Measurement of tritium with plastic scintillators in large vials of a low background LSC -an organic waste-less method-

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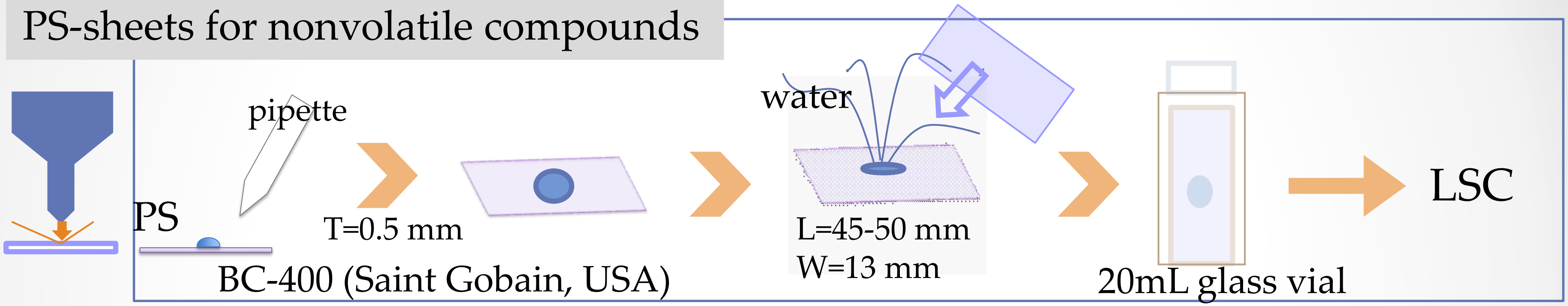
Japan

Past studies; how to use PS

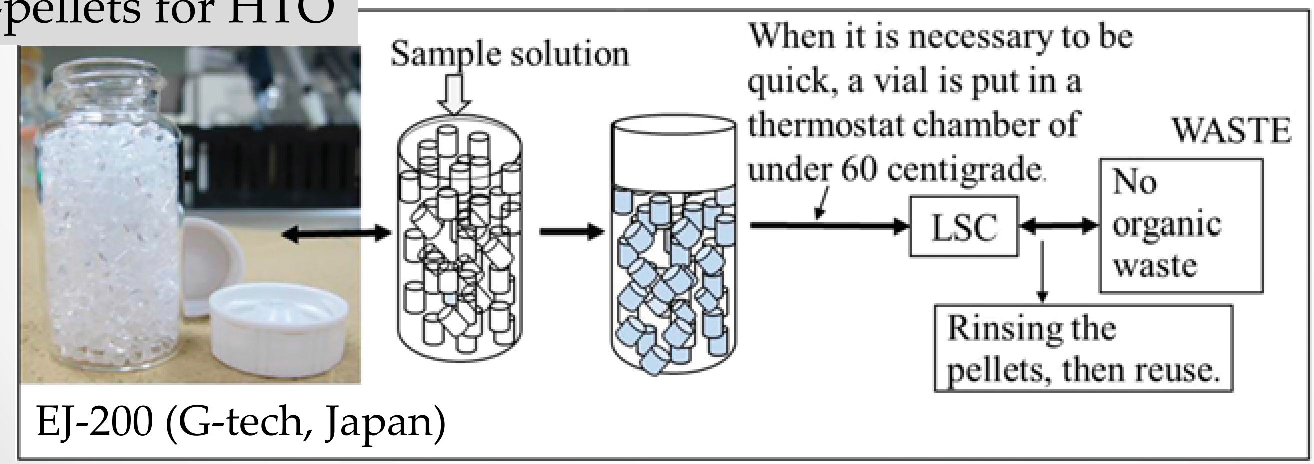
PS=Plastic scintillator, which is an alternative material of liquid scintillator

