Oxygen buster and other stories

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One of the items that arrived with the Christmas goodies was a pack of Canterbury Biltong Air-dried Beef Snacks. Apart from the tasty snacks, the pack included a sachet labelled "O-Buster" oxygen absorber. It was obviously included to absorb oxygen and, along with the drying of the meat, further minimise the risk of the product spoiling. But what did it contain? A quick check on Google and Wikipedia indicated the most likely composition of the sachet contents to be iron and sodium chloride, with maybe some activated charcoal. In other words, the oxygen content of the pack was being reduced by rusting as air and moisture permeate in. According to the website, the mix requires a relative humidity of 65% before rusting can take place and can reduce the level of oxygen in the surrounding atmosphere to 0.1%. The advantage of the iron/sodium chloride mix over other technologies is that it is cheap, there are no odours and it is food safe.

Beef snacks with a sachet of "O-Buster" oxygen absorber

Hand warmers

This reminded me of hand warmers that have a very similar technology. One type of hand warmer comes in a sealed plastic pouch. Inside is a porous sachet rather like a tea bag. After gentle shaking to mix the contents and allow air in, the temperature increases and the bag becomes quite warm and stays that way for an hour or more. The contents have been optimised to make the strongly exothermic rusting process take place as fast as possible; finely divided iron, salt, powdered carbon and vermiculite which has absorbed water. The only reactant missing is oxygen which is available once the sachet is removed from the sealed bag and shaken.

If the equation

$$4Fe_{(s)} + 3O_{2(g)} + nH_2O \rightarrow 2Fe_2O_3.(H_2O)_n$$

is used to represent rusting, ΔH for the process is –1648 kJ mol^{-1}. Rusting is normally so slow that this energy is dissipated as fast as it is released but under the conditions in the hand warmer the exothermic nature of the reaction is very apparent. The reaction can be temporarily halted by sealing the sachet in a self-lock plastic bag that has been smoothed, prior to locking, to remove as much air as possible.

Fencing wire

While on the topic of rusting, there is an interesting sequence in the development of fencing wire. Originally "pure" iron wire, which does not rust, was used. Sadly, a strand of wire stretched taut in summer contracted in the cold temperatures of winter and pulled the corner posts in. The next summer they expanded again, and sagged in loose loops. This was solved by using steel wire that has a much lower coefficient of expansion. But steel wire rusts and, after a season or two, weakens to the extent that animals could break it down and get out. This was solved by galvanising the steel wire and we had the ubiquitous No. 8 wire - the symbol of New Zealand ingenuity and mainstay of the farming industry.

How thick is the zinc coating?

A colleague of mine developed an elegant experiment in which an accurately weighed 3 cm square of galvanised iron sheet is dissolved in dilute hydrochloric acid. The zinc dissolves readily but under these conditions the iron is passive. Once the reaction is complete (and it is obvious when it is – no more bubbles and a uniform appearance on both sides of the metal) the square is removed, rinsed, dried and reweighed. The difference in mass gives the mass of zinc coating which is typically about 0.32 g. Using the mass and density of zinc (7.14 g cm^{-3}) the volume of zinc is calculated. Dividing the volume by the area (remember there is zinc on both sides) the thickness is calculated at 0.0025 cm. Taking the diameter of a zinc atom as 3.06 ´ 10^{-8} cm shows the layer is approximately 82,000 atoms of zinc thick.

Bluing

If the square of iron with zinc removed is heated strongly a blue coating forms. This is a coating of Fe_3O_4 which adheres to the iron and protects it from corrosion in the same way as aluminium oxide protects aluminium. It is a totally different process to rusting which is an electrochemical process unique to iron. Rusting creates a significant increase in volume and flakes off. Bluing is commonly used for protecting rifle barrels from corrosion. Commercially and industrially there are various techniques for bluing. In one, the items are heated in a solution of potassium nitrate and sodium hydroxide reaching temperatures of 135 °C to 154 °C (which indicates pretty concentrated solutions). Historically razor blades were blued, a necessity as they were constantly wet when in use. An interesting property of blued steel is that it has a non-linear resistance and World War II soldiers found they could utilise this feature and use razor blades as the detector in crystal sets.

References

http://en.wikipedia.org/wiki/Oxygen_scavenger

http://en.wikipedia.org/wiki/Hand_warmer

http://en.wikipedia.org/wiki/Bluing_(steel)