Production of the polyethylene target of the electron scattering for the proton radius puzzle

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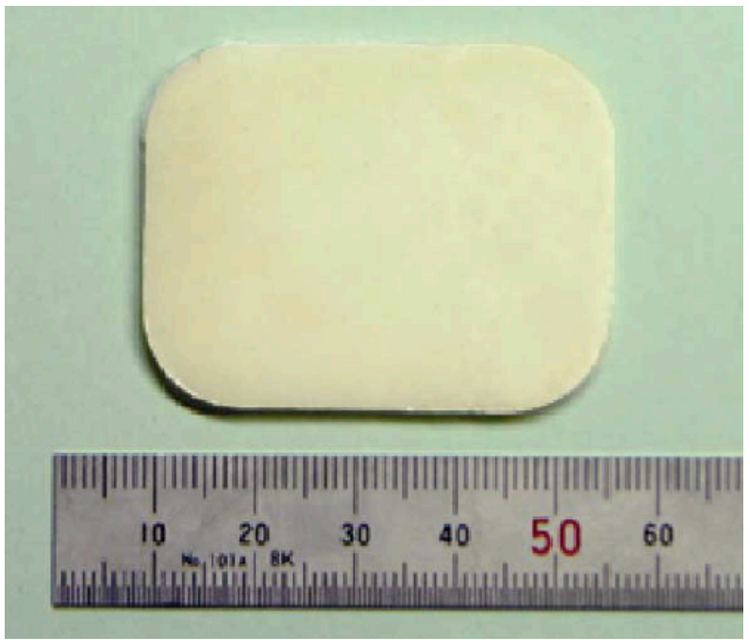
Self introduction

- Research topics
  - Low energy (a few - 400 MeV/A) experiments
  - Three-body nuclear force via N-d scattering
  - Production of deuterated polyethylene (CD_2) targets
    - Y. M. et al., NIMA 490 (2002) 518.
      - Making self-supporting sheets from CD_2 powder
      - 20 - 600 mg/cm^2 (0.2 - 6 mm) thickness with the uniformity of +/- 20 μm

