Superoxide Radical as a Green Reagent and an Ultimate Solution for Soil and Water Contamination

Uri Stoin, Ph.D., Chief R&D, Alpha Cleantec AG

About Us

Alpha Cleantec AG („ACT“) was founded in 2016 as an environmental technology company.

- **The Team:**

  Our experts are bringing in depth knowledge and experience in the fields of optimization of the chemical process, scale-up, advanced oxidation process, green chemistry, and environmental technologies.

- **Our Vision:**

  Is to provide **safe, green, rapid, efficient and cost-effective technologies** to resolve environmental harms and hazards caused by inadequate human and industrial activities.

- **Our Technologies:**

  Have been developed in collaboration with well-known experts and specialists and with support from the Casali Institute of Applied Chemistry, the Hebrew University of Jerusalem, Israel, which is one of the leading research centers in the field of applied chemistry.

Our Team

Prof. Dr. Yoel Sasson
Consultant Environmental Chemistry
ACT Switzerland

Dr. Uri Stoin
Chief of R&D
ACT Switzerland

Hansjörg Plaggemars
Degreed Merchant
Member of Directorate
ACT Germany

Mathias Schmid
Stock Exchange Expert,
Board Member
ACT Switzerland

Andreas Danner
Degreed Merchant
Finance & Controlling
ACT Germany

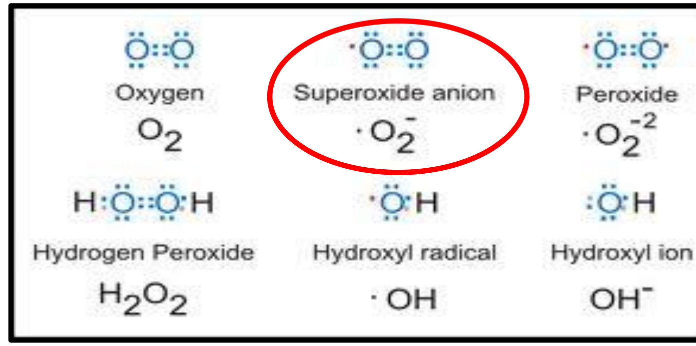
Our Technologies

- ACT team in cooperation with the Casali Institute of Applied Chemistry of Jerusalem have developed innovative environmental-friendly **super-oxidation processes AFA, SOA, RBO and WWO** .

- Our technologies are based on chemical oxidation of contaminants by highly efficient oxygen radicals as **superoxide radical** and **hydroxyl radical**.

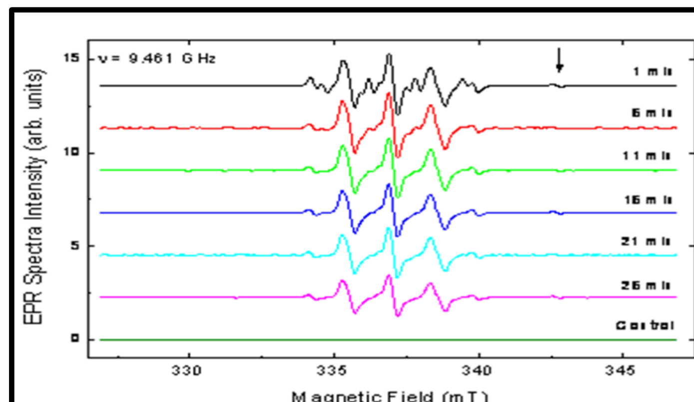
- Superoxide is well known as a by-product of metabolic processes and hydroxyl radical is known as a strong agent at Fenton and photocatalytic processes.

- Our technologies allow fast and efficient decomposition and mineralization of hydrocarbon-based contaminants.



$$C_xH_y + NaO_2 \rightarrow Na_2CO_3 + H_2O + 1.5\,O_2$$

$$HC + H_2O_2 \xrightarrow{Cat./Fe^{2+}} CO_2 + O_2 + H_2O$$



Our Technologies

Our technologies are based on *in-situ* synthetic generation of concentrated and stable superoxide radicals.

Range of Treatable Contaminants

- ACT processes can efficiently treat a wide range of contaminants from ***petroleum hydrocarbons***, ***chlorinated solvents***, to ***cosmetic and pharmaceutical industries leftovers*** and by-products.