PS-sheets for nonvolatile compounds



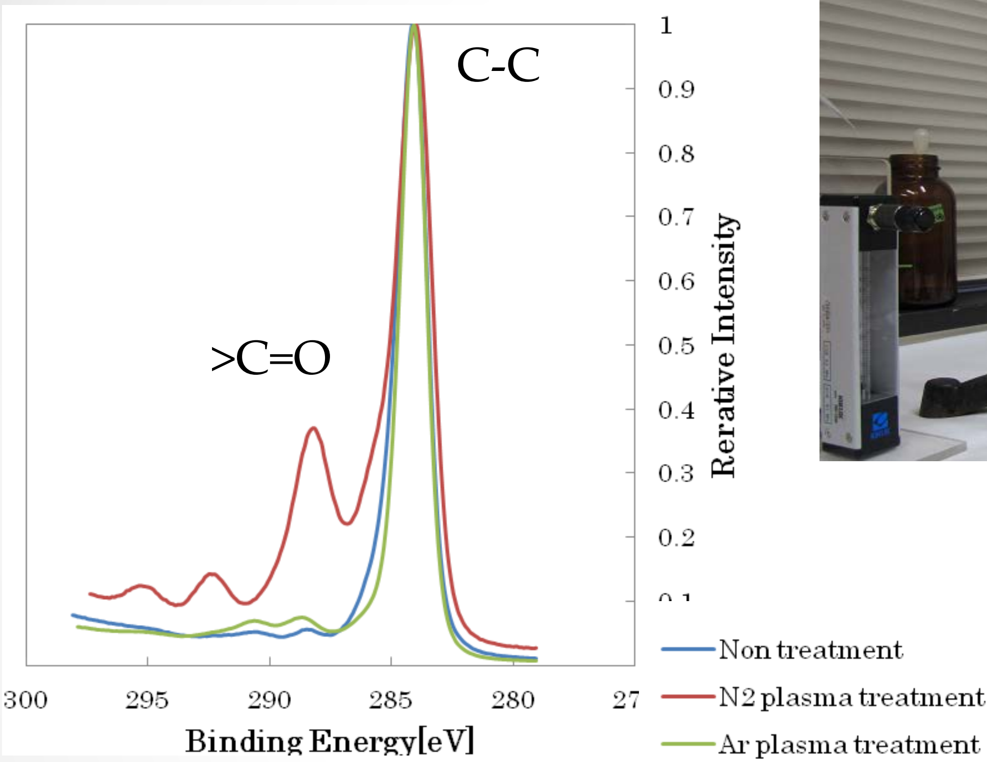
Fusion Science and Technology, 67(3), 654-657, 2015.

PS-pellets for HTO

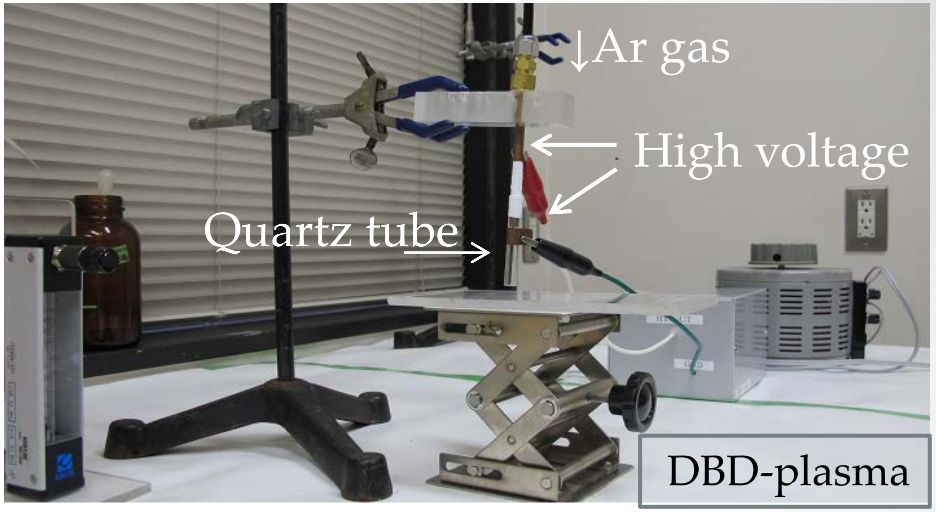


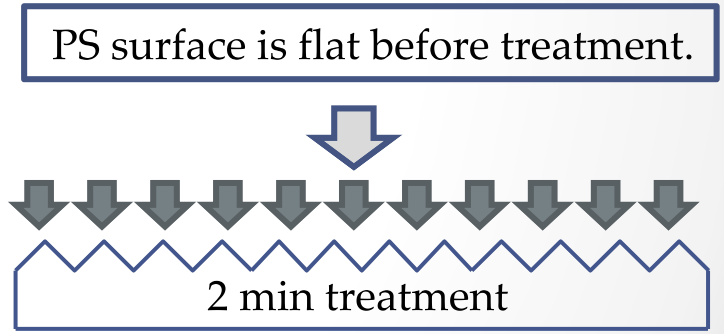
Isotopes in Environmental & Health Studies, 52(4), 560-566, 2016.