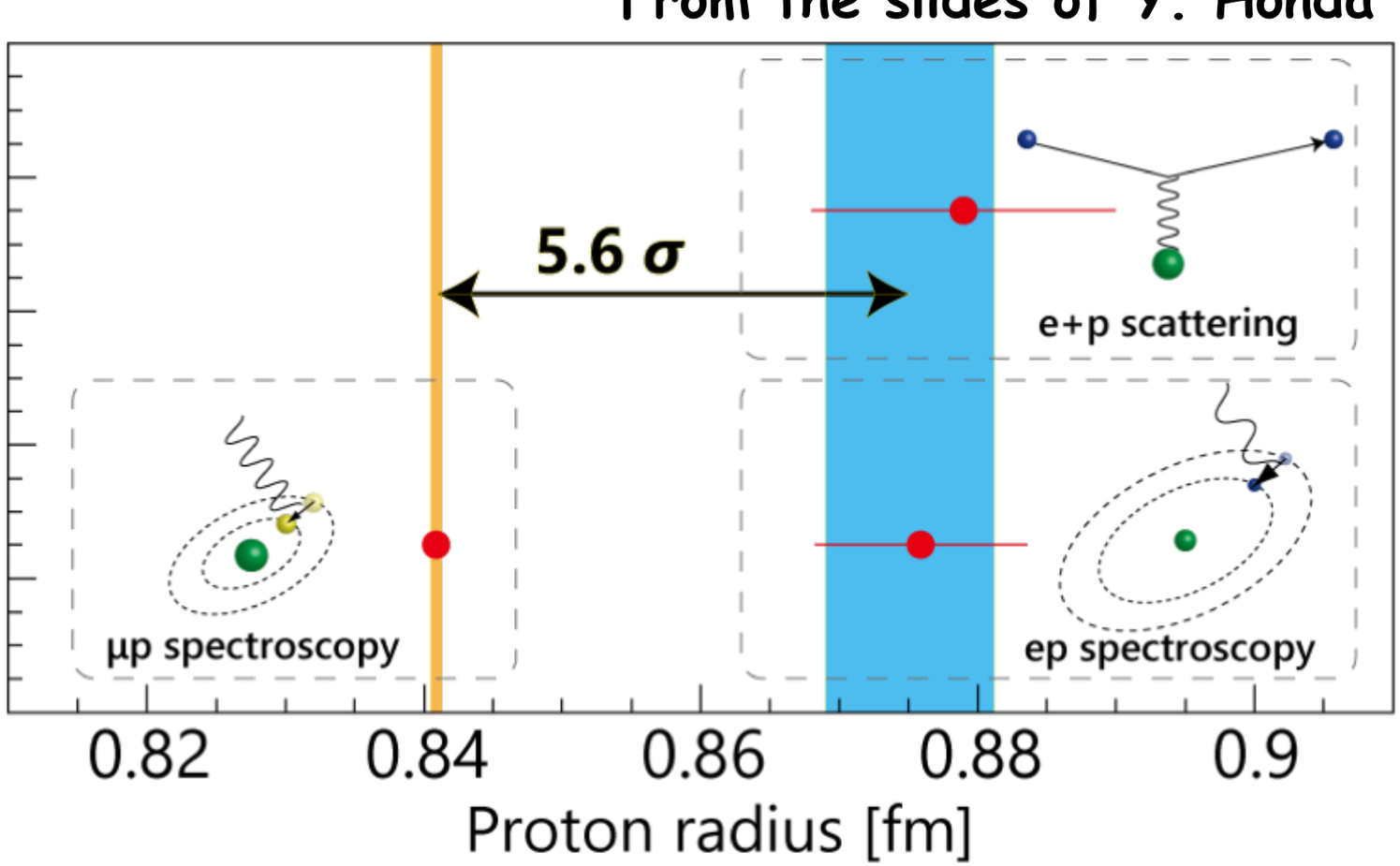


Proton radius puzzle & ULQ2

- Ultra low Q^2 (ULQ2) experimental plan @ ELPH
  - e+p cross section @ E_e = 20-60 MeV, θ =30°-150°
  - Relative meas. of (e+p)/(e+C) with using CH_2 target

- Requirement on polyethylene
  - ^{12}C enriched (if possible)
  - C/H ratio with 0.1% precision
  - ~ 100 μm^t

From the slides of Y. Honda



Anticipated difficulty

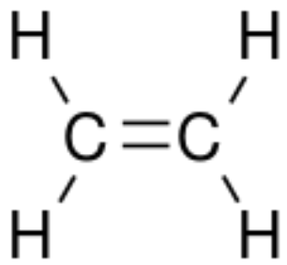
- Comments by a chemist colleague (Prof. J. Matsumoto)
  - Polyethylene w/o additives (添加剤) has “glass transition point (ガラス転移点)” instead of “melting point”.
    -> Hard to melt & mold 100% pure CH_2 powder.
  - In general, polyethylene powder on market contains additives (in secret): includes O and N.
  - Polymerization (重合) technique of polyethylene is basic. But it is hard to avoid isotopic contaminations.

^{12}C enriched polyethylene

- Isotope enriched polyethylene products
  - CD_2, $^{13}CH_2$; purchasable
  - $^{12}CH_2$; not on sale
- How to product polyethylene ?
  - polymerize monomers into polymer by catalytic reaction

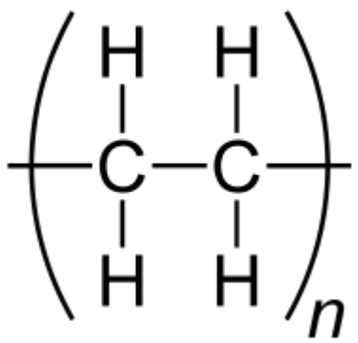
Welcome any information about $^{12}CH_2$ or $^{12}C_2H_6$ products !

ethylene (ethene)

