Non-Toxic Corrosion Inhibitor for Ammonia-Water Absorption Heat Pumps

The Challenge
Ammonia-water absorption heat pumps offer high heating and cooling efficiencies without the use of refrigerants that are harmful to the environment. In addition, gas-fired absorption systems reduce electrical demand and provide an economic benefit for the user by avoiding the electrical peak demand charges associated with running electrically powered vapor-compression systems. Traditionally, chromate based inhibitors, such as sodium chromate or dichromate, have been used in ammonia-water absorption systems. However, chromates are highly toxic and environmentally harmful, and their use is being phased out in many localities. In addition, chromates are known to react with ammonia at temperatures greater than about 170°C, resulting in the loss of refrigerant, the generation of non-condensible nitrogen gas, and the loss of inhibitor. Advanced absorption heat pumps such as the Generator-Absorber heat eXchange (GAX) cycle operate at peak temperatures on the order of 200°C, so an alternative corrosion inhibitor is required to make advanced absorption practical and marketable. Such an inhibitor, or inhibition strategy, must match the lower-temperature effectiveness of chromates for practicality, and be non-toxic for marketability.

Our Approach
Rare Earth Metal Salts (REMS) have been demonstrated to be effective corrosion inhibitors for aluminum alloys, and have been used as replacements for chromate based inhibitors and protective coatings. AMTI has pioneered the application of non-toxic REMS compounds as corrosion inhibitors for steel in ammonia-water absorption heat pumps. Our approach is to form a cerium based protective coating on the wetted surfaces of high temperature components, and to use a cerium based solution inhibitor, as well as pH adjustment, to protect steel surfaces in lower temperature regions of an absorption heat pump. The protective coating is formed using a simple, low-temperature process prior to charging the system with the ammonia-water working fluid.

The Results
Testing our approach in a high-temperature apparatus designed to simulate the range of temperatures and ammonia concentrations found in the generator component of typical GAX cycles resulted in no significant indication of corrosion, and a rate of non-condensible gas generation about one third as great as that of a baseline test using sodium chromate as an inhibitor. Analysis of non-condensible gas from the cerium protected test showed it to be the result of the thermal breakdown of ammonia, whereas gas from the chromate inhibited test was found to be a result of ammonia breakdown by chromate plus thermal breakdown. This proprietary process was developed with funding from the U.S. Department of Energy, and is available for license from AMTI.