Past studies; plasma effects for PS-sheets



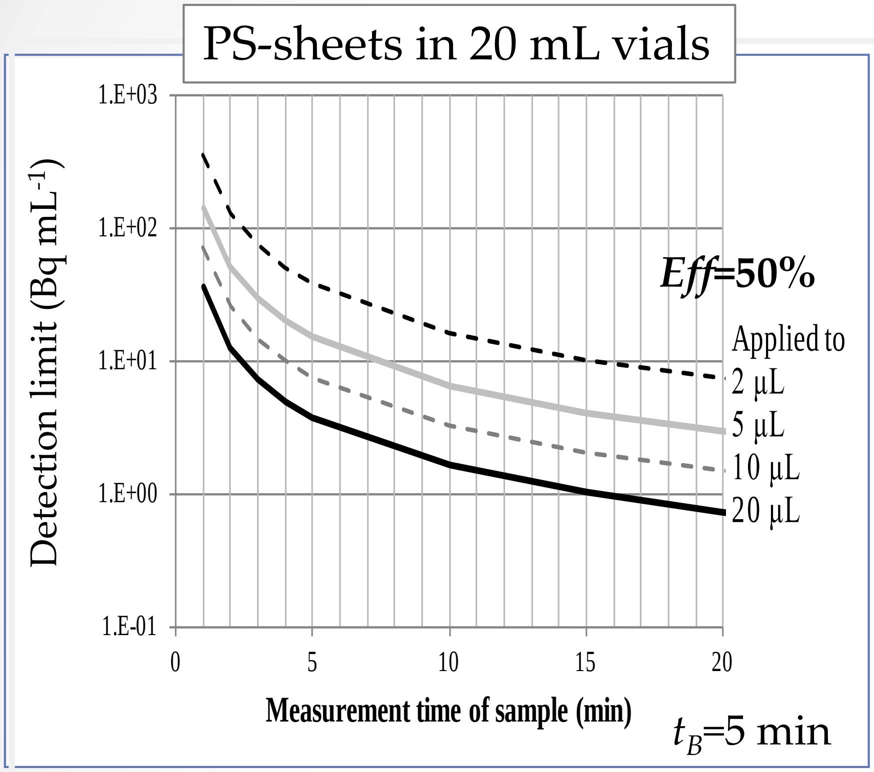
XPS; K-Alpha (Thermo Fisher Scientific, USA)

