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Rusting – the demon harnessed

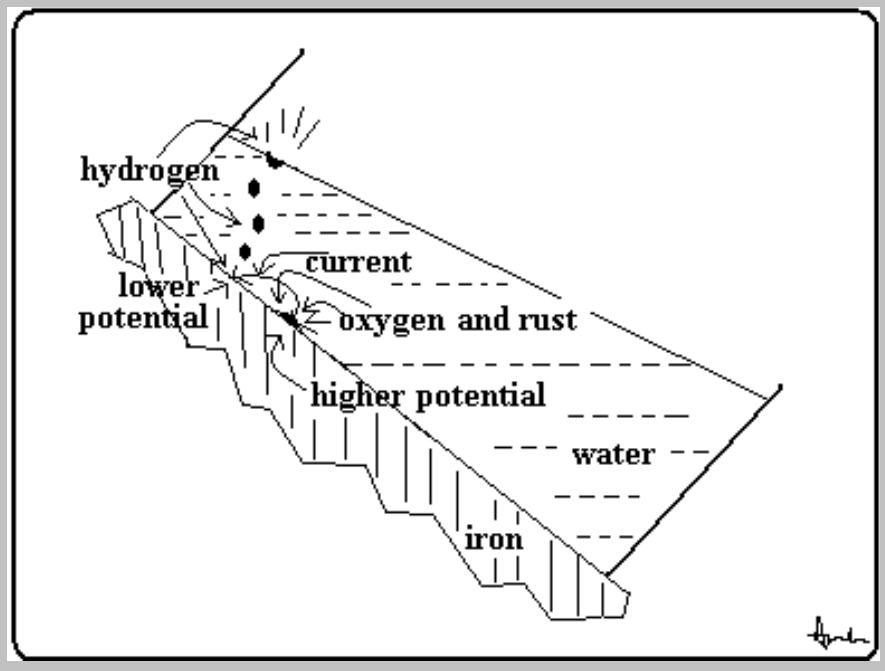
Rusting, that scourge of civilization since the discovery of iron, can be put to work as an industrial process, says S.Ananthanarayanan

Scientists in Grenoble, France have discovered things about rusting by which the degradation of metals itself could be used for creating porous materials of technological value.

Rusting is electrochemical

Rusting of iron takes place in the damp, provided there is both a hint of salt or acid in the moisture and also oxygen, so that rust, which is iron oxide, can form. Rusting does not happen if the water is pure and electrically non-conducting. Nor does it happen if the water has no dissolved oxygen.

Different parts of submerged iron are in contact with different concentrations of oxygen. This, or impurities in the iron can cause different parts of an iron object to be at different electric potentials. The differences are routine at the low, crystal structure dimensions. When iron like this is surrounded by water that is at all conducting, then, an electric



current flows . The current flows with the help of the electrically *positive* Hydrogen part of water and the electrically 'negative', oxygen part of water (which is H_2O). The result is that some hydrogen gets given off at some places and at others, the oxygen combines with iron – to produce RUST!!

Complex process

The actual process of millions of electric cells getting active at the surface of iron in contact with water, and carrying out this electro-chemical reaction is highly complex and has been studied by different groups over years. The Grenoble scientists took a close and continuous look at what took place at the surface of a single-crystal of a copper and gold alloy, which undergoes ***electro-chemical degradation***, ie, rusting, in the presence of sulphuric acid.

This week's *Nature* reports how the scientists observed the minute, nanometer-scale action with the help of interference patterns of X Rays getting scattered by the crystal. The result has been a detailed picture of what parts of a bit of a metal get affected first, how that part protects other parts, when the protection breaks down, the effect of the crystal structure and the relation of each of the metals involved with each other – a virtual rule book of how mounds and platforms can form, to create, in the process, a complex and porous rabbit's warren matrix of the metal!

The benefit of creating such small dimension porosity in metals is that the total exposed surface area of a piece of the metal can be increased thousands of times. This could increase the effectiveness of catalysts, which speed up chemical reactions, for instance, or generally increase the speed of things that depend on the area exposed. Even car batteries, for instance. Study of the process of rusting is hence showing the way to make industrial processes more efficient!

To make use of crystal-level electro-chemical processes is to apply nano-technology through knowing the process, rather than actually handling things are the microscopic level.

A villain put to serve

It is estimated that the loss caused by rusting is around 3% of the GDP of the world. Apart from the cost of assets made of iron or steel (mostly) actually lost, there is the huge cost incurred to save things from rusting. All the paint that is used on the hulls of ships, on bridges, building facades, railway wagons and carriages, motor cars, all iron or steel things that we use – all add to the cost we have to bear.

The same rusting process appears to be compensating, in part, for the damage it does by providing industry with a way to manipulate materials at microscopic levels.