Corrosion and Material Compatibility with Klozur® Persulfate

BACKGROUND

Klozur® Persulfate is a popular technology used to treat contaminated soil and groundwater. It has a long history of effectively treating a wide range of organic contaminants. As Klozur Persulfate is a very strong oxidant, and its solutions may become very acidic (pH ≤ 2), persulfate solutions may result in a corrosive environment for many metals and materials. In addition, Klozur Persulfate is often applied using alkaline activation, with conditions of greater than pH 10.5. This Technical Bulletin presents the results from corrosion studies using persulfate and activated persulfate solutions and provides guidance regarding potential materials of compatibility. For additional information regarding the safety of Klozur Persulfate, please refer to the Safety Data Sheet (SDS), available from PeroxyChem.

CORROSION

Laboratory tests were conducted to evaluate the performance of commonly-used engineering materials exposed to Klozur persulfate solutions. The tests were performed at two different persulfate solution concentrations: 20 wt% intended to represent typical make-up solution being injected, and 40 g / L representing typical in situ ground water concentrations. These tests were conducted per the guidelines outlined in ASTM G31-72.

Corrosion rates for metallic coupons were calculated based on changes in weight over the exposure time. Non-metallic coupons were observed for visual changes and changes in physical properties. Structural properties of concrete and non-metallics were not measured.

RESULTS

For Klozur persulfate-only solutions (without an added activator), no observable corrosion on stainless steel (304L and 316L) was observed during the testing. However, severe corrosion was observed for carbon steel, copper and brass, shortly after the testing was initiated, for both the concentrated (20 wt%) and 40 g/L persulfate solutions. The corrosion rates for carbon steel and brass were observed to decrease when evaluated after one and two months as compared to the one week exposure. The rates were sufficiently high to indicate that general corrosion was ongoing throughout the two month period. Polyvinylidene fluoride (PVDF) and fiber reinforced plastic (FRP) demonstrated satisfactory performance over the one month exposure with no noticeable weight gain or softening observed. Concrete, natural rubber and synthetic rubber also showed indications of degradation with long-term exposure to the persulfate-only solutions.

In general, the test results of the Fe-EDTA activated persulfate solution was similar to those of the persulfate-only solution. No significant increases in corrosion were observed due to the presence of the activator system or subsequent formation of sulfate radicals.

For alkaline activated persulfate solutions, sodium hydroxide was added to raise the pH to above 10 and to neutralize sulfuric acid formed upon persulfate decomposition. Significant decreases in corrosion rates were observed for high pH activated persulfate in contact with copper, brass and carbon steel. Negligible corrosion was observed for these metals after one month exposure for both concentrations of persulfate. In addition, no noticeable corrosion was observed for stainless steel. Significant weight gain (5 – 10%) and bleaching were observed for the concrete after one month exposure to the high pH activated persulfate solution, and some dissolution of the concrete was noted during the test.

Table 1: Results for 20 wt% Klozur Persulfate-Only Solutions at Room Temperature After 1 Week and 1 Months Exposure Time

mpy – milli-inches per year; ✓- compatible material, Θ - non-compatible material

Material	1 week	1 month	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 2 months
Copper Brass	> 100 mpy Θ	20 – 50 mpy Θ	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 200 mpy Θ	50 – 100 mpy Θ	Severe general corrosion, etching at welds, corrosion rate decreases with time.
PVDF	✓	✓	No noticeable changes after 2 months exposure
FRP	✓	✓	No noticeable changes after 2 months exposure
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Increasing weight gain over time. Some dissolution observed as residue in test chamber.
Natural Rubber	Slight weight gain	Slight weight gain	Cracks and blisters observed after 1 month exposure
Synthetic rubber (neoprene)	Slight weight gain	Slight weight gain	Cracks and blisters observed after 1 month exposure

Table 2: Results for Klozur Persulfate-Only Solutions (40 g / L) at Room Temperature After 1 Week and 2 Months Exposure Time

mpy – milli-inches per year; ✓- compatible material, Θ - non-compatible material

Material	1 week	1 month	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 2 months
Copper Brass	> 50 mpy Θ	< 20 mpy Θ	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 50 mpy Θ	< 20 mpy Θ	Several general corrosion, etching at welds, corrosion rate decreases with time.
PVDF	✓	✓	No noticeable changes after 1 month exposure
FRP	✓	✓	No noticeable changes after 1 month exposure
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Increasing weight gain over time. Some dissolution observed as residue in test chamber.
Natural Rubber	Slight weight gain	Slight weight gain	
Synthetic rubber (neoprene)	Slight weight gain	Slight weight gain	

