Name of Process:
Potassium-tert-butoxide (t-BuOK)
Applicable POPs wastes:
Low contaminated PCBs from several ppm to 100 ppm.

Status:
Since November 2003, a Japanese Power company has treated approximately 30,000 m^3 of low contaminated PCB oil with the potassium-tert-butoxide (t-BuOK) process at its treatment plant in Osaka city.

Technology description:

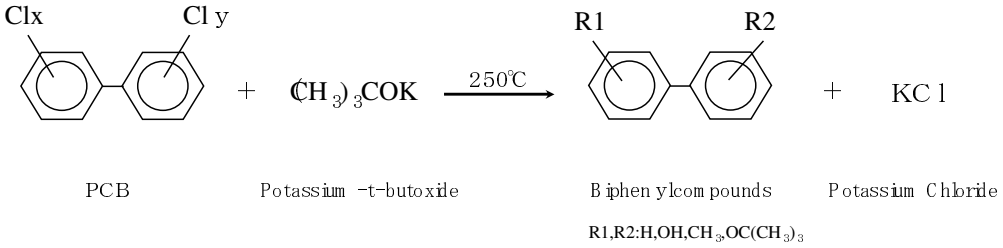

Figure 1 Mechanism of dechlorination of PCB with t-BuOK

Description of Flow sheet:

Process basis

Description of the different process steps

Detoxification proceeds within a continuous stirred tank reactor (CSTR) using potassium-tert-butoxide (t-BuOK), (0.5wt/vol%) as reaction reagent. Reaction time is 30 minutes; reaction temperature is 250°C under normal pressure. PCB concentration of low contaminated PCB oil is from several ppm to100 ppm, and it decreases to less than 0.5 ppm after the reaction. The oil after reaction is washed by the water to remove the reaction products (biphenyls and KCl) and the unreacted t-BuOK. The water is reused after neutralization by sulphuric acid and separation of the generated salt (KCl and K_2SO_4) by crystallizing. The insulation oil detoxified has been sold off and reused.

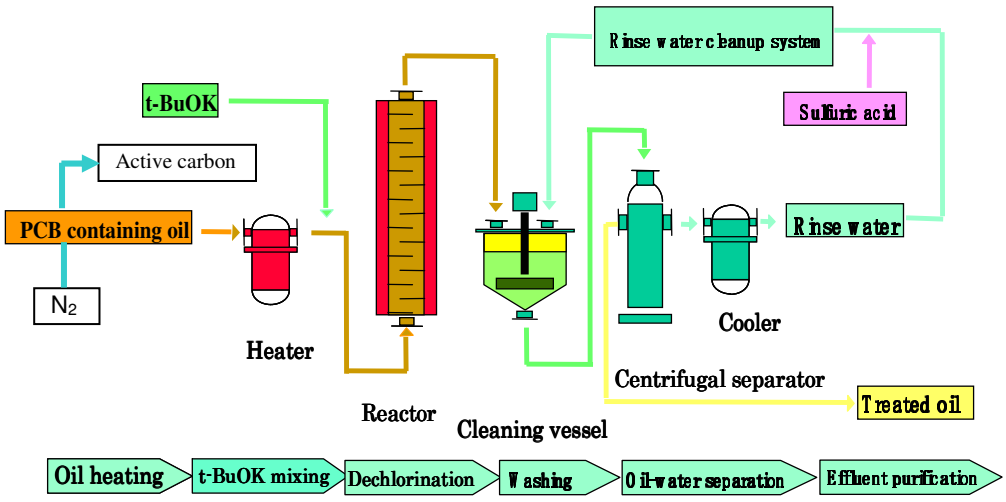

Figure 2 t-BuOK process in the KEPCO facility

Mass balance:

Below is indicated the Mass balance in the KEPCO (Kansai Electric Power Co., Inc.) facility 36m^3/day of low contaminated PCB oil and 180kg/day of t-BuOK are fed to the reactor continuously. 36m^3/day of water is cycled and is infused to the reacted oil to be washed. Non-reacted t-BuOK in the oil reacts with water, and changes to t-BuOH and KOH. 120kg/day of t-BuOH is separated from treated oil and collected by distillation. During the purification of water, 0.5m^3/day of sludge is collected.

