Research Interests

High temperature corrosion in molten salts (“hot corrosion”) and aqueous corrosion have some features in common, e.g., both typically involve the oxidation of metal as the predominant corrosion reaction, and both typically involve an electrolyte environment. However, the differences between them are profound and have tended to separate, rather than join, the two disciplines. High temperature molten salts, such as alkali sulfates and chlorides, are aggressive to most materials that might be considered for constructing and containing experiments, including most alloys, ceramics and glasses. This factor continues to be a challenge in the design of elegant hot corrosion experiments. Unlike most aqueous corrosion experiments, most molten salts of interest to hot corrosion interact strongly with the gaseous environment. Therefore, for experiments in which an understanding of the corrosion processes is the goal, it is imperative to carefully control the gas composition, which in turn, controls the salt composition. The oxidant in hot corrosion can be either a component of the gas environment or a salt species, and this leads to quite different corrosion processes due to a thin film of salt compared to the same salt present as a deep melt. Similar considerations also apply to aqueous corrosion due to a thin film of solution compared to a deep solution. Perhaps the most profound differences between hot corrosion and aqueous corrosion are concerned with the physical and transport properties of the corrosion products. Rarely are the corrosion products (which are most often oxides) soluble in the salt and very rarely do they form a passive film. This means that the product layer typically is porous and is permeated with salt. Consequently, the salt within the product layer is exposed to a strong chemical potential gradient, leading to a range of compositions across the thickness of the corrosion product layer, and even to different phases near the metal surface compared to the external surface. The higher temperature also means transport is rapid, leading to a fast rates of oxidation. In alloys where one or two components comprise the majority of the corrosion product, diffusion within the alloy leads to a depletion zone just below the corrosion product layer, and this can affect the local corrosion reactions. Such a depletion zone is rarely, if ever, observed in aqueous corrosion.

One area of research interest where the perceptions alluded to above have been applied are corrosion processes in fuel cells, including high temperature fuel cells, such as the molten carbonate and solid oxide fuel cells, and also aqueous corrosion in PEM fuel cells. Another area of interest is the corrosion of medical implant alloys, especially in cases where the issue is not damage to the physical integrity of the implanted device, but rather the release of potentially toxic soluble corrosion products. In these cases relatively slow corrosion rates may impose a limitation on the use of the device.

Selected Publications


