

Development of a Simple PCB Removal Method for Contaminated Transformers and a Rapid PCB Measurement Method

Background and Objective

It was reported in 2003 that PCBs might be still be present as a contaminant in insulating oil in a large number of transformers. Cost effective procedures for PCB measurement and removal are therefore highly desirable. The first object of this project is to develop a rapid, cheap screening method using a PCB biosensor along with an accurate, quantitative PCB measurement method using gas chromatography. The second object is to develop a simple process for removing PCBs from the core and coil assembly of contaminated transformers using flushing or energizing with circulation of heated PCB-free insulating oil after draining of original contaminated oil.

Main results

1. PCB biosensor - Official registration for PCB measurement method -

PCB biosensor developed by us was further improved in both speed and accuracy by employing an effective separation of PCBs from oil and a more sensitive detection to visualize reaction of antibody to PCBs. The improved biosensor was officially registered as a screening method for PCB contamination in oil by the ministry of environment in the Japanese government* (Table 1). A new method for PCB extraction from oil by using microfabrication technology was further developed as a simultaneous extraction by the solvent in vast cavities along with micrometer scale flow channel of oil (Fig.1) [V10027].

2. PCB measurement using instrument -Official registration for PCB measurement method -

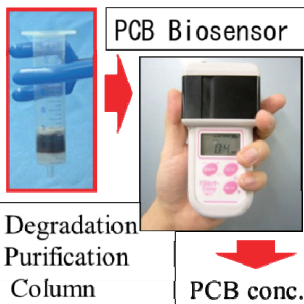
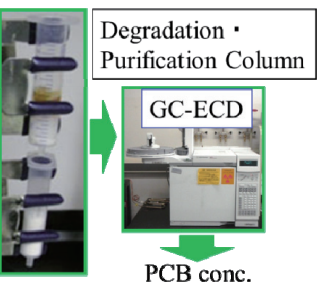
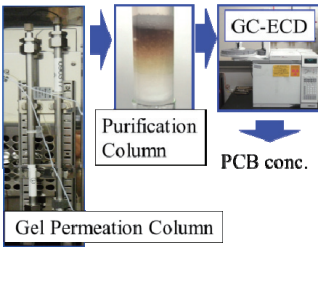
The separation of PCBs from oil matrices on the basis of molecular size using gel permeation column chromatography followed by gas chromatography with electron capture detection (GC-ECD) was officially registered as a rapid quantification method for PCB concentration in oil by the ministry of environment in the Japanese government* (Table 1) [V09023]. The separation of PCBs using two-layer silica gel column followed by GC-ECD was also registered as a screening method for PCB contamination in oil* (Table 1) [V10017]. Newly developed analysis for PCB congeners was proposed as rapid PCB concentration converter on GC-ECD applicable to these methods [V10020].

3. Washing technologies for low level PCB contaminated transformer -Official registration as PCB treatment -

Circulative washing and energizing washing experiments using small scale PCB contaminated transformers were demonstrated to prove PCB removal. PCB analysis of the core assembly of treated transformer after flushing or energizing showed less than regulatory criteria as PCB status [V09403]. These washing technologies were evaluated by a technical council for PCB treatment in the ministry of environment in the Japanese government, and were officially registered as PCB treatment technology in December 2010.

* The ministry of environment in the Japanese government, 'Manual for rapid analysis for PCB in insulating oil, second edition', June, 2010.

Table 1 List of officially registered measurement methods developed by us

Method	PCB biosensor ¹	Two layer column/GC-ECD ²	GPC/GC-ECD ³
Operation			
Detection limit(mg/kg)	0.2	0.2	0.05
Time ⁴	40minutes	3hours	6hours
Number ⁵	100	30	20

- 1: High concentration sulfuric acid silica gel column/flow through based immunoassay
- 2: SO₃ added sulfuric acid multilayer silica gel treatment/GC-ECD.
- 3: Gel permeation chromatography/multilayer silica gel column/ GC-ECD.
- 4: Time to measure one sample.
- 5: Number of measurements that can be performed by one operator with single equipment.

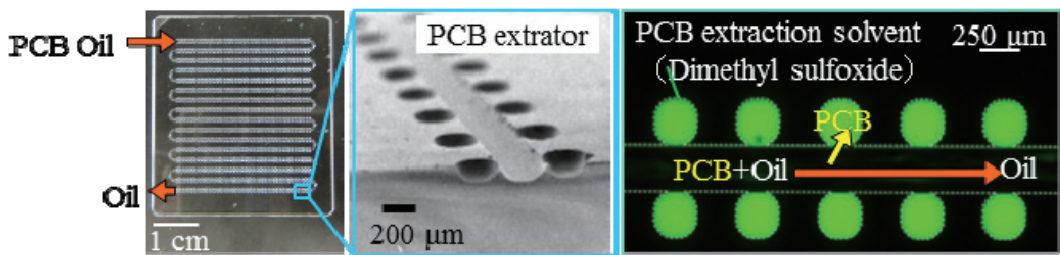
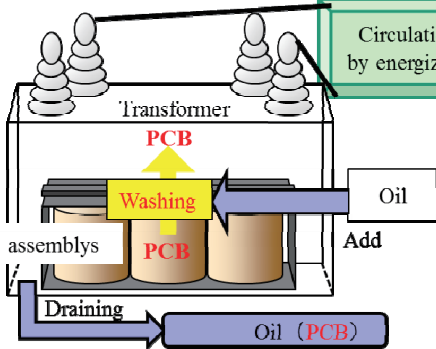
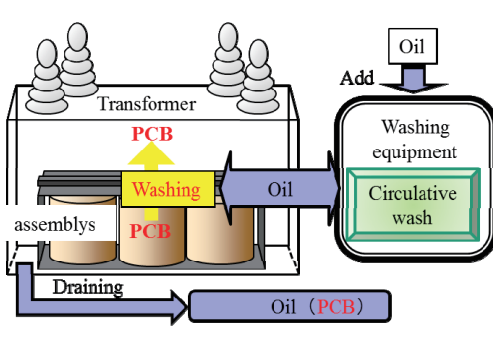


Fig. 1 A rapid PCB extraction using microfabrication technology

Ax PCB extractor fabricated on several square centimeters of glass plate. PCB is continuously extracted into swirl solvent in cavities when oil containing PCB flows through the flow channel.

Table 2 Officially registered treatment technology developed by us

Method	Circulative wash	Energizing wash
Image for treatment		
Summary	Heated washing oil was circulated by equipment to leach PCB out into the washing oil from the core assemblies	Washing oil was circulated by energizing to leach PCB out into the washing oil from the core assemblies
PCB conc. ¹	45~73mg/kg	37~59mg/kg
Time for treatment ²	60~72hours	77~113hours

- 1: PCB concentration of the transformer used for experiments.
- 2: Time for treatment in experiments.