Table 3: Results for Fe-EDTA Klozur Persulfate Solutions, 20 wt% and 40 g / L at Room Temperature After 1 Month Exposure Time

mpy – milli-inches per year; ✓- compatible material, Θ - non-compatible material

Material	20 wt% concentration	40 g / L	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 1 month
Copper Brass	20 – 50 mpy Θ	< 20 mpy Θ	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 50 mpy Θ	20 – 50 mpy Θ	Several general corrosion, etching at welds.
PVDF	✓	✓	No noticeable changes after 1 month exposure
FRP	✓	✓	No noticeable changes after 1 month exposure
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Increasing weight gain over time. Some dissolution observed as residue in test chamber.
Natural Rubber	Slight weight gain	Slight weight gain	
Synthetic rubber (neoprene)	Slight weight gain	Slight weight gain	

Table 4: Results for Alkaline Activated Klozur Persulfate Solutions, 20 wt% and 40 g / L at Room Temperature After 1 Month Exposure Time

mpy – milli-inches per year; ✓- compatible material, Θ - non-compatible material

Material	20 wt% concentration	40 g / L	Comments
Stainless steels (304L, 316L)	✓	✓	< 1 mpy. No noticeable corrosion over 1 month
Copper Brass	✓	✓	Negligible general corrosion (< 2 mpy). Black film formation observed.
Carbon steel	✓	✓	Negligible general corrosion (< 2 mpy). Isolated rust spots observed
Concrete	Weight gain, bleached appearance	Weight gain (5 –10%), bleached appearance	Bleached appearance, increasing weight gain over time, some dissolution observed as residue in test container.

MATERIAL COMPATABILITY WITH KLOZUR SODIUM PERSULFATE SOLUTIONS

Recommend and Compatible Materials:

- Butyl rubber
- EPDM
- Fiber Reinforced Plastic (FRP)
- Glass
- Neoprene
- Polymethyl methacrylate (PMMA)
- Polyethylene
- PVC
- Stainless steel (304L and 316L) for all mixing, conveyance and storage equipment
- Polytetrafluoroethylene (PTFE)
- Viton®

Incompatible Materials:

- Aluminum
- Carbon steel
- Galvanized pipe
- Monel
- Nitrile rubbers
- Brass
- Copper
- Iron
- Nickel

GENERAL GUIDANCE

It is recommended that all wetted parts and any other equipment or material that may come in contact with the Klozur Persulfate solution be evaluated to ensure they are chemically compatible with the reagents at concentrations with which they could contact. Wetted parts typically include any part of the injection or batching equipment that may come in contact with the Klozur Persulfate solution including pumps, flow meters, pressure gauges, pipes, fittings, adhesives, joint sealant, gaskets, hoses, valves, disconnects, well heads, injection tooling, injection wells, mixing devices, and tanks among others.

SPECIFIC GUIDANCE

Well Construction:

- Use compatible materials, such as PVC or Stainless Steel (304L, 316L)

Pumps:

- Check compatibility of all wetted parts including all seals, diaphragms, gaskets, tubing and hoses

Direct Push Rods:

- Direct Push Rods are typically made from carbon steel. Carbon steel was observed to react with persulfate-only and FeEDTA activated persulfate. Even when alkaline activated persulfate is used, the rods should be inspected frequently.
- Threaded joints of rods can be susceptible to corrosion. To help reduce corrosion, several practical measures can be taken, such as applying a chemically compatible barrier layer, such as a PTFE or other chemically compatible grease to the threads. Threaded joints should be inspected frequently during operation.

Subsurface Utilities:

- Always identify and check for location of subsurface utilities prior to applying Klozur Persulfate.
- Make certain that either the subsurface utilities would not be contacted by the Klozur Persulfate solution or that all parts that may be contacted by the Klozur Persulfate solution are chemically compatible. These could include pipe, gaskets, bolts, straps, supports, and sacrificial anodes.

Fittings:

- 304 Stainless – Schedule 40
- CPVC – Schedule 80 preferred (could lose strength when heated)
- PVC (may become embrittled with extended use)