

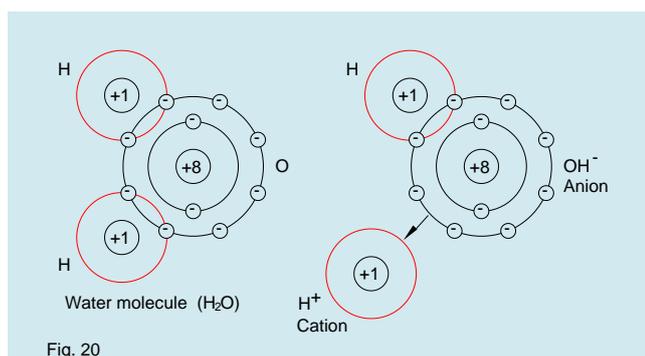


10 Fundamental Terms of Corrosion

1. Electrolytic Dissociation

In aqueous solutions like acids, bases and sulphates, their molecules are partially dissolved in electrically loaded, free-moving particles – ions. These solutions are called electrolytes. The process itself is known as electrolytic dissociation. Due to the positive ions (cations) and negative ions (anions), the solutions can conduct electricity and facilitate the electrochemical corrosion of “non-precious” metals.

However, dissociation also occurs in pure water. In this case too, although to a lesser extent, water molecules disintegrate into ions, that is to say, hydrogen ions (H^+) and hydroxyl ions (OH^-).



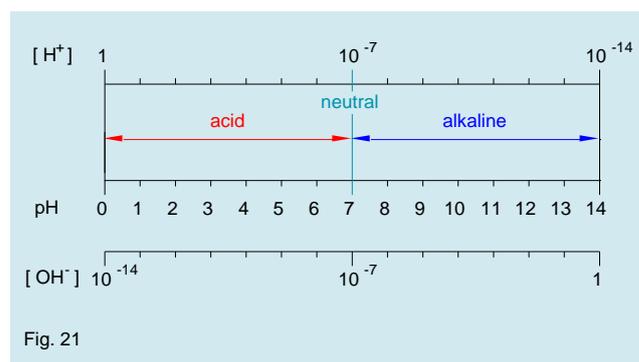
The experimental concentration in pure water is $[H^+] = 10^{-7}$ and $[OH^-] = 10^{-7}$ mol/l. Positive and negative charges are balanced; such water is defined as neutral. However, it would be wrong to assume that there is no corrosion in neutral water; this will be shown later.

Older but more illustrative is definition 1 mol of a substance in a chemical compound of as many grams as the relative molecules mass (molecular weight). 1 mol Water (H_2O) is $2 + 16 = 18$ g. In 10000000 litres pure water, only 18 g of water is split in 1 g H^+ and 17 g OH^- ions.

The ion product in pure water is $10^{-7} \times 10^{-7} = 10^{-14}$. This product remains constant also in aqueous solutions. If the concentration of $[H^+]$ ions increases by adding an acid, the concentration of $[OH^-]$ ions decreases and vice versa.

2. The pH Value

The constant ion product, also known as dissociation constant, makes it possible to define the reaction of an aqueous solution by providing only $[H^+]$ concentration. For practical reasons, instead of 10^{-7} ; 10^{-6} et cetera, the exponents with positive algebraic signs are used 7; 6 etc. The so changed number is called “hydrogen exponent” or abbreviated “pH value”.



The increase in temperature also leads to a higher dissociation and a higher dissociation constant. At the temperature of e.g. $115^\circ C$, a tenfold number of H_2O molecules are dissolved into ions. Thus, in pure water the concentration of $[H^+]$ and $[OH^-]$ ions is 10^{-6} mol/l. The dissociation constant increases to 10^{-12} and the neutral pH value to $pH = 6$. This is why the measurement of a pH value must be accompanied by a temperature measurement.