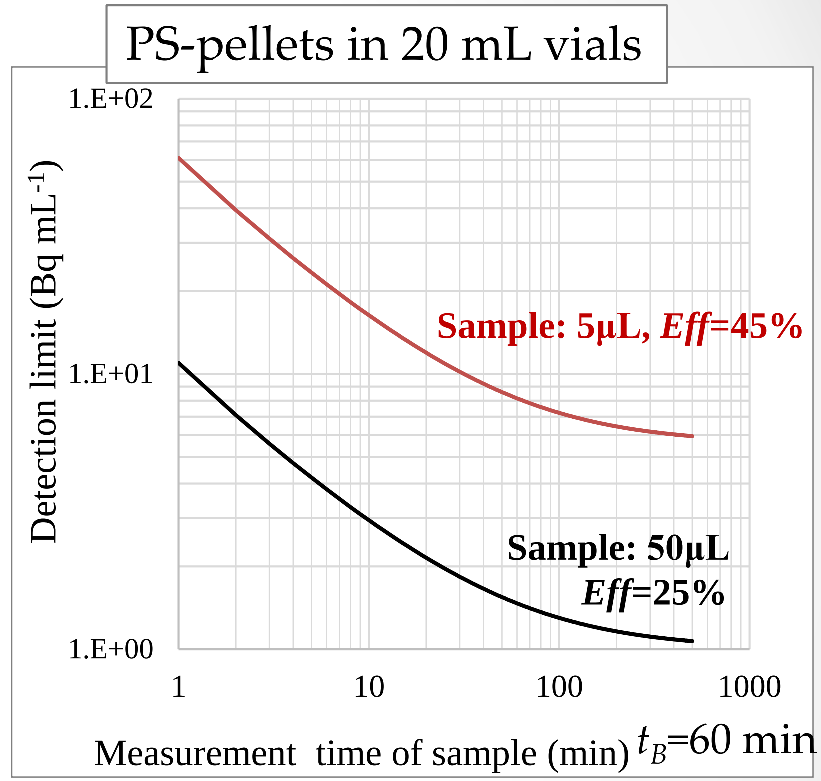




Plasma treatment effects were addition of a carbonyl group on the PS surface and at the same time, etching by DBD-plasma.

Past studies; detection limits





Both detection limits are not enough to measure environmental samples, directly.

$$n_D = \frac{k^2}{2}\left[\frac{1}{t_S} + \sqrt{\frac{1}{t_S^2} + \frac{4n_B}{k^2}\left(\frac{1}{t_S} + \frac{1}{t_B}\right)}\right] \quad k=2$$

Small ⇒ Large amounts

Tri-Carb3110TR, vials (Perkin Elmer)

Max. 20 mL vials for normal LSC

Vials for LSC-LB7 (Hitachi)

For example, pellets put in each vial are 15 g in 20mL vial, 97 g in 145 mL poly-vial ,and 117g in 100mL wide-mouth Teflon vial. One sheet size was increased 2 times and the sheet number was utmost 64 in a wide mouth Teflon vial.

Purpose

To confirm large vials with the plastic scintillators are effective for large volume

⇨ For some applications in the future

Monitoring post,

Plastic scintillation counter

(Poster No119 on Tuesday)

Expiration measurement apparatus

(Friday, 2nd oral presentation in the morning)

Experimental

Factors to study

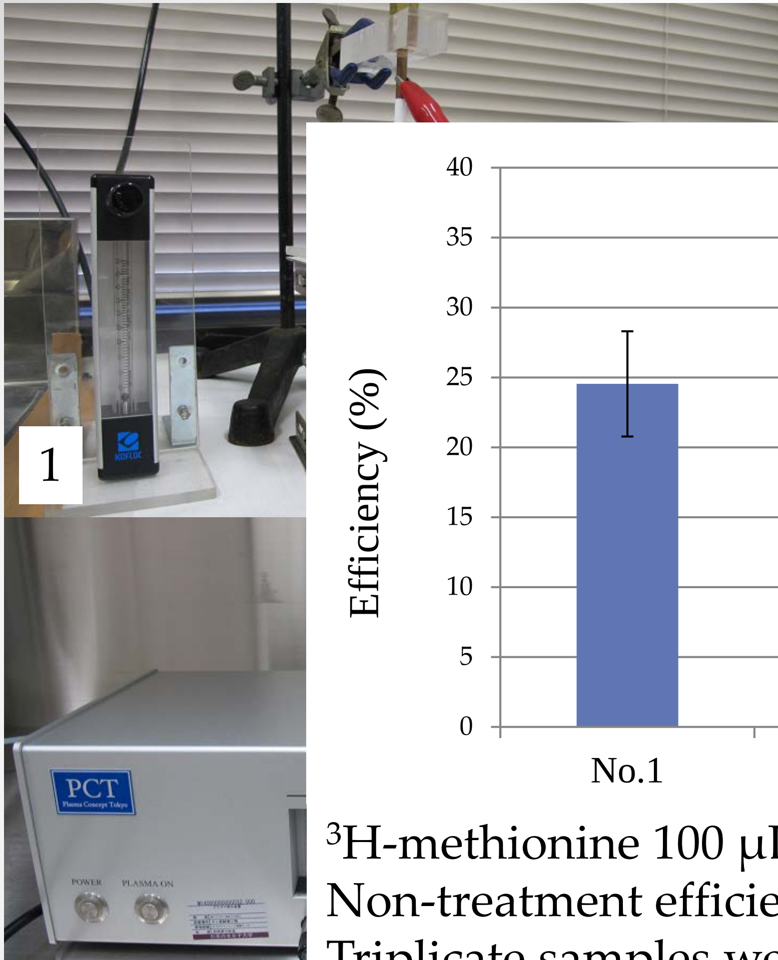
- Difference of plasma devices
- Protection/ damage from UV light
- Difference of vials
- Linearity and detection limits