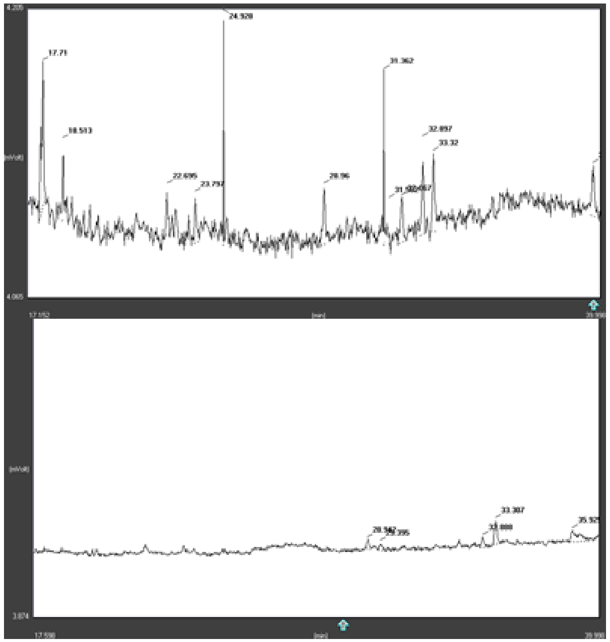
- Our technologies can be applied as in-situ, ex-situ and on-site processes.

- Our processes show amazing results in comparison to the existing solutions.

- **Our technologies are efficient and environmental friendly as proven by independent laboratory tests.**

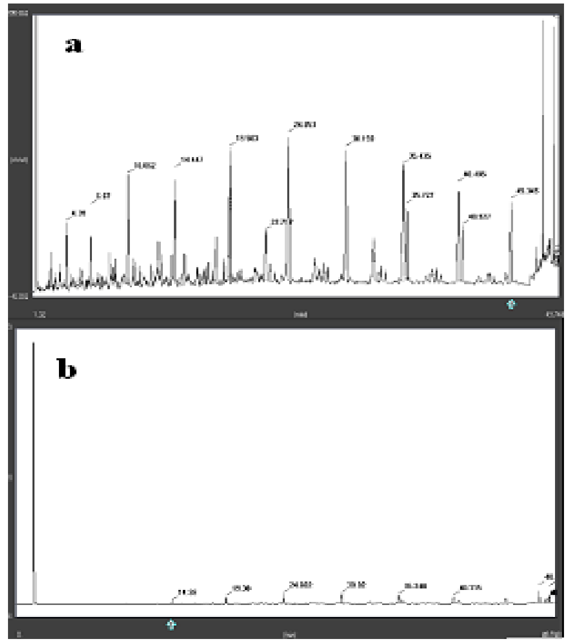
CONTAMINANTS	SOA	AFA
BTEX		
Benzene	◆	◆
Toluene	◆	◆
Ethylbenzene	◆	◆
Xylene	◆	◆
PETROLEUM HYDROCARBONS		
Gasoline Range Organics (GRO)	◆	◆
Diesel Range Organics (DRO)	◆	◆
Oil Range Organics (ORO)	◆	◆
AROMATICS		
Chlorobenzene	◆	◆
Bromobenzene	◆	◆
Dichlorobenzene	◆	◆
Nitrobenzene	◆	
Phenol	◆	
Styrene	◆	◆
Naphthalene	◆	◆
Trichlorobenzene	◆	
Trimethylbenzene	◆	◆
PAHS		
Phenathrene	◆	◆
Naphthalene	◆	
Acenaphthylene	◆	
CHLORINATED SOLVENTS		
Tetrachloroethylene	◆	
Trichloroethene	◆	◆
Dichloroethene	◆	◆
Vinyl chloride	◆	
Tetrachloroethane	◆	◆
Trichloroethane	◆	
Dichloroethane	◆	◆
Dibromochloroethane	◆	◆
Bromodichloromethane	◆	
Carbon tetrachloride	◆	◆
Chloroethane	◆	◆
Chloroform	◆	◆
Chloromethane	◆	◆
Chlorotoluene	◆	◆
Methylene chloride	◆	
PCBS	◆	◆
DIOXINS	◆	◆
PESTICIDES AND HERBICIDES		
Glyphosate	◆	
Goal	◆	