3. Acid Corrosion

This is an electro-chemical process as it occurs in its most known form between metals immersed in an electrolyte, with metals being connected to each other. From the less noble metal, anode, metal atoms dissolve leaving electrons as positive ions. At the same time, on the other electrode, electrons are driven to the positive hydrogen ions. A special feature of this corrosion is the building up of hydrogen on the cathode. This type of corrosion is also known as hydrogen corrosion. The dissolution of metals and thus of the material always occurs in the electrode whose capacity is lower than the capacity of hydrogen. This electrode becomes anode. The cathode having a higher potential remains protected from corrosion.

In this procedure, there were 2 electrodes of different metals. Acid corrosion can also occur if there is only one metal in a solution. In such a case, destruction can be attributed to local elements. The creation of elements is due to certain non-homogeneity of metal surfaces that are also the cause of potential differences.



The outside appearance of an acid corrosion is almost always the same, namely, a homogenous erosion of the material on the surface. In case of materials with an inhomogeneous composition, a selective corrosion might occur. This corrosion attacks only one component of the alloy, and does not affect the others. A good example of this is the spongiosis of cast iron. In such corrosion, the graphite has the function of a cathode while cast iron is dissolved anodically. The graphite network becomes very soft so that it can be abraded even by a simple knife.

4. Oxygen Corrosion

The acid corrosion dealt with in the last section occurs in a "pure" form only if the delivery liquid contains no air, something that is possible only with great technological efforts and costs. In general, liquids contain oxygen. In such cases, another chemical reaction takes place. On a cathode, it is not hydrogen but oxygen ions that are receiving electrons. The oxygen ions take on electrons and create hydroxyl ions that cannot continue to exist but combine themselves with water molecules to create hydroxyl ions:



The resulting potential is considerably higher than the potential resulting from a hydrogen corrosion; in this case even metals are attacked that were not attacked by an acid corrosion. However, these explanations should not lead to the conclusion that the presence of oxygen is detrimental in every case. On the contrary, in pump plants, the presence of oxygen prevents corrosion, as we will see later.

5. Salts

If an acid is mixed with a base, free $[\text{H}^+]$ ions of the acids combine with the free $[\text{OH}^-]$ ions of the base to create unionized water (H_2O), they become neutral. At the same time, the acid rest creates a neutral salt with the base rest. This contains neither $[\text{H}^+]$ ions nor $[\text{OH}^-]$ ions, and it does not release any. In general, salts show neither acid nor alkaline reaction, they are neutral.

With a certain composition, however, they can promote corrosion.

6. Carbonic Acid

Carbonic acid leads to an increase in $[\text{H}^+]$ ion concentration and thus to a hydrogen corrosion. All natural waters contain carbonic acid (CO_2) in a bound or free form. In the case of ground water, the purpose of free carbonic acid is to keep calcium bicarbonate ($\text{Ca}(\text{HCO}_3)_2$) dissolved. It is only the free carbonic acid that is aggressive.

If the concentration of free carbonic acid is reduced, e.g. through heating, to an extent that the balance between carbonate density and pertaining CO_2 does not exist anymore, by leaving half of the bound carbonic acid, calcium carbonate turns into calcium carbonate that is hardly soluble in water and thus mainly falls out. The result is unwanted sedimentations.

7. Special Forms of Corrosion

a) In case of carbonic acid corruptions in neutral and especially in alkaline areas, there is the so-called pitting corrosion. This occurs also in case of ferrous material, especially stainless steel if the delivery water contains a high level of chloride ions. This is why the pitting corrosion can be fatal, given that housings and pipes can be destroyed by a low amount of corrosion within a very short period of time.

b) Narrow gaps are touched by fluid without a flow occurring. These gaps are exposed to the danger of crevice corrosion. The occurring destruction is mainly due to the effects of oxygen. The cause is different ventilation in and outside of the gap. It is primarily the spots to which oxygen has no access that are attacked. Stainless steel is particularly endangered by this.

c) If the delivered material contains sanding elements, at a sufficient speed of delivery, metal surfaces will be mechanically abraded by all-solids. This process is known as erosion. In many cases corrosion will follow. Such a combination of erosion and corrosion is defined as erosion – corrosion. Metal is abraded very quickly and often shallow pits will appear. A corrosion connected to a cavitation has a different appearance. In that case, metal's surface is covered with scratches and gaps.