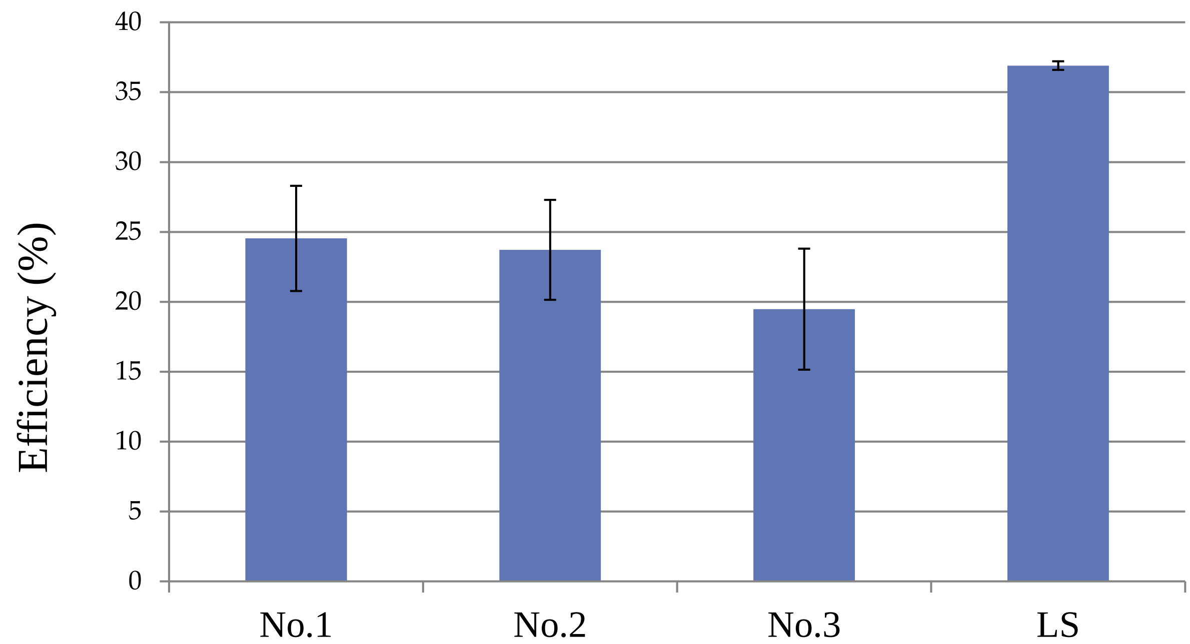
Check of counting efficiency

Materials used

- Plastic scintillator; sheets of **BC-400** (Saint-Gobain, USA) and pellets of **EJ-200** (G-tech, Japan)
- Vials; Teflon (Sanplatec Co., Japan), Polyethylene (ZINSSER ANALYTIC, Germany) and its cap was uGV2-CAP(Meridian, UK)
- Plasma devices except for making by myself; PR-101(Izumi Co., Japan), PCT(Tokyo Plasma Factory, Japan)
- UV auto-fade-meter; U48AUHB (Suga Test Instrument Co., Ltd. Japan)
- LSC; AccuFLEX LSC-LB7(Hitachi Ltd., Japan)
- HTO and ^{3}H-methionine (Moravek Biochemical Inc., USA)
- 5 mL liquid scintillator ACS-2(GE Healthcare, UK) was used to get activity.

Pl… …vice





^{3}H-methionine 100 µL/200 Bq applied to each PS-sheet.
Non-treatment efficiency was approximately 14%.
Triplicate samples were measured.

…here.