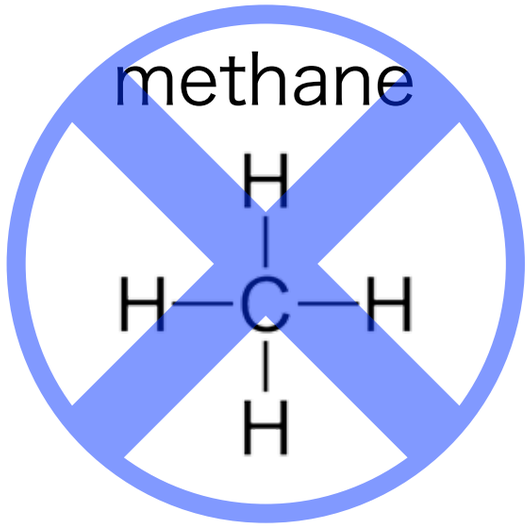


No isotope enriched products on market

polyethylene



methane



Enriched products on market

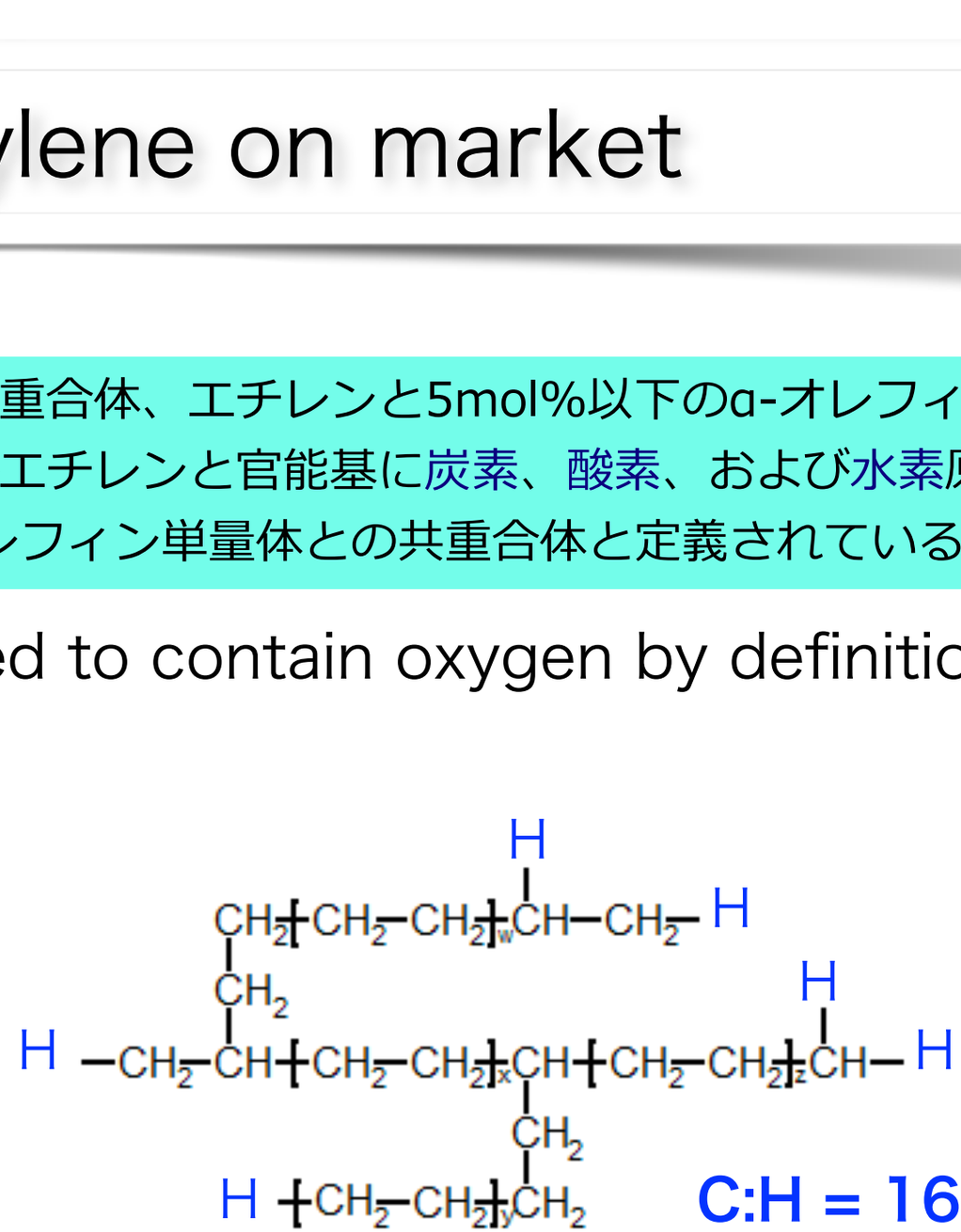
Purity of polyethylene on market

ウィキペディア
フリー百科事典

ポリエチレンはエチレンの単独重合体、エチレンと5mol%以下のα-オレフィレン単量体との共重合体、およびエチレンと官能基に炭素、酸素、および水素原子だけを持つ1mol%以下の非オレフィン単量体との共重合体と定義されている。

Polyethylene is allowed to contain oxygen by definition!