Efficiency of Soil Treatment



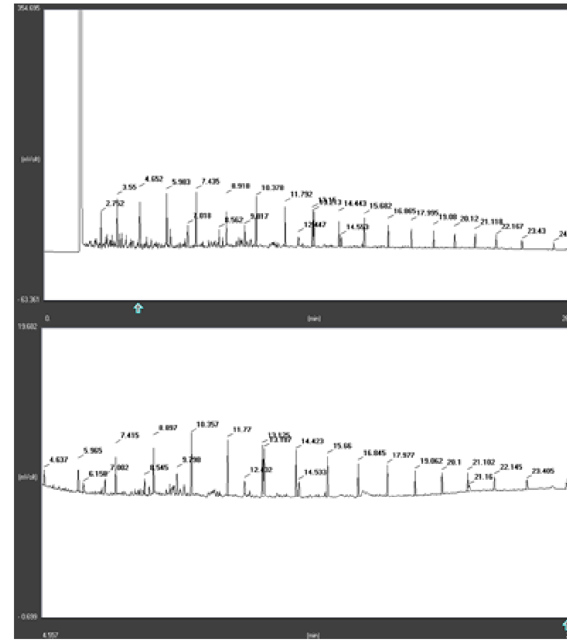
Treatment of PCB

Conversion > 90%



Treatment of Diesel

Conversion > 90%



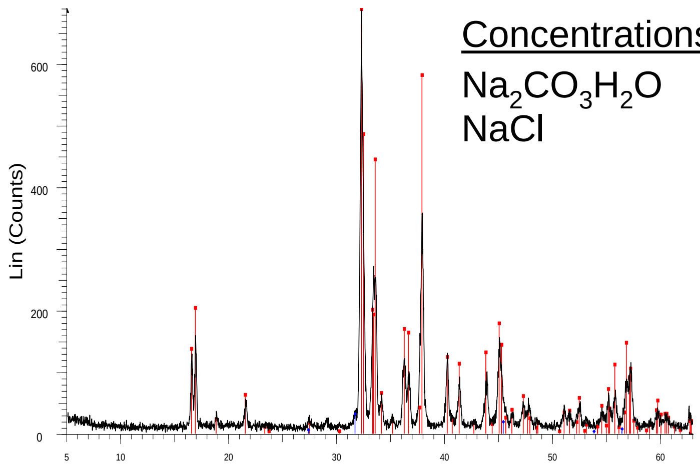
Treatment of Crude Oil

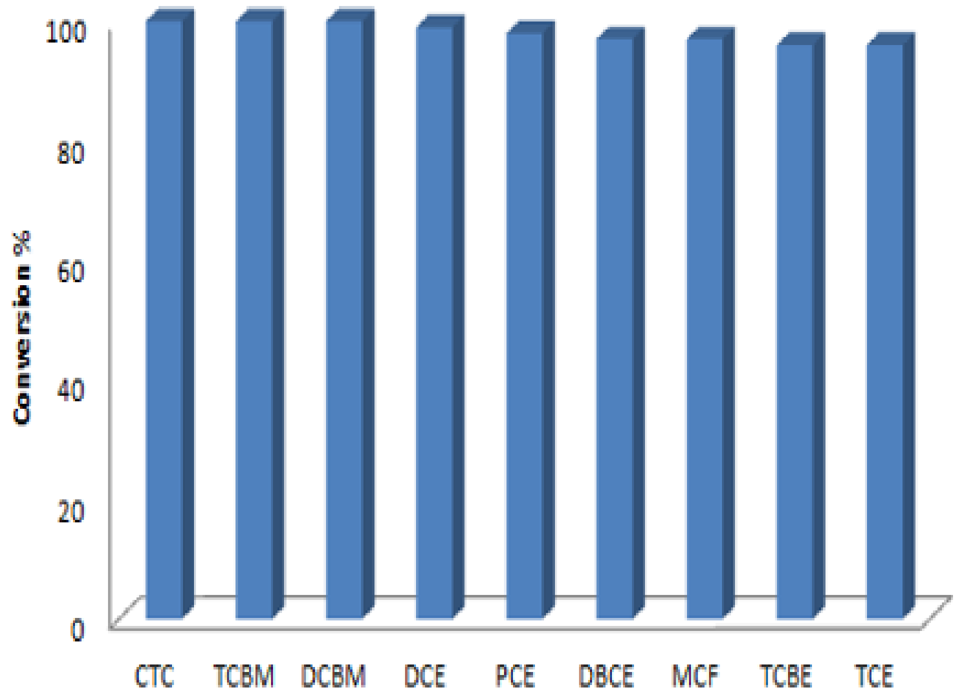
Conversion > 90%

Our oxidation processes are efficient for hydrocarbons decontamination in the range of 0.1 – 100'000 ppm.

Efficiency of Soil Treatment – CHC Decontamination

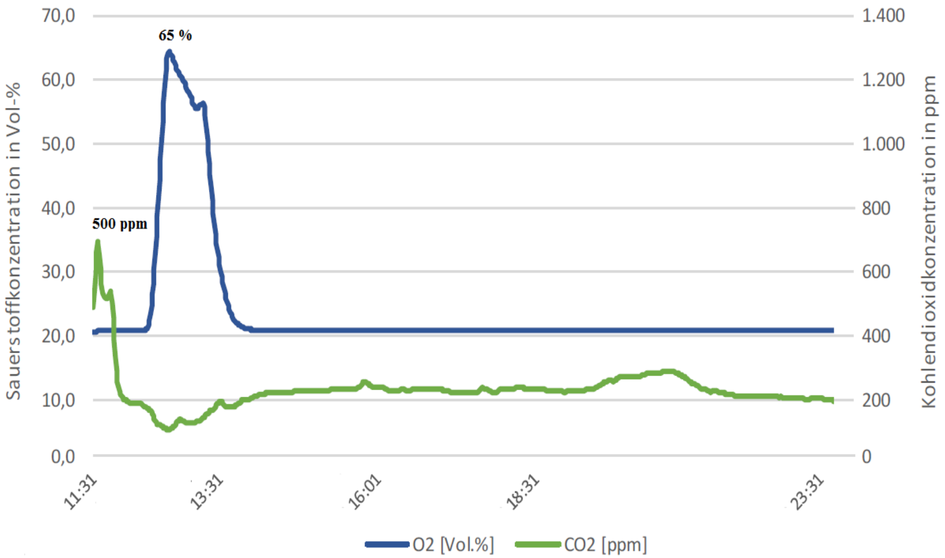
$$C_2HCl_3 + 6NaO_2 \rightarrow Na_2CO_3 + NaHCO_3 + 3NaCl + 3O_2$$

