

## THE COLLOID THEORY OF THE CORROSION OF IRON AND STEEL.

BY J. NEWTON FRIEND.

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Ten years ago <sup>1</sup> I had occasion to direct attention to the close similarity between the phenomena attending the corrosion of iron—using the word iron in its broadest chemical sense to include steels and ferrous metals generally—and the formation and precipitation of colloids. This similarity was too striking to be merely accidental, and later research has fully confirmed the observations then made.

In the same paper I showed that if ordinary tap water is made to flow over the surface of iron, the rate of corrosion rapidly increases with the velocity of the water, a maximum effect being reached at a speed of about 0.1 mile per hour. Further increase in the rate of flow of the water resulted in a decrease in the rate of corrosion, until, at a velocity of about 6 miles per hour no corrosion in the ordinary sense of the term will take place. It is true that a slight loss in weight occurs, but this is probably due in the main to mechanical erosion. The experiment may be varied by first rendering the water milky with bubbles of air, but the result is the same, showing that lack of oxygen is not the cause of the freedom from rusting.

In order to ascertain whether or not the same kind of retardation would occur under conditions of rapid movement in acid solutions discs of pure iron foil were made to rotate at varying speeds in glass tanks containing dilute sulphuric acid.<sup>2</sup> It is admitted that the two sets of experiments were not strictly comparable. In the tap water tests the water flowed over the iron contained in a glass tube and ran to waste so that the same water never passed over the metal a second time. To have adopted the same method with acid would have required enormous supplies of acid, and this was impracticable. Nevertheless the results obtained were very instructive, for it was found that, within the error

<sup>1</sup> Friend, *Trans. Chem. Soc.*, **119**, 932, 1921.

<sup>2</sup> Friend and Dennett, *ibid.*, **121**, 41, 1922.

of experiment, the rate of solution of the iron was directly proportional to the velocity of rotation. At 4000 revolutions per minute, corresponding to a velocity at the rim of the disc of some 35 miles per hour, there was no sign of falling off in the rate of solution. Whitman and his co-workers<sup>3</sup> have confirmed and extended these results.

The conclusion was inevitable that a great difference exists between corrosion in more or less neutral solution and corrosion which is the result of acid attack, in which the products of corrosion are soluble and readily wash or diffuse away from the seat of attack. I was therefore led to suggest a new theory of corrosion according to which iron is relatively noble or passive to pure aerated water, and only passes into solution with extreme slowness in the absence of a catalyst. The dissolved iron is probably present at first in solution in the more or less completely ionised condition, and it was suggested that agglomeration of ferrous hydroxide then took place, the colloid thus formed catalytically assisting the as yet unattacked metal to undergo corrosion.

At first the *modus operandi* of the colloid was assumed to be chemical, the ferrous hydroxide functioning as an oxygen carrier being alternately oxidised by dissolved oxygen and reduced by the metallic iron.

Such a series of reactions is theoretically possible, and harmonises with the well-known catalytic activity of iron and its salts in numerous reactions. But a series of carefully planned experiments carried out with the object of testing this theory have yielded negative results. Whilst, therefore, the foregoing scheme is still possible, it seems more likely that the action of the colloid is simply mechanical. That is to say, in rapidly moving aerated water the iron passes very slowly into solution and the ferrous hydroxide is swept away. Under stationary or slow-moving conditions the iron passes into solution as before, but the ferrous hydroxide agglomerates to sol or gel and is adsorbed on to, or otherwise clings to, portions of the metallic surface, thus partially screening them from oxygen and inducing anodic corrosion in accordance with recognised electrochemical principles.

The corrosion of iron under such conditions, therefore, is largely interwoven with colloid phenomena, for it is evident that any reaction or process that will retard adsorption and the consequent screening of the metal surface will tend also to retard anodic attack.