Name of Process:
Gas-Phase Chemical Reduction (GPCR)

Vendor:
ELI Eco Logic International Inc.
Web site: http://www.ecologic.ca

Applicable Pesticides and related POPs wastes:
Pesticides such as Hexachlorobenzene, DDT, Aldrin, Dieldrin, HCB's, DDT, PCB's, dioxins and furans and other POPs.

Status:
A Commercial system operated in Australia for more than 5 years, treating more than 2,500 tons of PCB's, DDT and other POPs. In 1999 a full-scale test on HCB was conducted using the commercial plant.

Eco Logic's partners in Japan have recently built a semi-mobile GPCR plant for the treatment of PCB wastes, which will be operational in 2003.

In combination with Foster Wheeler and Kvaerner the company is participating at present in the ACWA (Army Chemical Weapons Assessment) Program for the destruction of chemical warfare agents.

Eco Logic has partnered with Torftech Inc. for the treatment of soils and sediments at rates of up to 20 tons per hour. Eco Logic has also been selected by UNIDO for a pilot project for treatment of 1000 tons of PCB wastes in Slovakia.

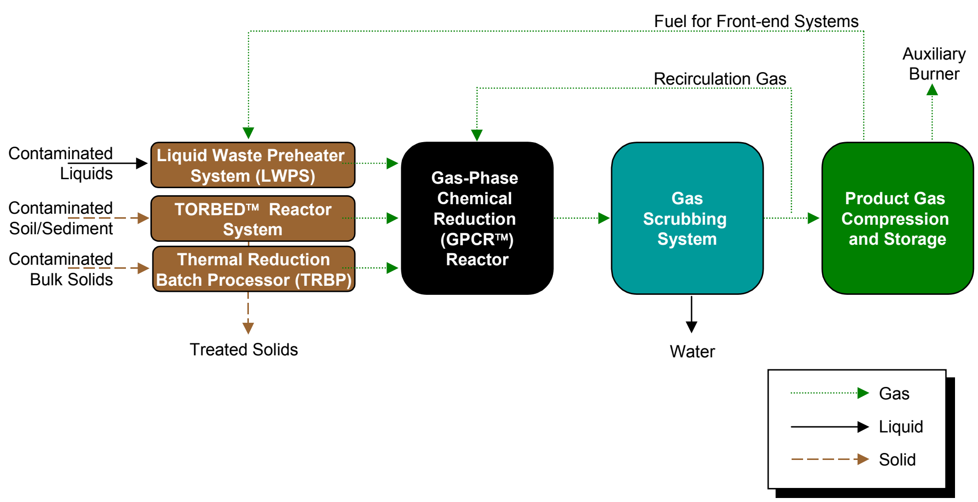
Additional approvals received:
-for PCB and dioxin waste in Japan
-for PCB's TSCA permit in USA
-for PCB's and other toxic compounds in the Province of Ontario (Canada)

Technology description:
Eco Logic's GPCR technology involves the gas-phase chemical reduction of organic compounds by hydrogen at a temperature of 850°C or higher. Chlorinated hydrocarbons, such as HCB, polychlorinated dibenzo-p-dioxins (dioxins) and other POPs, are chemically reduced to methane and hydrogen chloride (HCl). Unlike oxidation reactions, the efficiency of these reduction reactions is enhanced by the presence of water, which acts as a heat transfer agent as well as a source of hydrogen. Therefore, dewatering of input waste is unnecessary. The water shift reactions produce hydrogen, carbon monoxide and carbon dioxide from methane and water. These reactions can be used at higher efficiencies to generate hydrogen for reuse in the system by subjecting scrubbed methane-rich product gas to high temperatures in the presence of a catalyst. This is particularly useful when a hydrogen source for plant operations is not immediately available.

Solid and bulk waste materials are processed in a Thermal Reduction Batch Processor (TRBP). This waste is placed in the TRBP, which is sealed and heated in an oxygen-free atmosphere to about 600 °C. Organic components are volatilised and swept into the GPCR reactor, where complete reduction takes place at 850-900 °C. Gas leaving the Gas leaving this reactor is scrubbed to move particulate and acid and then stored for reuse as a fuel.

Process diagram:

Block Flow Schematic:



John Vijgen, International HCH and Pesticides Association, Fellowship report: "New and emerging techniques for the destruction and treatment of pesticides wastes and contaminated soils." NATO/CCMS Pilot Study: Evaluation of Demonstrated and Emerging Technologies for the Treatment of Contaminated Land and Groundwater (Phase III)"

Performance:

Treatment efficiency:
The GPCR has treated HCBs and PCBs and DDT, other chlorinated pesticides and POPs related wastes such as dioxins and furans. The Table below provides a complete list of contaminants treated.