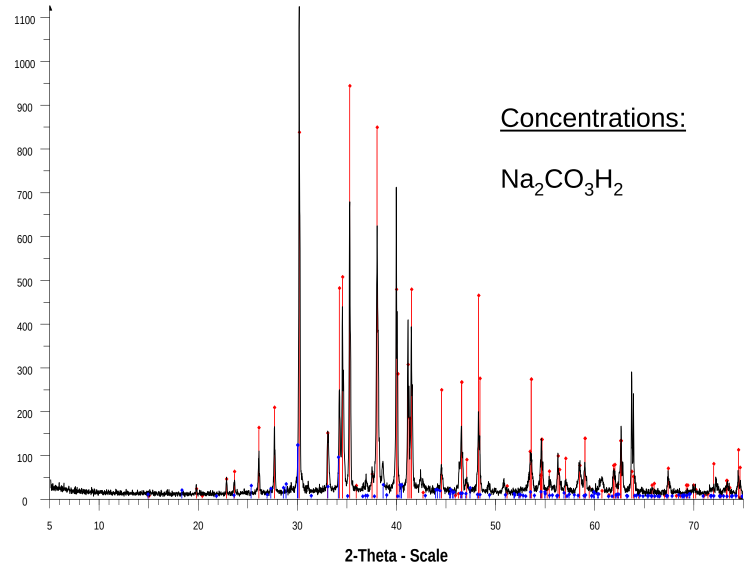




Our oxidation processes are efficient for CHC decontamination in the range of 100 ppb – 100'000 ppm.

Soil Treatment - End Products





Very low CO2 foot print

Leftovers in soil

The technologies are not damaging the soil matrix and quality. Our materials are not generating dangerous leftovers in the groundwater.

Soil Treatment – ACT vs. Common Market Solutions

Treatment Type	Treatment Time	Einvironmental Disruption	Hazardous Reagents	Production of Harm By-Products	Temperature Requirement	Problematic Contaminants	Conversion (%)
Thermal / Vapor	Hours	High	None	Air Contamination	High	None	> 99%
Bioremediation	Months / Years	Low	None	Low	Warm Climate	Heavy HC	> 70%
ISCO Permangante Persulfate	Months / Weeks	Low	Yes	Low	High	PCB / PCDD/DF	> 85%
ISCO Ozone	Months / Weeks	Low	Yes	Low	High	None	< 90%
ISCO Fenton	Months / Weeks	Low	Yes	Low	High	PCB / PCDD/DF	< 90%
Soil Washing	Hours	Low	None	None	> 10°C	Heavy HC	95%
Thermal Desorption	Hours	High	None	Air Contamination	High	PCDD/DF	> 99%
Landfill	No Treatment	High	None	Contaminants Remain	None	All	0%
Incineration	Hours	High	Explosion Danger	Air Contamination	High	PCDD/DF	99%
AFA	Hours / Days	Low	Yes	Low	> 10°C	PCD/DF	> 95%
SOA	Hours	Low	Yes	Low	> 10°C	None	> 95%