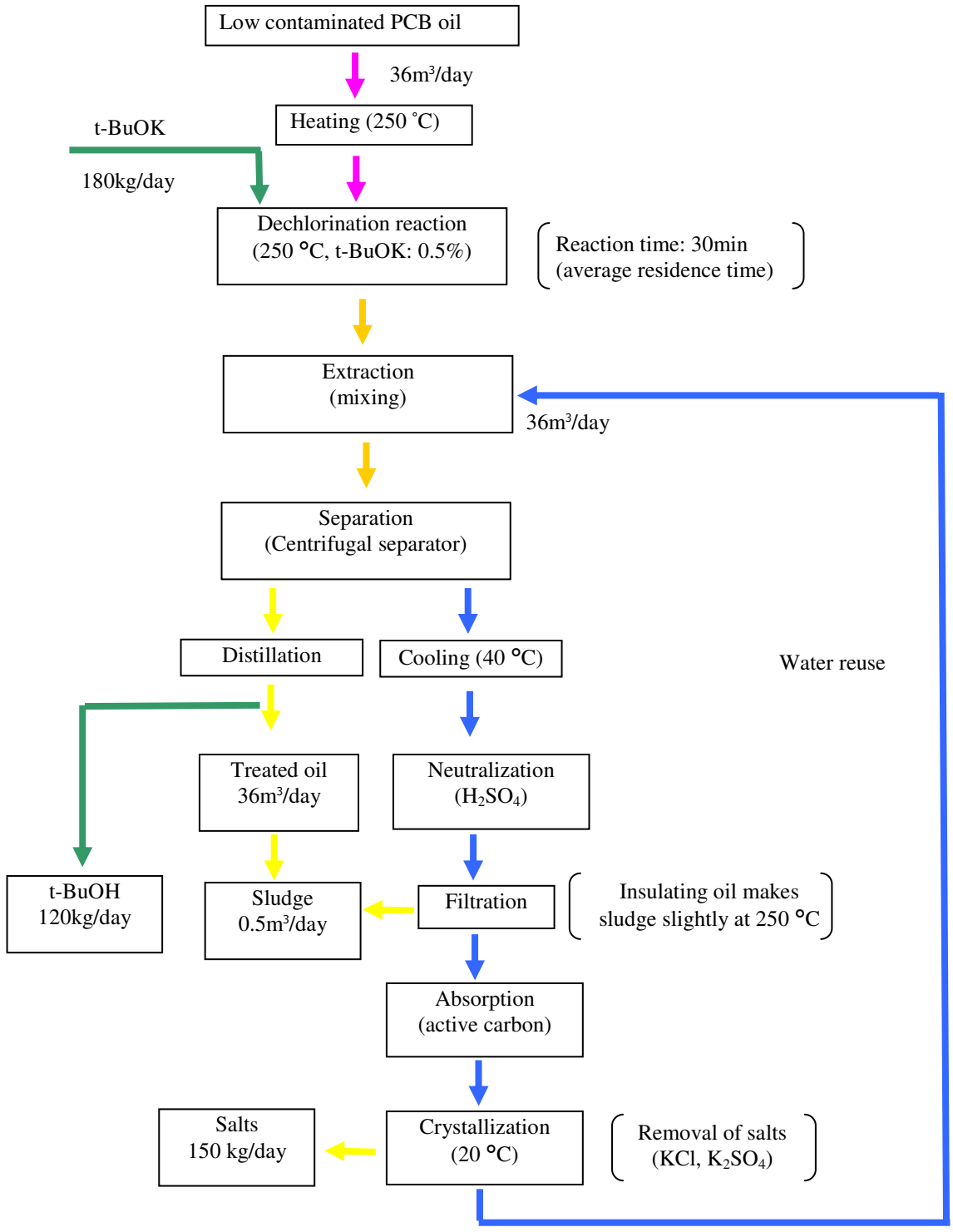

Figure 3 Mass balance in KEPCO facility

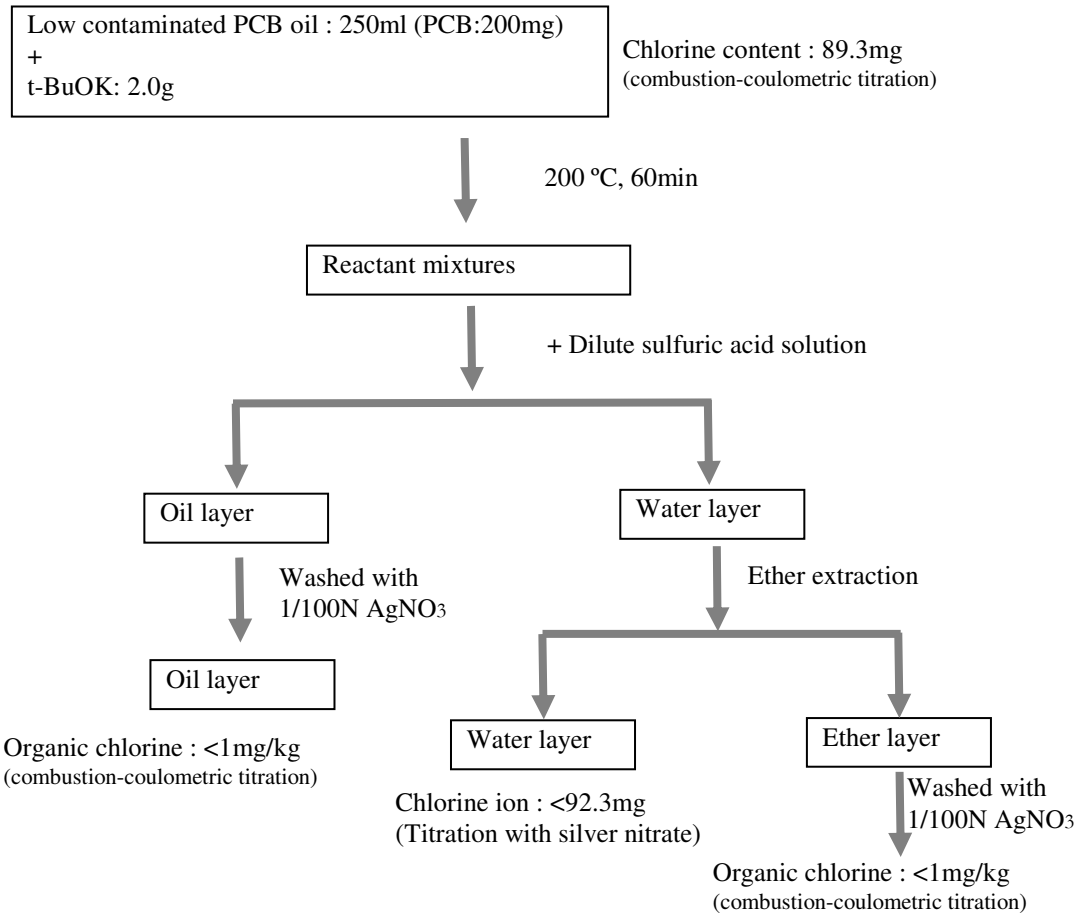

Figure 4 Mass balance of chlorine

Solvent regeneration and recycling

Features of the KEPCO facility

1. Detoxification system is very simple because no other reagent, solvent used except t-BuOK
2. Operation of equipment is easy because system is simple
3. Processing performance is large (36KL/day) because of consecutive reaction type
4. Chlorines combined with PCB are released completely (See Figure 4), then chlorinated hydrocarbons such as hydroxyl-PCBs are not generated
5. Treating cost is cheap for the above-mentioned reasons

PART I: Criteria on the Adaptation of the Technology to the Country

A. Performance:

1. Minimum pre-treatment:
Removal of air from the waste oil by N_2 gas bubbling.
Mineral oil is the main component of the waste oil. Sludge is produced by the reaction between oxygen in the air and the mineral oil at high temperature. Then air from the oil is removed thus avoiding production of sludge in the heat exchanger.

