Consolidative Reduction of Lead Objects

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Object

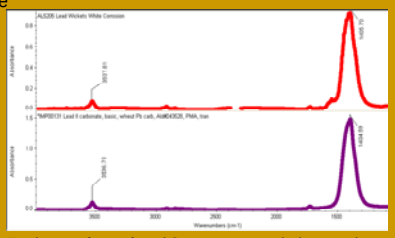
• Table top croquet game (American, 1880-1900) – contains wood, textile and metal game components stored within original pine wood box

• **Wickets**: lead feet cast onto ferrous wire. The wicket feet are actively corroding.

Compartment for lead wickets

Ferrous wire

Lead feet



Fourier-transform Infrared Spectroscopy analysis: corrosion product from lead wickets (above) and reference spectra for basic lead carbonate (below)

Corrosion:

• Wood and wood products off-gas organic acid vapors such as acetic and formic acid. In the presence of these vapors, the passive oxide layer will be replaced by a powdery, loosely adhered corrosion layer: basic lead carbonate.

• **Power Supply** – Heathkit IP27 with alternating current to propel the redox reaction

• **Cathode** (working electrode) – the wicket feet, wrapped in lead foil – reduced, or receives electrons

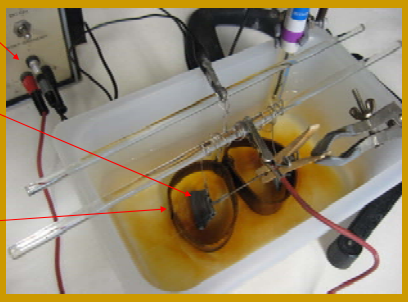
• **Anode** (counter electrode) – stainless steel plates shaped into rings to surround the lead feet – oxidized, or donates electrons.

• **Electrolyte** – .5M sodium sulfate –allows for the flow of ions between anode and cathode

•**Voltage** – 2.3V-2.4V

• **Current** – less than 200mA

Treatment



• Connection wires link anode and cathode to the power supply. Stainless steel wire links the anode and cathode to the connection wires.

• To prevent corrosion, the ferrous wire component of the wicket was coated with 10% B-48N in acetone. The portion submerged in the electrolyte was further coated with Museum Wax. Breaks and cracks in the lead feet where ferrous wire was exposed were also covered with wax.

Consolidative Reduction

Uses:

• Objects with surfaces that need to be preserved

• Metals predominantly transformed into corrosion products

Method

• Corrosion products are converted back to metal through the transfer of electrons from another metal with a lower electrode potential (reduction).

• Low voltage and current enables gentle reduction process and prevents aggressive removal of corrosion through evolution of hydrogen bubbles

Research and Testing

• Lead wicket mock-ups created and artificially corroded in the presence of acetic acid then tested for consolidative reduction using either sulfuric acid or sodium sulfate electrolyte

• Sodium sulfate selected as the most appropriate electrolyte

•Advantages: least corrosive to the lead, should the electrical circuit be interrupted, and least toxic to handle.

•Disadvantages: corrodes the stainless steel anode, necessitating frequent changes of electrolyte

Results

Wax on ferrous wire

Before reduction

After 6.5 hours

After 13 hours

After 20.5 hours

• Corrosion was fully reduced on the lead feet, resulting in a stable surface that is darker and slightly porous.

Before reduction

After reduction

• The wickets will all be coated with Renaissance wax (Cosmolloid 80 hard and BASF A waxes) to prevent future corrosion

• The compartment in the pine box was lined with Alpharag Artcare matboard which contains zeolites that will absorb volatile organic acids

Acknowledgements

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