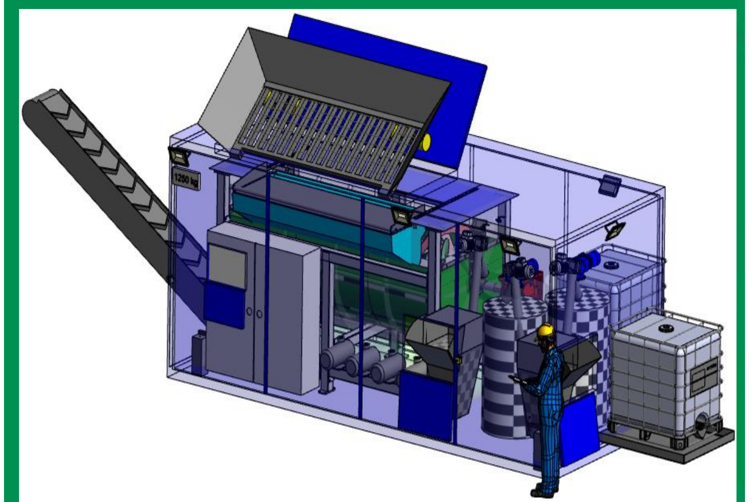
Soil Treatment

SOA
SUPER OXIDATION AGENT

AFA
ADVANCED FENTON AGENT

REACTION TIME	HOURS
CONVERSION	57 – 97 %

Based on independent laboratory tests



Applications

- ✓ Treatment of crude oil spills.
- ✓ Factories and industrial zones.
- ✓ Historical industrial areas.
- ✓ Industrial waste landfills.
- ✓ Refineries.
- ✓ Military bases.
- ✓ Gasoline stations
- ✓ Private and public service stations.

INDEPENDENTLY TESTED
Conversion rates up to 97 %

Attestation for laboratory degradation of 2 different hydrocarbons by the innovative AFA- and SOA-method, based on the following patent numbers:

- **AFA: US 62 / 731,911**
- **SOA: WO 2013 / 093903 and WO 2015 / 170317**

The TÜV SÜD Industry Service GmbH testifies hereby the proper execution of hydrocarbon-degradation tests by the innovative AFA- and SOA-method in the accredited laboratory of „görtler analytical services gmbh" in Vaterstetten, Germany (see laboratory report from 29th March 2019, 33 pages).

The degradation tests, which have been executed under ideal conditions in laboratory scale, were made with the following hydrocarbons, at which in each case different soil types (pure sand, homogenized sand-clay mixture (1:1), agricultural soil/rich in humus) have been tested.

- Diesel fuel
- Dichloromethane

The test attendant quantitative laboratory analytics on following measurement parameters (material respectively material classes):

- HC-Index (C10 - C40)
- Dichloromethane
- CO_2 and O_2 (measurements by TÜV SÜD)

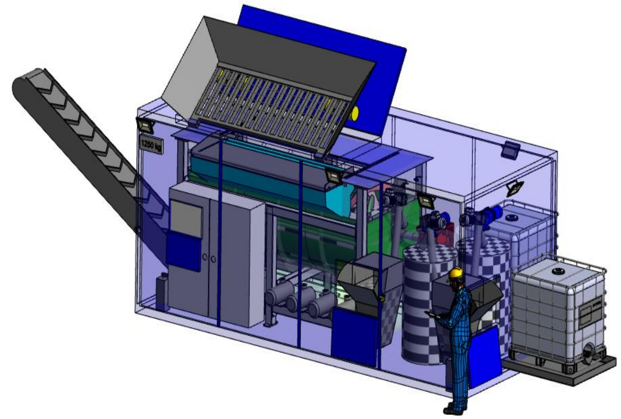
In summary it is hereby testified from an expertise-technical prospective, that the novel and forward-looking AFA- and SOA-method is basically suitable for the fast and partly very effective decomposition of hydrocarbons (polar and nonpolar hydrocarbons) on various soil types without an explicit increased content of clay minerals.

Department Environmental Service
Chief Geotechnics/Legacy of pollution
Dr. Peter Schenk

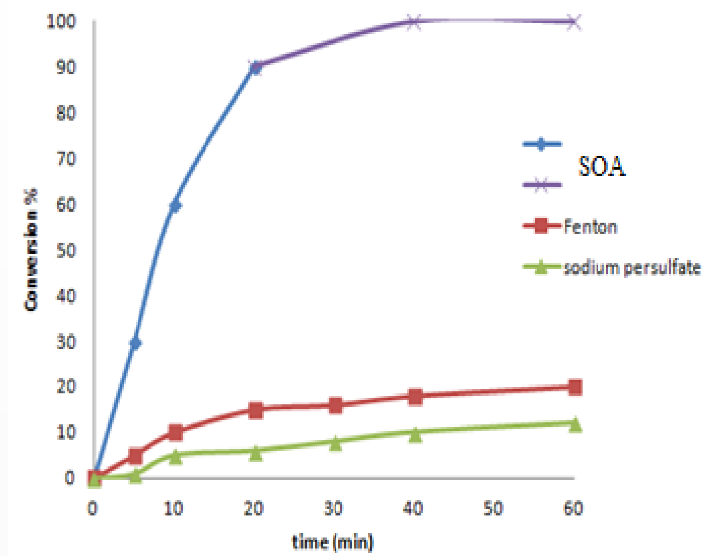
Geotechnics/Legacy of pollution
Hans Betko (Dipl.-Geol.)

Soil Treatment - Future Pilot Projects

- ✓ ACT has accomplished the laboratory stage for AFA and SOA technologies and is currently in the pilot phase of scaling up and commercializing of the technologies.