- C:H = 1:2 ?
- Branch structure
- Molecular weight (size)
- Additives



C:H = 16:34

We started to find a way to

1. analyze C/H ratio in polyethylene on market
2. make polyethylene sheets

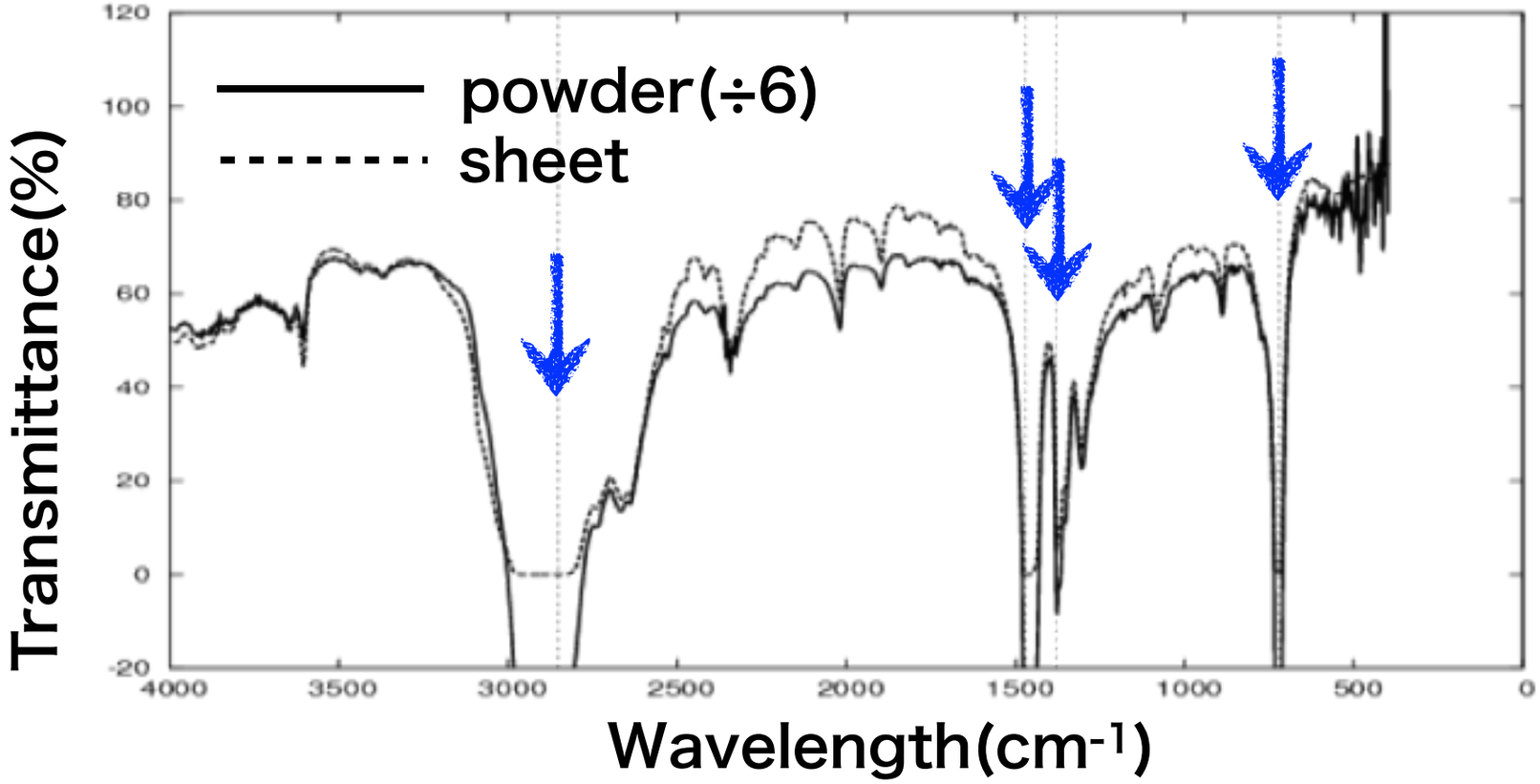
FTIR (Fourier transform infrared spectrometer)
フーリエ変換赤外分光光度計

- All spectra are consistent with polyethylene data.
- No additive is identified.
- Each powder and sheet show same peaks
  -> No contamination

住友精化株式会社
SUMITOMO SEIKA CHEMICALS CO.,LTD.