Compounds treated by GPCR

Industrial Chemicals and Manufacturing By-products			
PCBs	Dioxin and Furans	Hexachlorinated Wastes	Pentachlorophenol
Polyaromatic Hydrocarbons			
Acenaphthene	Benzo(a)Pyrene	Chrysene	Indeno(123-cd)Pyrene
Acenaphthylene	Benzo(b)Fluoranthene	Dibenzo(ah)Anthracene	Naphthalene
Anthracene	Benzo(ghi)Perylene	Fluoranthene	Phenanthrene
Benzo(a)Anthracene	Benzo(k)Fluoranthene	Fluorene	Pyrene

Organochlorine Pesticides				
o,p'-DDE	Chlorodimeform	Endosulfan I	Mecoprop	Pirimphos ethyl
p,p'-DDE	Chlorofenviphos	Endosulphan	Metalaxyl	Procymidone
o,p'-DDD	Chloropropham	Endosulphan II	Methiocarb	Procynidone
p,p'-DDD	Chloropyrifos	Endrin	Methomyl	Propachlor
o,p'-DDT	cis-Chlordane	Endrin Ketone	Methoxychlor	Propargite
p,p'-DDT	Coumoiphos	Ethephon	Metoxuron	Propazine
2,4,5-T	Crotoxyphos	Ethion	Metribuzin	Propoxur
a-BHC	Dieldrin	Fenamiphos	Mevinphos	Quinomethionate
a-chlordane	Diazinon	Fenitrothion	Naproamide	Quintozene
Alachlor	Dicambamethyl	Fenoprop	Nicotine	Rotenone
Aldrin	Cyanthoate	Fenthion	Nornicotine	Secbumeton
Atrazine	Dacthal	Folpet	Oxydisulfoton	Simazine
Azinphos ethyl	d-BHC	g-BHC	Parathion	SWEP
b-BHC	DCPA	g-chlordane	Pendimethalin	Technazene
Bendiocarb	DDMU	Glyphosate	Permethrin I	Terbufos
Bis-2-chloroethylether	Dichlorfuanid	Heptachlor	Phenolthiazine	Terbutryn
Bupirimate	Dichlorobenil	Heptachlor Epoxide	Phorate	Tetrachloro-m-xylene
Captan	di-Chlorovos	Hexachloroethane	Phorate Sulfone	Thiabendazole
Carbaryl	Dicloran	Lindane	Phosmet	Trans-chlordane
Carbofenthion	Dicofol	Linuron	Phosphorodithioic Acid	Triadimefon
Carbophenothion	Dimethoate	Malathion	Piperonyl butoxide	Triallate
Carboxin	Disulfoton	Manoczeb	Pirimicarb	Tridimefon

Chemical Warfare Agents and other Military Wastes			
VX	HD (Distilled Sulphur Mustard)	GB (Sarin)	DPE Suit Material (Plastic, Teflon)
Napalm	Chemical Agent Neutralents		
Other Compounds Treated			
Benzene	Toluene	Mineral oil	Vegetable oil

Commercially the system has been working more than 5 year at Kwinana in Western Australia, where it has been treating PCB's, HCB's and DDT. Here efficiencies of at least 99.9999 % [1], [2], [3], [4].

In commercial-scale performance tests in Canada, the gas-phase reduction process achieved destruction efficiencies (DE) and Destruction and Removal Efficiencies (DRE) with high-strength PCB oils and chlorobenzenes as shown below in Table 1. Dioxins that were present as contaminants in the PCB oil were destroyed with efficiencies ranging from 99.999 to 99.9999 percent [5], [6].

An evaluation for the US Department of Energy (DOE) [7] noted that contaminants are "completely destroyed in the process" and that the process, "features a high degree of internal waste recycle and has no waste generating side streams." The authors did however note that the front-end components for introducing solids and large equipment, was a limiting factor. A more recent assessment of the applicability of GPCR for chemical weapons destruction noted that the TRBP should be "completely effective in decontaminating metal components" to the stringent requirements of the ACWA program [8] and that "[a]n advantage of the GPCR process with regard to solids treatment is that the solids would not have to be size-reduced or shredded before being treated. Treatment could be as simple as removing the lids from the solids waste drums and treating the drums in the TRBP."

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Engineering testing on batches of 3, 9 and 27 drums (205 litre size) of HCB wastes showed that, "Results of the trials indicated that the system effectively desorbed approximately 98 percent of the waste input to the TRBP. In excess of 99.9999 percent of the HCB and chlorobenzene present in the waste was volatilized in the TRBP and swept to the reactor for destruction." Destruction efficiencies for the desorbed HCB and chlorobenzenes in the GPCR reactor were reported to be 99.99999% and 99.9999% respectively [9].