- ✓ The first pilot project is expected with:



References and Pilot Projects

Eberhard

Contamination	Contamination Level (ppm | mg/kg)	Required Level for soil type B (ppm | mg/kg)	After treatment (ppm | mg/kg)
C_{10}-C_{40}	1020	500	492-517*
PAH	780	25	48-51*

*Depends on the treatment procedure.

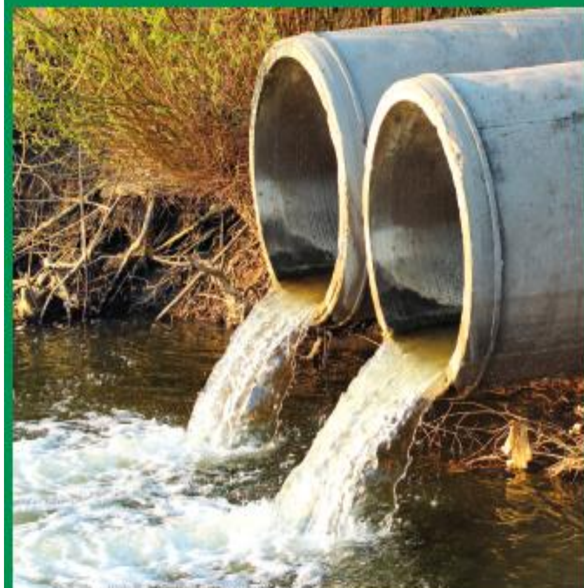
KÄSTLI

Contamination	Contamination Level (ppm | mg/kg)	Required Level for soil type B (ppm | mg/kg)	After treatment (ppm | mg/kg)
C_{10}-C_{40}	1500	500	65-400*
PAH	40	25	10-35

*Depends on the treatment procedure.

Wastewater Treatment

WASTEWATER TREATMENT



WWO

PHYSICO CHEMICAL OXIDATION PROCESS

REACTION TIME	HOURS
CONVERSION	80 – 97 %

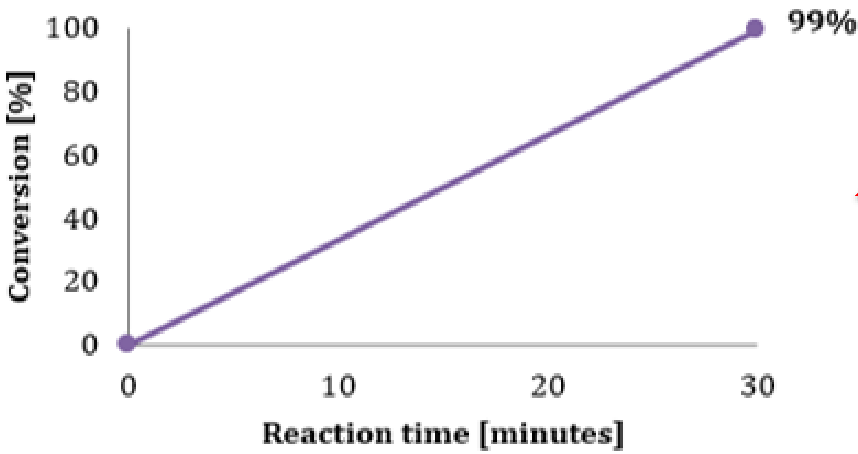
Based on tests in our laboratory

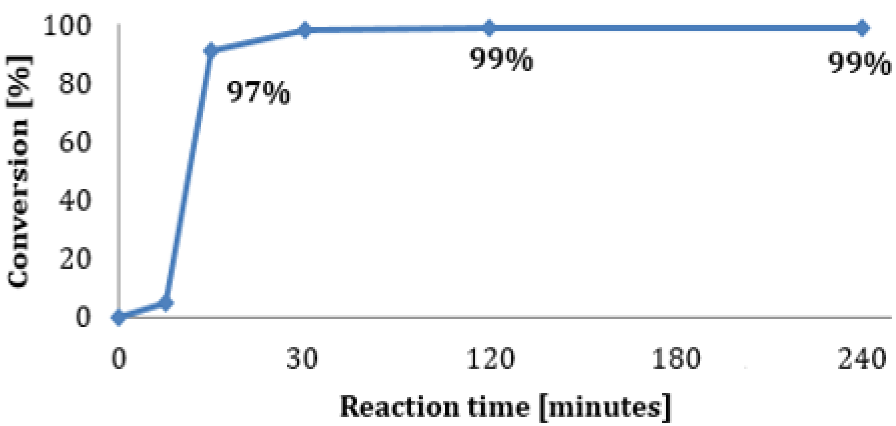
Decomposition of NAPLs and Dissolved Organic Materials