Flo-thene

- MG701N
- M13152N
- MA1003N



CHN (Carbon, Hydrogen, Nitrogen) elemental analysis

Burn samples with pure O_2 and measure mixture gas (CO_2, H_2O, NOx, etc) by thermal conductivity detector

	Carbon (%)	**Hydrogen (%)**	Nitrogen (%)
Calculations	12/14 = 85.7	2/14 = 14.3	0
Data (mean)	**85.71 +/- 0.09**	**18.11 +/- 0.02**	-0.09 +/- 0.01

C & **N** : OK

H & **O** : should be checked

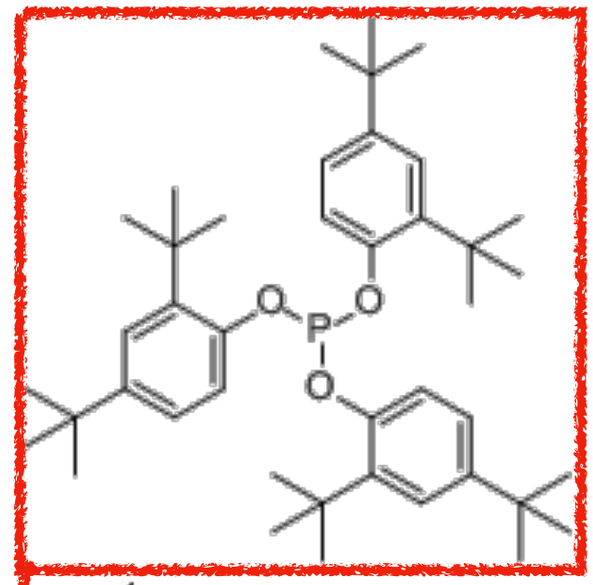
MAYBE, H_2O gas leaked in because of pipe damages inside the device

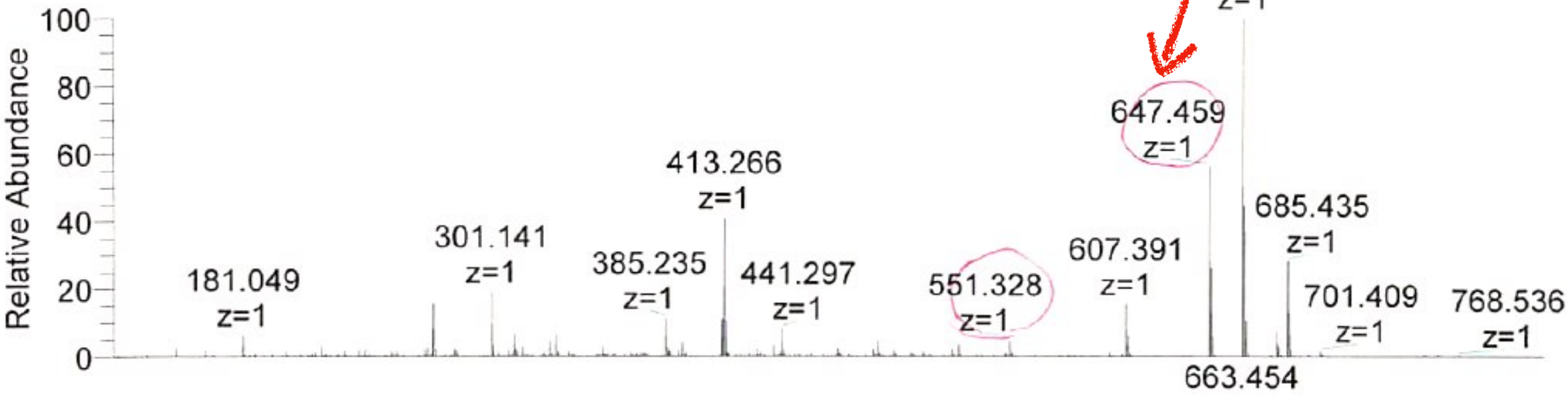
LC/MS　液体クロマトグラフィー
(Liquid Chromatography-Mass spectrometry)

Irgafos(R)168 was found.