Throughput:
150 tons pre month or 1800 tons per year. Capacities can be doubled due to modular design. In the Annex is also given an overview of the estimated utility requirements for semi-mobile GCPR plant with a capacity of 70 tons pesticides per month.

Throughput of the technology will depend on the scale of GPCR plant that is deployed. The following give the rough throughput estimates for each plant size:

Full-Scale Plants:

- Full-scale plants in operation since 1995 (Kwinana: 1995 to 2000; GMCL: 1996 to 1997)
- For use at sites with large waste stockpiles, or where waste can be brought in from surrounding area
- Footprint: 4,000 m^2 (approximately 8 to 10 trailers)
- Throughput: up to 200 tons per month bulk solids and liquids (2 TRBPs)
- Soil and Sediment Treatment Capability: 1000 to 5000 tons per month (1 TORBED) ➔ *throughput highly dependent on characteristics of waste*

Semi-Mobile Plants:

- Semi-Mobile plant recently constructed in Japan
- For use at sites or in regions with smaller waste stockpiles, or where mobility is important
- Footprint: 1,000 m2 (approximately 4 trailers)
- Throughput: 70 tons per month bulk solid or liquid material (2 TRBPs)
- Soil and Sediment Treatment Capability: 500 to 2000 tons per month soil or sediment (1 TORBED reactor) ➔ throughput highly dependent on characteristics of waste

Portable Plants

- Small size (fits into single sea container or gooseneck trailer; 800 ft2 footprint)
- Highly mobile
- First developed as a unit for conducting treatability tests
- Commercial applications are on-site, in-process treatment of manufacturing wastes and carbon filter material
- Throughput: 50 - 250 (or greater) tons/year, depending on reactor configuration, chemical concentration and waste matrix

Wastes/Residuals:
All process and waste residuals are contained and can be tested and reprocessed as necessary. No uncontrolled releases in normal operation. The USEPA recently noted that, "All outputs are stored and analyzed for regulatory compliance prior to off-site disposal or reuse." and that "The principal waste stream is the scrubber residuals which include decant water (which is recycled into the process) and scrubber particulate (which is stored and analyzed and then retreated or shipped off-site for disposal)"[10].

Reliability:
Bizzigotti et al [6] assessed the reliability of the process as, "GPCR is a straightforward operation and should be inherently stable and robust (tolerant of large changes in operating conditions without becoming unstable or unpredictable)." They also noted that, "Eco Logic reports their Kwinana plant has 84–90 percent availability (this includes allowance for four days planned shutdown every month), which is considered good for a chemical processing plant." The DOE review rated the development of the technology as "high"[5].

Limitations:

The DOE review noted a limitation in respect of heavy metal contamination [5] "GPCR is non-selective and capable of destroying agents, Schedule 2 compounds, and hazardous intermediates, which ensures organic destruction and eliminates the risk of agent reformation. However, treatment of arsenic- and mercury-containing wastes produces volatile elemental metals; although GPCR has successfully treated arsenic-containing wastes, removal of arsenic and mercury from the air effluent poses a challenge that must be considered in the design of the pollution abatement system." They also noted a concern related to the use of hydrogen, "Transportation of large quantities of hydrogen may present a risk of transportation-related accidents. However, hydrogen is a standard commercial product, and should be available locally (or generated on-site), minimizing transportation distances" [11].

The system does not produce slag or ash – the only residual we have (other than the treated steel and that sort of thing) is our filter systems, and even these are not an output. When the filters are "spent", we simply place them in the TRBP, heat them to desorb and destroy the contaminants, and then reuse them. This is a common practice with our commercial operations [12].

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Transportability:
See also under Throughput under Semi mobile and portable plants.
The DOE review [5] noted that, "The process is offered commercially as an integrated transportable (7-10 trailers) system for on-site hazardous waste treatment." And Bizzigotti et al [6] commented, "The GPCR is a robust system that should be able to withstand transportation and other motion- or vibration-induced stresses. In addition, system integrity checks that will be performed prior to operation should detect leaks and other minor damage caused by transportation." [11]

Detailed information:
See Data in Annexes

Full Scale treatment examples:
See Annexes

Conclusion:
The GPCR process is a well-developed technology and has a proven record of practical and commercial experiences for pesticides and related POPs compounds.

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**Note: This NATO/CCMS fellowship report does not certify any particular technology, but tries to summarise the state of the art of the concerned technology on the basis of data delivered by the company or other source, which have been made available to the author and refers the reader to original documents for further evaluation. Without the efforts of the Technology supplier it would not have been possible to set up this fact sheet.*
*** Note:The text for this report is verified by the Technology supplier on 1. October 2002*

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