2. Destruction efficiency (DE):
Over 99.995% (below 0.005ppm after treatment of 100ppm oil).

3. Toxic by-products:
None

4. Uncontrolled releases:
None

5. Capacity to treat all POPs:
PCBs in low concentrations

6. Throughput:

6.1 Quantity [tons/day, L/day]
Present plant has a capacity of 36 m^3/day (about 10000 m^3/year) and has treated the following amounts:

Period	Volume treated m^3
November 1, 2003 to March 31, 2004	1700
April 1, 2004 to March 31, 2005	6500
April 1, 2005 to March 31, 2006	9700
April 1, 2006 to March 31, 2007	10300
April 1, 2007 to March, 2008	9800
November 1, 2003 to March, 2008	38000

6.2 POPs throughput : [POPs waste/total waste in %]
From several ppm to 100 ppm

7. Wastes/Residuals:
The following overview gives the governmental requirements on treatment, the mean treatment results and the analytical control methods for the treated materials.
This is

Table 2 PCB concentration of treated oil and waste materials

	Analytical method	Results	Criteria
Treated oil	GC/MS	< 0.005 mg/kg	< 0.5 mg/kg
Waste t-BuOH	GC/MS	<0.005 mg/kg	< 0.5 mg/kg
Waste generated salt (K_2SO_4)	ECD/GC	< 0.0005 mg/L	< 0.03 mg/L
Waste sludge	GC/MS	<0.005 mg/kg	< 0.5 mg/kg

The detoxified insulation oil has been sold off and reused.

7.1 Secondary waste stream volumes:

Waste:
Salt (K_2SO_4): 0.50% (152kg/day) of the total waste treated (36KL/D=30.6t/d). (T-BuOK has been excessively added against the total chlorine atoms of PCBs. It is difficult to separate oil sludge from the washing water when washing water contains t-BuOK, because t-BuOK alkalizes water. Therefore H_2SO_4 is added to washing water for neutralization The remaining t-BuOK changes to K_2SO_4 and t-BuOH. The K_2SO_4 is collected as crystal by cooling the washing water. K_2SO_4 is collected as waste by an external waste company that incinerates the waste.

T-BuOH: 0.46% (142kgs/day) of the total waste treated. T-BuOH is recovered by distillating. T-BuOH is collected as waste by an external waste company that incinerates the waste.

Sludge:
During the purification of water, 0.5m^3/day of sludge is collected. The density of the sludge is about 1kg/l; 500kg of the sludge is collected per day. The sludge is produced from the mineral insulated oil by the heat deterioration at the reaction temperature of 250□. The main element of sludge is an oxide of mineral oil and the sludge is used for fuel.

Water:
Waste activated carbon: 25m^3/year, which is reused after regeneration at an external waste treatment company.

7.2 Off gas treatment:

KEPCO plants are equipped with activated carbon filters in the N_2 blow line for the removal of air from the waste mineral oil (See Figure 2)

7.3 Complete elimination:

Detailed information and treatment examples:

At KEPCO Plant 30 000 m^3 from 2003 – 2007

If there are further individual projects we could add them into the Annex.
Table 1: Technology Overview – Summary Technical Details
Table 2: Overview Project Experience per Technology Supplier
Table 3: Overview detailed project information per project – Project name (from Table 2):
Table 4: Client References Overview project experience per technology suppliers
Table 5: Utilities Required for Low Contaminated PCB Oil

PART II: Criteria on the Adaptation of the Country to the Technology

Note: This part has to be filled in every time the "suitability" of the technology has to be examined for a certain country situation!!