Device					…tching
1	DBD	(myself)	Ar(He)	One by one	Yes
2	Low pressure	IP-220P	Air(compressor)	multiple	No
3	Low temperature	TPF	Air, Noble gas, N_2, O_2 (Mixture is possible.)	One by one	Maybe No

Implication of UV light irradiation

An UV auto-fade-meter

- Carbon arc lamp was used.
- Total irradiation time was 12h*365d.
- The irradiation was 500 W/m^2.
- Humidity in the irradiation room was 50%.
-

The counting efficiency (%) of PS-pellets put under natural sunlight through a window glass among 1 year

Vial	UV irradiation	non-irradiation
Polyethylene 145 mL	30.36 ± 1.01	34.65 ± 0.23
Teflon 100 mL	39.61 ± 7.19	46.42 ± 0.90

HTO: 50μL/170 Bq

Counting efficiency depending on vials

Counting efficiency (%)* of tritiated water with PS-pellets filled full in each vial

HTO volume	20 mL glass vial	Polyethylene vial 145 mL	Teflon vial normal cap	100 mL wide mouth a special cap in a bag
5 μL	46.4 ± 1.0	38.9 ± 3.5	-	69.0 ±3.3
25 μL	36.0 ± 0.4	36.3 ± 0.3	-	62.5 ±0.8
50 μL	22.3 ± 0.4	35.8 ± 0.1	46.4 ± 0.9	43.8 ±0.4
100 μL	13.0 ± 0.1	32.1 ± 0.4	-	37.1 ± 0.3
500 μL	3.1 ± 0.1	7.4 ± 0.1	-	20.3± 0.4
1 mL	-	6.5± 0.1	5.8± 0.1	11.1± 0.1
3 mL	-	2.6 ± 0.1	2.3± 0.1	3.7± 0.1
5 mL	-	1.6 ± 0.1	-	1.3 ± 0.1
7 mL	-	1.2 ± 0.1	-	1.0 ± 0.1
10 mL	-	0.80 ± 0.1	-	0.6 ± 0.1
full**	0.085 ± 0.014	0.14±0.0035	0.18±0.0047	-
Weight of PS-pellets	15.5 g	97 g	117 g	72.5 g

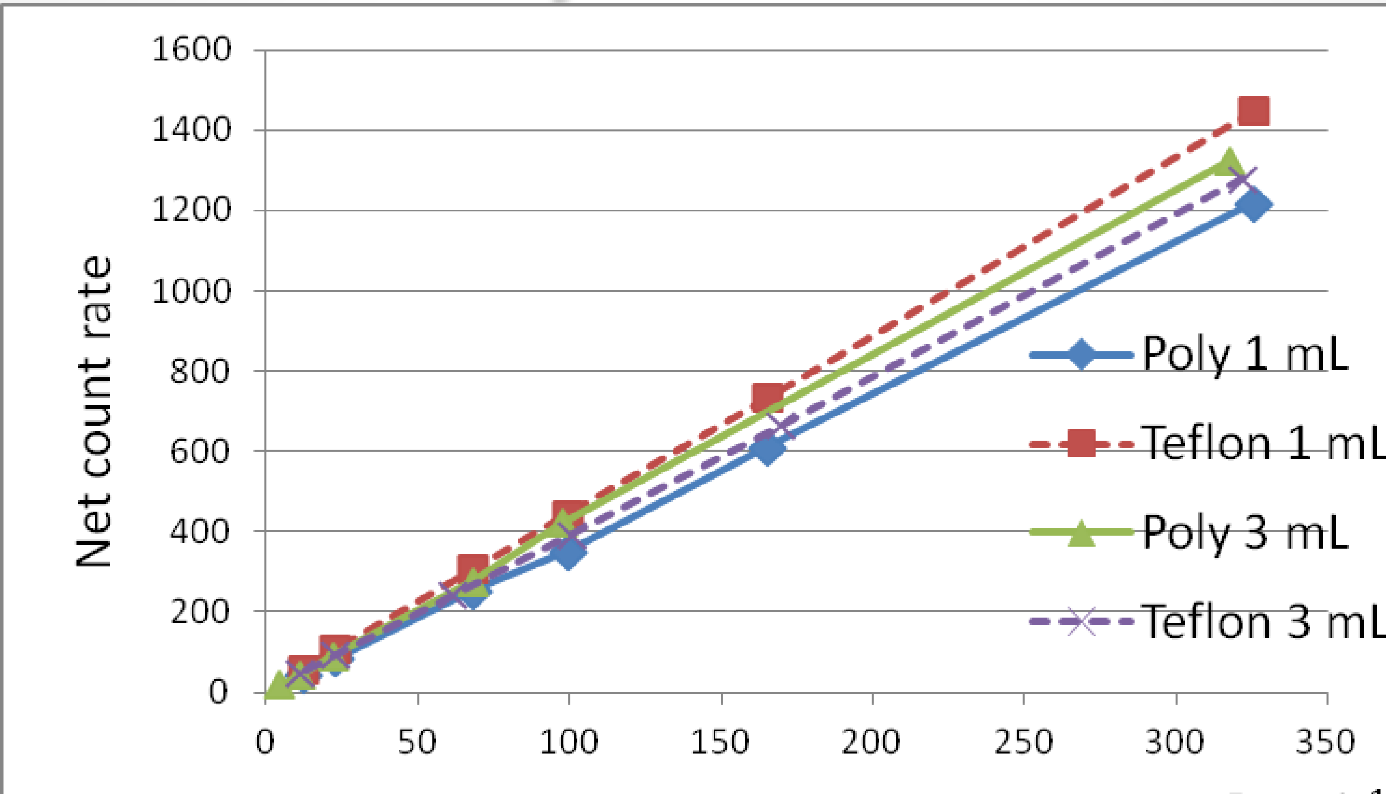
By LS, it was approx. 39%. (5 μL – 10 mL)