	Pollutant	Initial Concentration (ppm)	Treatment Time (min)	Final Concentration (ppm)	Decomposition (%)
Organic solvents	Dichloroethane	850	10	0	100
	Carbon tetrachloride	800	10	0	100
	Toluene	500	10	5	99
	Chlorobenzene	500	10	9	98
	Xylene	100	10	1	99
	Naphthalene	30	10	0	100
Drugs or molecular model of drugs	Rhodamin B	1000	11	2	99
	Rhodamin B	125	2	0.16	99
	Carbamazepine	100	10	10	90
Bacteria	E- coli	$3*10^7$ (CFU/ml)	10	0 (CFU/ml)	100

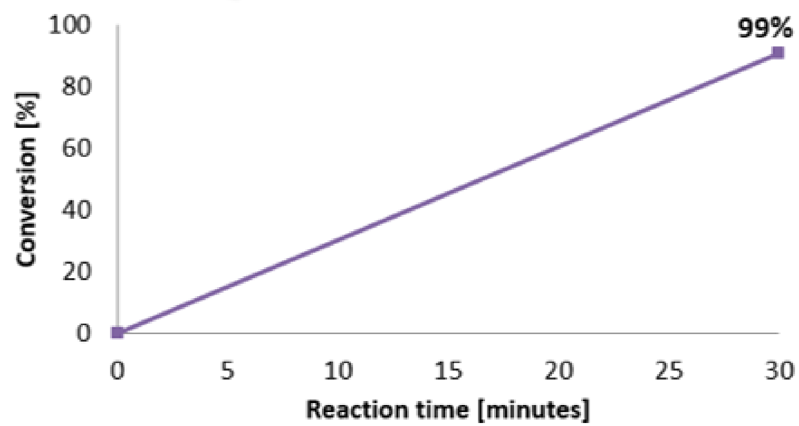
Wastewater Treatment

Decomposition of 250,000 ppm of TCE in wastewater



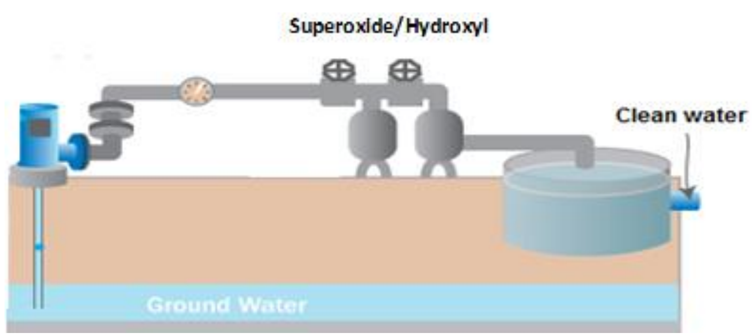


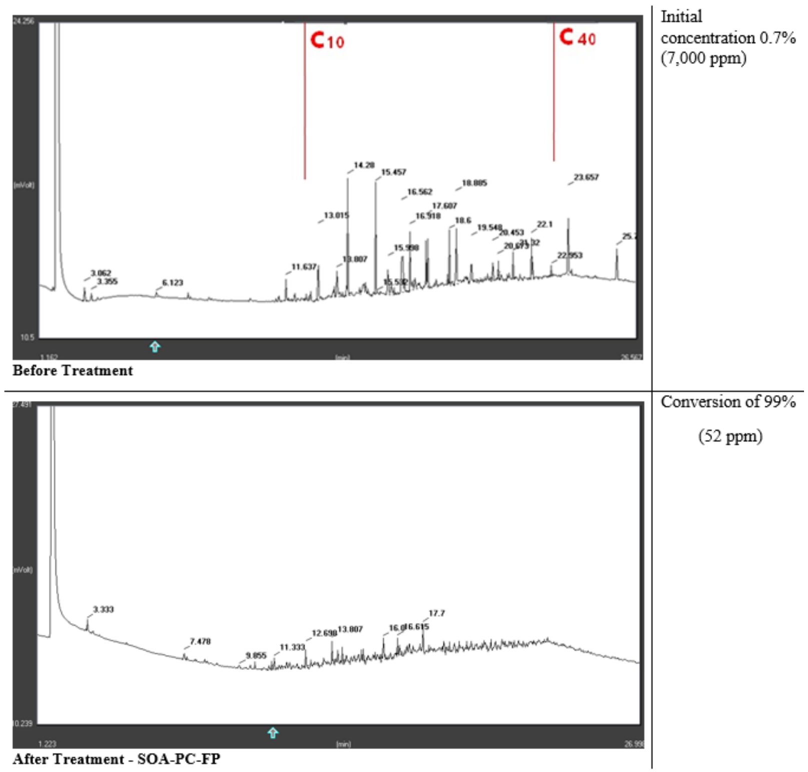
Decomposition of 100,000 ppm of diesel in water



Wastewater Treatment

✓ ACT has accomplished the laboratory stage for AFA and SOA technologies and is currently in the pilot phase of scaling up and commercializing of the technologies.





