Polymeric Materials

Polymers are complex molecules formed by chains of duplicated groups of atoms (monomers); these groups are typically linked by covalent bonds along a “backbone” of carbon or silicon atoms. Important polymeric materials related to corrosion include plastics and synthetic rubbers (elastomers).

Production and utilization of polymeric materials have increased tremendously during the past 50 years. These materials are now available in a great variety of forms and can be produced by a multitude of processes, such as casting, molding, extrusion, and calendering. They are available as solid parts, linings, coatings, foams, fibers, and films.

When compared with metals, polymeric materials tend to be more resistant to chloride ions and hydrochloric acid (HCl). However, polymeric materials are generally weaker, softer, less resistant to concentrated sulfuric and oxidizing acids (e.g., nitric), less resistant to solvents, and subject to temperature limitations. Cold flow, or creep, at ambient temperatures is a problem, particularly with thermoplastics.

Polymeric materials do not generally dissolve like metals. Degradation or corrosion occurs from three basic mechanisms:

- Some active species from an environment can be absorbed into the polymer and swell or react internally with the polymer chains. Softening and distortion normally develop, although actual loss of weight from the polymer can occur.
- Oxidation of the resinous molecule can occur in the atmosphere or other oxidizing conditions. This often results in hardening and cracking of the polymer.
- Continued polymerization of the resin can also occur with certain resinous components, resulting in hardening, shrinkage, and cracking of the material.

The important aspect of the corrosion mechanism is that degradation is not a surface effect but occurs internally in a polymer. The intrinsic problem with polymers, to their ultimate detriment, is their capability of selectively absorbing parts per million of organic species from industrial waste water. For example, traces of chlorinated solvents or aromatic hydrocarbons will ultimately attack many elastomers; and polypropylene has been destroyed by accumulations of sorbic acid. In industrial wastes, the polymeric material selected should be resistant to a 100% concentration of any contained organic species from industrial waste water. For example, traces of chlorinated solvents or aromatic hydrocarbons will ultimately attack many elastomers; and polypropylene has been destroyed by accumulations of sorbic acid. In industrial wastes, the polymeric material selected should be resistant to a 100% concentration of any contained organic species from industrial waste water.

Polymeric materials are inherently resistant to natural waters, typically to about 80 °C, or within their inherent temperature and pressure limitations. The selection of materials may start with solid polymeric material (e.g., polypropylene, polyethylene, or polyvinyl chloride), then move to the reinforced polymers (e.g., fiberglass-reinforced polymer), and then to polymer-lined steel (e.g., polypropylene-lined steel pipe).

The selection of polymeric materials, including elastomeric materials, should be based on a thorough evaluation of the functional requirements for the specific application. Dependent upon application, properties to be documented and included in the evaluation are as follows:

- Thermal stability and aging resistance at specified service temperature and environment
- Physical and mechanical properties
- Thermal expansion
- Swelling and shrinking by gas and by liquid absorption
- Gas and liquid diffusion
- Decompression resistance in high-pressure oil/gas systems
- Chemical resistance
- Control of manufacturing process

All important properties relevant for the design, area, type of application, and design life should be thoroughly documented, including results from relevant and independently verified tests, and/or confirmed successful experience in similar design, operational, and environmental situations.

The chemistry and compounding of polymeric materials are quite complex and information is not readily available to consumers because of proprietary limitations. The best procedure is to discuss the situation at hand with suppliers to obtain the proper material for a given problem. If corrosion testing is involved, it is imperative that the specimens be representative of the actual installation. Furthermore, if coating or lining of components is involved, adhesion must be evaluated, as bond failure is sometimes the primary cause of unsatisfactory performance.

This article is adapted by MP Editorial Advisory Board Member Norm Moriber from Corrosion Basics—An Introduction, Second Edition, Pierre R. Roberge, ed. (Houston, TX: NACE International, 2006), pp. 333-334. MP