*counting efficiency (%) = cpm/dpm×100

**full: Sample was 9 mL in a 20 mL glass vial, 52 mL in a polyethylene vial, and 46 mL in a Teflon vial.

Special cap is appeared at the "Tritium study", tomorrow morning, 2nd.

Linearity of PS method



PS-pellets filled full in each vial.

^{3}H-n

In the case of 1 mL*8sheets.

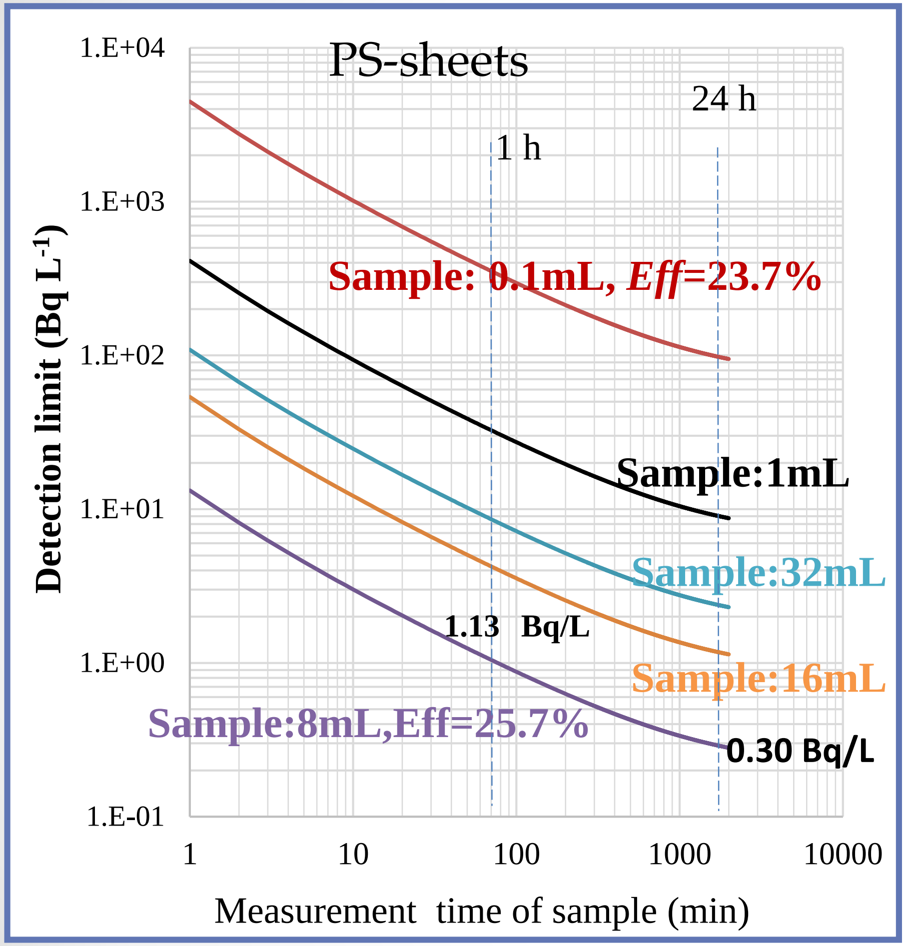
Bq mL-1

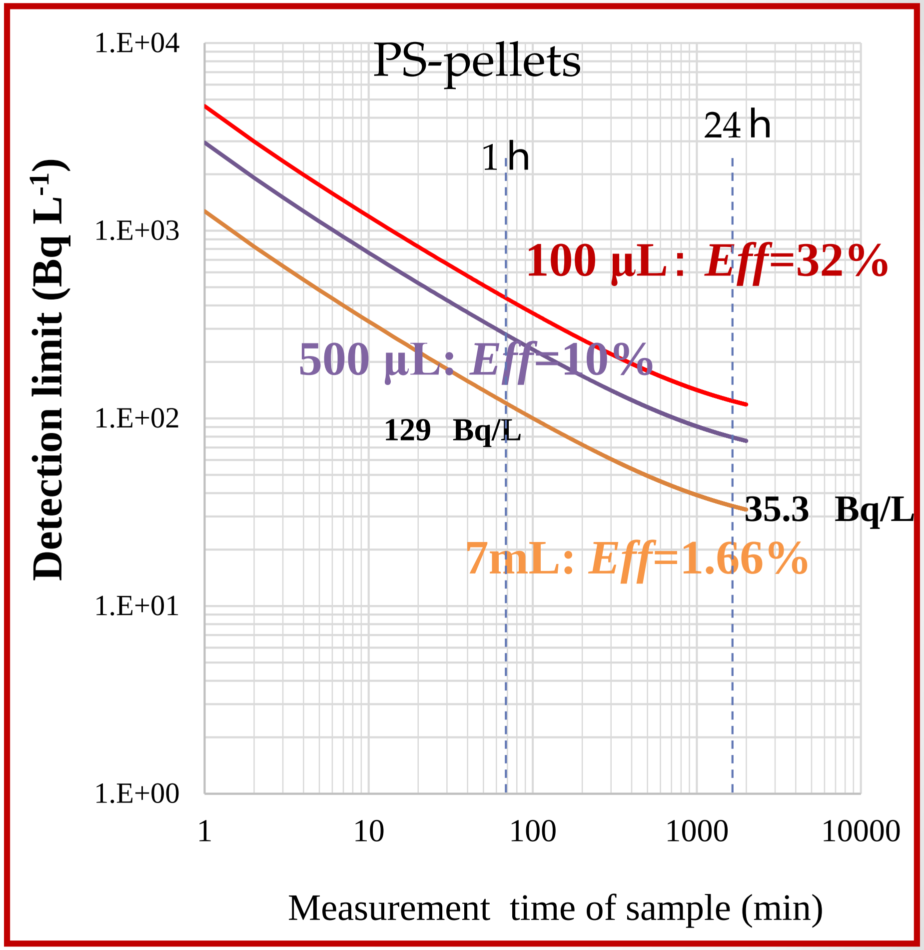
d full

with PS-pellets.

Quantitative analysis is possible with plastic scintillator using LSC-LB7.

Detection limits of PS method





$$n_D = \frac{k^2}{2}\left[\frac{1}{t_S} + \sqrt{\frac{1}{{t_S}^2} + \frac{4n_B}{k^2}\left(\frac{1}{t_S} + \frac{1}{t_B}\right)}\right]$$

- k=2

Both were measured in the 100 mL Teflon vials; 1 mL/ 1 PS-sheet applied to.

Summary

For low energy beta emitters measurement, plastic scintillators (PS) are useful:

- Usage of PS is same with that of liquid scintillator use.
- The counting efficiency is approximately same as that of liquid scintillator use.
- The **PS-sheets** are suited for non-volatile compound, and the **PS-pellets** are suited for volatile compound.
- The **plasma treatment for PS-sheets are useful** especially for tritium, because the wide contact area is effective for short range beta-rays.
- It is necessary to avoid UV-light for stocking the PSs.
- The PSs uses are **organic waste-less** methods.
- Large vials with wide mouth for LSC-LB7 are useful to get low detection limits.

Thank you for your attention !!

Please check a poster No.119.

Please watch the second oral presentation on Friday.