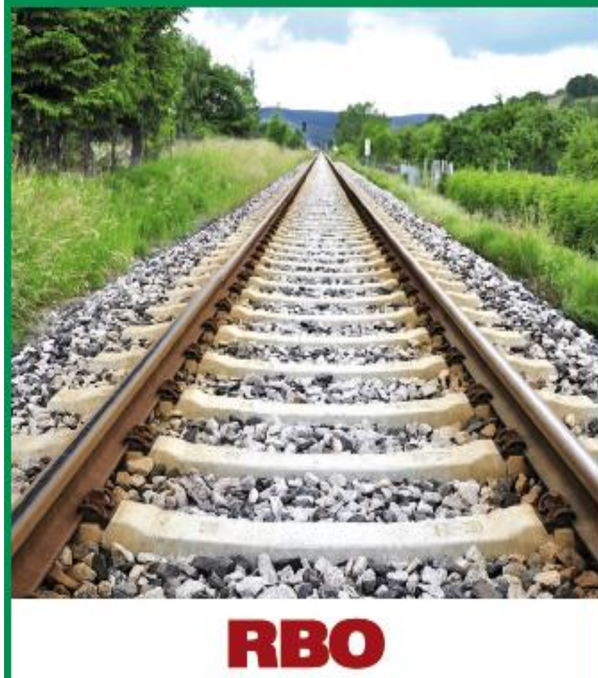
✓ The first pilot project is expected with:

ZULBERTI

ELECTRA GREENTECH
CONSIDER IT DONE

Railway Ballast Treatment

RAILWAY BALLAST TREATMENT

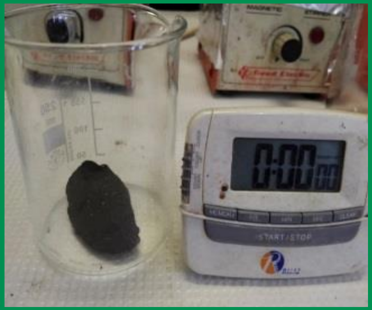


RBO

PHYSICO CHEMICAL OXIDATION PROCESS

REACTION TIME	HOURS
CONVERSION	70 – 80 %

Based on tests in our laboratory



Based on the synthetic generation of highly concentrated superoxide radical with surfactants and phase transfer catalysts.

Our Technology – Independently Tested

Industrie Service

Attestation for laboratory degradation of different chemicals in railway ballast by the innovative SOA-method, based on the following patent numbers: SOA: WO 2013 / 093903 and WO 2015 / 170317

The TÜV SÜD Industry Service GmbH testifies hereby the proper execution of chemical degradation tests by the innovative SOA-method in the accredited laboratory of „görtler analytical services gmbh" in Vaterstetten, Germany (see laboratory report from 27 th August 2019). The degradation tests, which have been executed under ideal conditions in laboratory scale, with different soil types and layers (track ballast, pure sand, agricultural soil/rich in humus) and testing of percolate water which had been contaminated prior with:

- Diesel fuel
- Used oil
- Glyphosate

The analytical laboratory tests have been carried out measuring the following parameters:

- HC-Index (C10 - C40)
- PAH
- Glyphosate/AMPA
- pH
- Electric conductivity
- DOC (Dissolved Organic Carbon)
- Dry residue

As a result, the technology showed high conversion rates for different treatment layers. Railway ballast (first layer): conversion up to 81% for oil and diesel leftovers and conversion of 93% for glyphosate decomposition. Railway sand (second layer): conversion up to 56% for oil and diesel leftovers and conversion rate of 94% for glyphosate decomposition. Railway groundwater (lowest layer): the conversion of oil and diesel leftovers was not measured. However, in this layer, the methodology reached a conversion of 99 % for glyphosate leftovers decomposition. These conversion rates were reached after single ballast treatment under normal temperature and pressure conditions with short treatment time. In summary it is hereby testified from an expertise-technical prospective, that the novel and forward-looking SOA-method is basically suitable for the fast and partly very effective decomposition of hydrocarbons and herbicide on track ballast and percolate water.

Department Environmental Service
Chief Geotechnics/Legacy of pollution

Dr. Peter Schenk

Geotechnics/Legacy of pollution

Hans Betko (Dipl.-Geol.)

Munich, 10 September 2019

	Railway ballast Conv. (%)	Railway sand Conv. (%)	Railway ground water Conv. (%)
Oil and Diesel	81	56	----
Glyphosate	93	94	99

THANK YOU FOR YOUR ATTENTION!

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