(One of typical 28 additives in plastic)

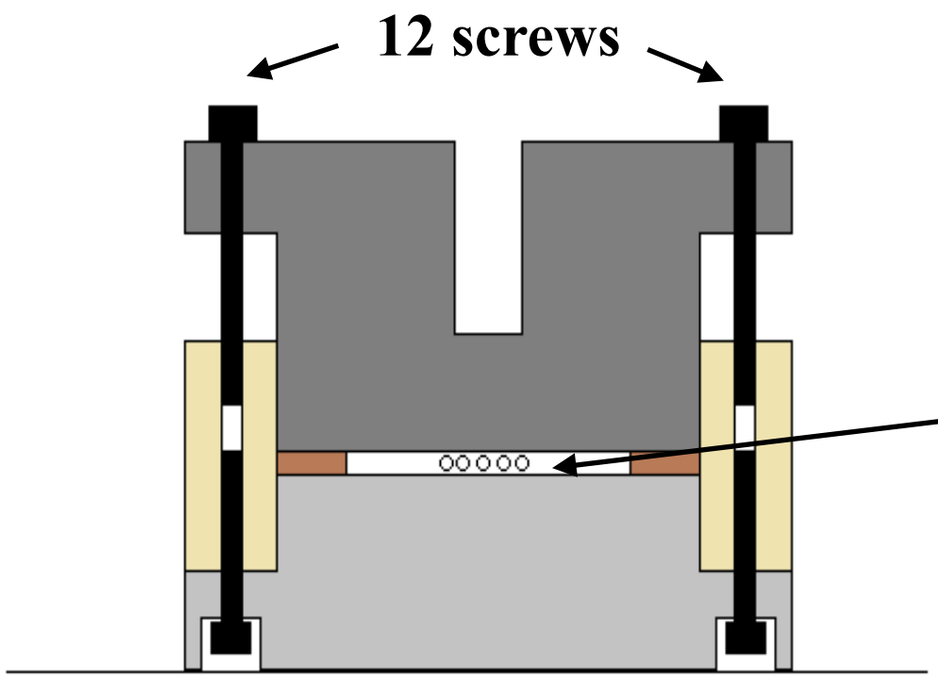
-> Quantitative analysis by LC in future



