



# Environmental Solutions

---



## Corrosion and Material Compatibility

Technical Bulletin

### Background

Klozur<sup>®</sup> Persulfate solutions are used to treat contaminated soil and groundwater and can remediate a wide range of organic contaminants. However, Klozur<sup>®</sup> Persulfate is a very strong oxidant, and its solutions may be very acidic ( $\text{pH} \leq 2$ ) under many conditions, resulting in a corrosive environment for many metals and materials. In this bulletin, results from corrosion studies using un-activated and activated persulfate solutions are presented and recommendations regarding materials of compatibility are made. For additional information regarding the safety of Klozur<sup>®</sup> Persulfate, please refer to the Material Safety Data Sheet (MSDS), which is available from FMC.

### Corrosion

Laboratory tests were conducted to evaluate the performance of commonly-used engineering materials exposed to Klozur<sup>®</sup> Persulfate solutions (both activated and un-activated). The tests were performed at two different persulfate solution concentrations: 20 wt% representing typical make-up solutions 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 un-activated Klozur<sup>®</sup> Persulfate solutions, no observable corrosion on stainless steel (304L and 316L) was observed during the testing. However, for carbon steel, copper and brass, severe corrosion was observed shortly after the testing was initiated, for both the concentrated (20 wt%) and diluted 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. However, the rates were sufficiently high to indicate that general corrosion was on-going throughout the two month period, indicating that there was no formation of a protective corrosion-product layer. Kynar<sup>®</sup> and FRP demonstrated satisfactory performance over the one month exposure with no noticeable weight gain or softening observed. Concrete, natural rubber and synthetic rubber showed indications of degradation with long-term exposure to the concentrated persulfate solution.

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

For high pH 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, even at the 20% persulfate concentration. In addition, no noticeable corrosion was observed for stainless steel. Significant reaction with concrete was observed, however. Significant weight gain (5 – 10%) and bleaching were observed for the concrete after one month exposure to the



# Environmental Solutions

high pH activated persulfate solution, and some dissolution of the concrete was noted during the test.

**Table 1: Results for Un-Activated Klozur® Persulfate Solutions (20 wt%) at room temperature after 1 week and 1 months exposure time**

mpy – milli-inches per year; ✓ - compatible material, ⊖ - 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 ⊖	20 – 50 mpy ⊖	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 200 mpy ⊖	50 – 100 mpy ⊖	Severe general corrosion, etching at welds, corrosion rate decreases with time.
Kynar® (PVDF)	✓	✓	No noticeable changes after 2 months exposure
FRP (fiber-reinforced plastic)	✓	✓	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 Un-Activated Klozur® Persulfate Solution (40 g / L) at room temperature after 1 week and 2 months exposure time**

mpy – milli-inches per year; ✓ - compatible material, ⊖ - 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 ⊖	< 20 mpy ⊖	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 50 mpy ⊖	< 20 mpy ⊖	Several general corrosion, etching at welds, corrosion rate decreases with time.
Kynar® (PVDF)	✓	✓	No noticeable changes after 1 month exposure
FRP (fiber-reinforced plastic)	✓	✓	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.



# Environmental Solutions

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, ⊖ - 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 ⊖	< 20 mpy ⊖	Severe general corrosion, corrosion rate decreases with time.
Carbon steel	> 50 mpy ⊖	20 - 50 mpy ⊖	Several general corrosion, etching at welds.
Kynar® (PVDF)	✓	✓	No noticeable changes after 1 month exposure
FRP (fiber-reinforced plastic)	✓	✓	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 high pH activate Klozur® Persulfate Solutions, 20 wt% and 40 g / L at room temperature after 1 month exposure time**

mpy – milli-inches per year; ✓ - compatible material, ⊖ - 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.



# Environmental Solutions

---

## Material Compatibility

Recommend and Compatible Materials:

- Butyl rubber
- EPDM
- FRP (fiber reinforced plastic)
- Glass
- Neoprene
- Plexiglas®
- Polyethylene
- PVC
- Stainless steel (304L and 316L) for all mixing, conveyance and storage equipment
- Teflon®
- Viton

Incompatible Materials

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

Well Construction

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

Pumps

- Check compatibility of all seals, gaskets, tubing and hoses

Geoprobe® Rods

- Threaded joints of rods are very susceptible to corrosion. To help reduce corrosion, several practical measures can be taken, such as applying a barrier layer like Loctite® or Teflon® grease to the threads, or utilizing the High pH activation system to reduce acidic corrosion.

Subsurface Utilities

- Always check for location and compatibility of subsurface utilities.

Hosing

- Klozur® persulfate solutions: 20 – 40%, neutral to mildly acidic conditions, moderate to low pressure

### Master-Flex 300 EPDM or Equivalent

<u>Specs</u> (diameter)	<u>Max Allowable Working Pressure</u> (PSI)
1"	80
2"	60
3"	50
4"	45
6"	35



# Environmental Solutions

---

- – 30 F to +140 F
- EPDM black inner liner of hosing with polyethylene helix
- Reinforced and a Type G (PVC) cover
- Medium oil resistance
  
- Klozur<sup>®</sup> persulfate solutions: 20 – 40%, mildly acidic conditions, high pressure
  - Alfagomma** (Italian Company)
    - Model T 505 4-4 SP
    - 6 BAF (240 PSI)
    - XLPE chemical S&D
  - Transporter Ultrachem** (brand name)
    - 250 PSI water pressure
  
- Fittings
  - 304 Stainless – Schedule 40
  - CPVC – Schedule 80 preferred (could lose strength when heated)
  - PVC (may become embrittled with continued use)