phil. Trans.,' 1884, Part II, p. 629; see also Brereton Baker, 'Trans. Chem. Soc.,' 1894, p. 611). Smithells states, however, that it will burn if the carbon monoxide is heated ('Trans. Chem. Soc.,' 1894, p. 610). This latter fact renders it possible for carbon monoxide to burn and yet not show the water-vapour spectrum, since, though a damp atmosphere may cause the gas to ignite, the flame will heat the jet and thus the gas subsequently will be heated and burned, although both it and the oxygen are dry. It may also serve to account for the original carbon monoxide spectrum not exhibiting the water-vapour lines.

The water-vapour spectrum was always more feeble in the photographs taken from the carbon monoxide flame under an exposure of from thirty-five to fifty minutes than in the oxyhydrogen flame under an exposure of only two minutes. This indicates the small proportion of the water or other substance present.

The result of these experiments shows that the spectrum of carbon monoxide consists entirely of a continuous spectrum decreasing in intensity towards the more refrangible part of the ultra-violet, about wave-length 3000. No carbon bands or any lines or edges of bands were photographed which could not be accounted for as due to other substances than carbon monoxide.