Chemical Oxidation Treatment of Transformer Oils that Contain Antioxidant Di-tert-butyl-para-cresol (DBPC)

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BACKGROUND/OBJECTIVES

Transformer oil is used as insulating and heat transfer media in the electrical industry. The oil is manufactured from a specific range of lubricating base oil to attain the physical and chemical properties to perform its functions. Transformer oil is composed of aromatic, paraffinic and naphthenic hydrocarbons.

DBPC (also known as butylated hydroxytoluene BHT) is used as a food and fuel additive for its antioxidant properties. This compound behaves as a synthetic analog of vitamin E. It converts peroxy radicals to hydroperoxides by donating a hydrogen atom. Each molecule of DBPC consumes two peroxy radicals.

In order to understand how releases of transformer oil that contains DBPC can be treated, a study was performed using sand and limestone spiked with high and low transformer oil concentrations and high and low DBPC concentrations. In situ chemical oxidation (ISCO) was tested on the spiked sand and limestone samples to test its effectiveness on transformer oils and DBPC. DBPC will absorb free radicals generated by the oxidant, therefore the oxidant dose delivered had to be high enough to overcome the neutralization by DBPC.

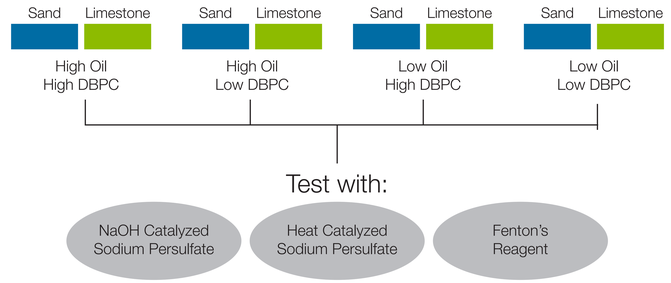
INITIAL CHARACTERIZATION

Parameters	Units	Oil Sample #1	Oil Sample #2
DBPC	mg/kg	3520	127

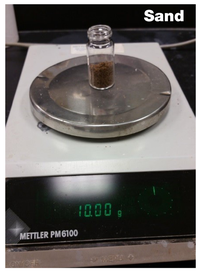
APPROACH/ACTIVITIES

A laboratory treatability study was performed to test the effectiveness of chemical oxidation treatment of transformer oils and DBPC. Batch microcosm tests were set up using spiked sand and limestone samples and different oxidant solution including hydrogen peroxide with ferrous sulfate as a catalyst, sodium persulfate with sodium hydroxide (NaOH) as a catalyst, and sodium persulfate with heat as a catalyst. Control tests were prepared similarly but without the use of the oxidizing agent solution. The consumptions of catalyst and oxidant was monitored over the three week study and each week duplicate microcosm vials for each treatment were sacrificed and analyzed for petroleum hydrocarbons (C10-C50) and DBPC.

PROCESS

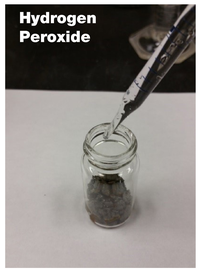


SETUP

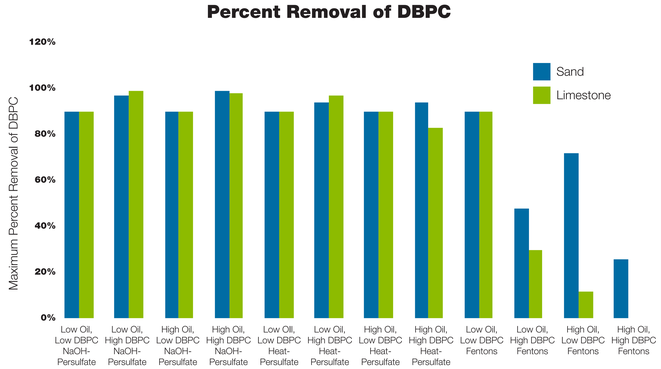


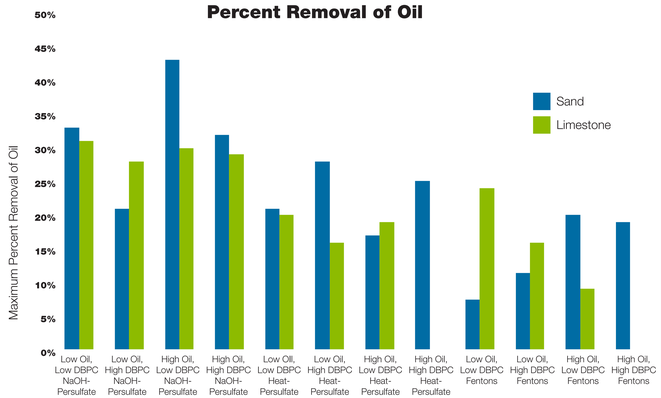
Adding Oil to Sand and Limestone:

Adding Oxidant:



STUDY RESULTS





SUMMARY OF RESULTS

Microcosm	Best Treatment	Maximum Removal of DBPC	Maximum Removal of Oil
Sand MG112 Low Oil, Low DBPC	NaOH Catalyzed Persulfate	To Non-Detect	33%
Sand MG112 Low Oil, High DBPC	Heat Catalyzed Persulfate	94%	28%
Sand MG112 High Oil, Low DBPC	NaOH Catalyzed Persulfate	To Non-Detect	43%
Sand MG112 High Oil, High DBPC	NaOH Catalyzed Persulfate	99%	32%
Limestone MG20 Low Oil, Low DBPC	NaOH Catalyzed Persulfate	To Non-Detect	31%
Limestone MG20 Low Oil, High DBPC	NaOH Catalyzed Persulfate	99%	28%
Limestone MG20 High Oil, Low DBPC	NaOH Catalyzed Persulfate	To Non-Detect	30%
Limestone MG20 High Oil, High DBPC	NaOH Catalyzed Persulfate	98%	29%

RESULTS / LESSONS LEARNED

The results show that chemical oxidation treatment is effective for the destruction of DBPC and also effective for treatment of transformer oil. DBPC appears to be more readily oxidizable than transformer oil and in many cases was completely removed before any treatment of transformer oil was observed. Sodium persulfate, both NaOH catalyzed and heat catalyzed, appears to be effective for the destruction of DBPC. Fenton's reagent was effective for the destruction of low levels of DBPC but was not effective when concentrations of DBPC were higher, particularly in the presence of higher concentrations of transformer oil.

Based on the results from the laboratory study, sodium persulfate would be the recommended oxidant and NaOH would be the recommended catalyst for the sodium persulfate. If initial concentrations of DBPC are low then treatment of the DBPC is expected to be fast. Higher concentrations will require a longer treatment time. A long treatment time and multiple oxidant injection events would be required to treat the transformer oil.