A. Resource needs:

1. Power requirements:
4,000,000kwh/year

2. Water requirements:
2,500m^3/year

3. Fuel volumes:
210KL/year

4. Reagents volumes:
Paraffin oil:66kl/year, t-BuOK:60,000kg/year, H_2SO_4:28,600kg/year, KOH:680kg/year, Activated carbon:9,500kg/year

5. Weather tight buildings
Process itself has no special requirements other than rain shelter

6. Hazardous waste personnel requirement:
Standard for manual work: helmet, gloves and security shoes.

7. Sampling requirements/facilities:
The samples have to be prepared before GC/ECD analysis.

8. Peer sampling:
The requirements from the authorities are monthly analysis of waste water, every 4 months of air in the surrounding of facility and annual analysis of soil.

9. Laboratory requirements:
ECD/GC and normal standard laboratory equipment.

10. Communication systems:

On site requirements:

Mobile network:

None

Requirements in country:
Depending on the requirements of the concerned authorities.

Fixed network:

Standard telecommunication facilities.

11. Number of personnel required: 17: 10 persons in 5 shift groups are working per shift, 5 persons are daytime workers, 2 persons are for analysis.

11.1 Number of Technicians required (skilled labour):
10 persons of 5 shift groups and 2 persons for analysis are skilled labours.

11.2 Number of Labourers required (unskilled labour):
6

B. Costs:

Total cost (100 yen /L-oil = 0,95 US$/L-oil, at Sept 2008 exchange rate) is very low, because no special equipments are in the facility, main reagent is only t-BuOK of 0.5%, a lot of waste oil (10,000KL/year) can be treated in a small apparatus because of the continuous treatment system.

1. Installation and commissioning costs [US Dollars]:
5 %

2. Site preparation costs [US Dollars]:
2 %

3. Energy & Telecom installation costs:
→ needs 300 KVA

4. Monitoring costs:
1 %

5. Complying costs:
Depending on local situation

6. Reporting costs:
1 %

7. Running costs with no waste:
Does not matter

8. running costs with waste:
0,3 to 0,5 USD/kg

9. Decommissioning costs:
2 %

10. Landfill costs:
only for ceramics depending of local costs

11. Transport costs of residues:
Depending on the local situation

C. Impact:

1. Discharges to air:
72 Nm^3 / day of N_2 gas is bubbling into the waste oil before t-BuOK reaction for excluding oxygen from the waste oil.

2. Discharges to water:
No wastewater is generated from the process.

The water used for washing the treated oil is recycled after purification.

3. Discharges to land:
Ceramics: 400 t / y of non-contaminated neutral material are landfilled.

4. Soil impact (noise etc):
Conform to the EU norms.

D. Risks

1. Risks of reagents applied:
t-BuOK is strong alkaline, so it is necessary to avoid catch one's eye and mouth.

2. Risks of technology:
In general the health and safety risks associated with operation of this technology are thought to be low, because of the mild reaction conditions (normal pressure and low temperature).

3. Operational risks:
All the operations are automatic. The operations are done in the operation room.

E. Constructability:

1. Ease of installation/construction of plant:
Construction is easy because there is no special equipment.

2. Ease of shipping/transit:
No experience yet. However, can easily be designed.

3. Ease of operation:
All operations are automatic. The operations are done in the operation room.

4. Ease of processing :
Processing is easy because the waste is liquid.

F. OUTPUT/GENERATION WASTE:

1. Generated waste (% of input waste)
Treated oil, collected t-BuOH and oil sludge are utilized for fuel. 18m^3 of collected K_2SO4 and 37m^3 of washing water are the output waste. Input waste oil is 10,000m^3, then 55m^3 (18m^3+37m^3) is 0.55%.

2. Deposited waste at landfill (% of input waste)
none

3. Waste quality properties (pH, TCLP)

**Note: This Technology Specification and Data Sheet (TSDS) 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 companies or other sources, which have been made available to the author and refers the reader to original documents for further evaluation. Without the efforts below listed technology suppliers it would not have been possible to set up this TSDS. Date: 01.12.2008*

Technology suppliers that have contributed to this TSDS:

Ohno Masayuki, Kanden Engineering Co., Ltd. Osaka, 552-0013, Japan

References:

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