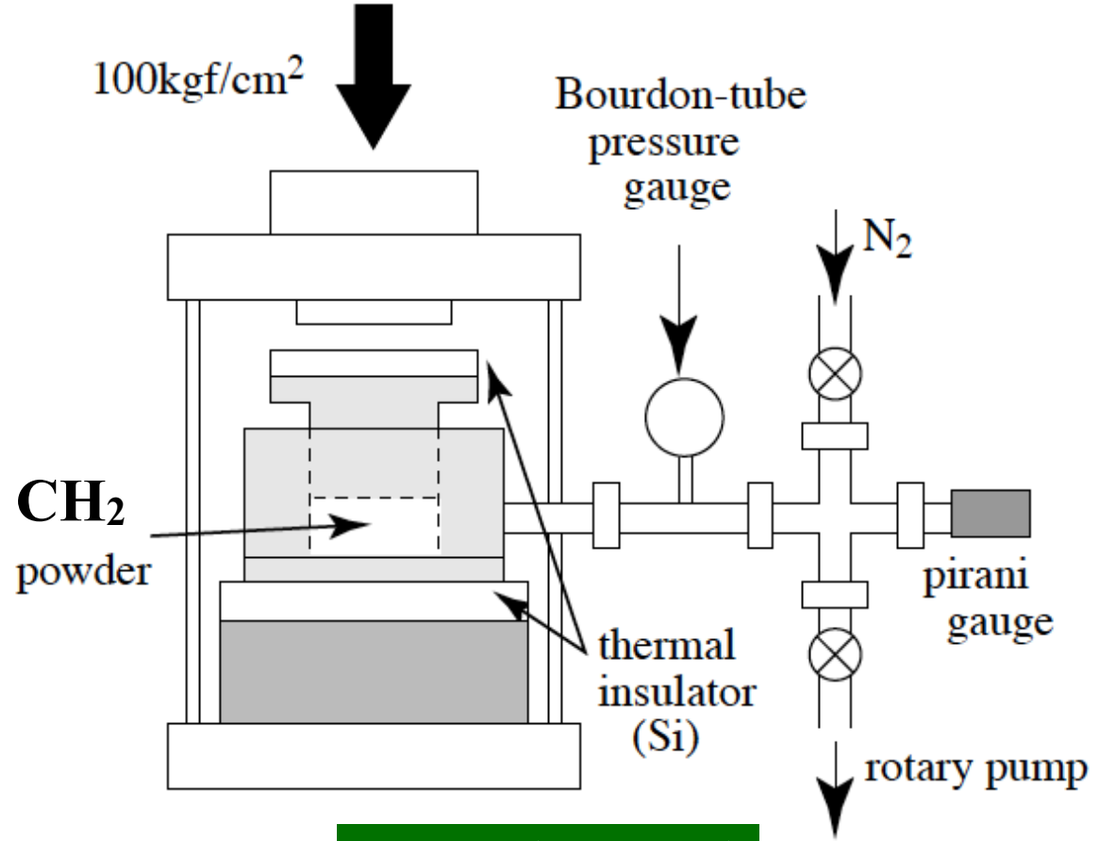


Recipe of polyethylene sheets

1. Put powder into SUS mold (2 types)
2. Heat a mold with a hot-plate or a ribbon-heater (150℃) for 3-6 hours
3. Press a mold by winding-up screws or oil-compressor
4. Cool a mold and remove a sheet



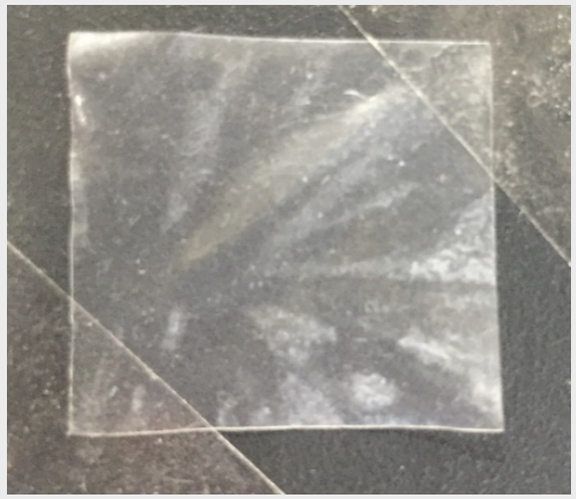
Mold(thin)

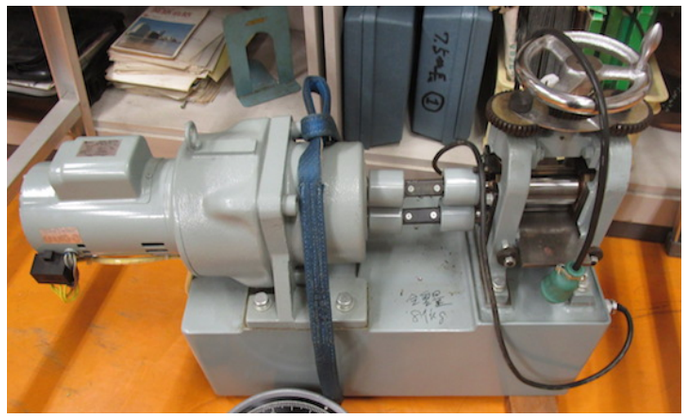


Mold(thick)

Products of CH_2 sheets up to now

Under trial to make 100μm^t sheets without bubbles & with better uniformity

	Mold(thin)	Mold(thick)
Photo	 2cm×2cm	 3.7cm×4.7cm
thickness (non-uni.)	**47μm (11%)**	**489μm (5.3%) ~ 1530μm (3.5%)**
before	47μm (11%)	489μm (5.3%)
1 rolling	**45μm (8.7%)**	—
4 rolling	—	391μm (3.8%)
8 rolling	—	**351μm (2.9%)**



A roller mill from Sugai-Lab. (KEK)

K. Nonaka (M1)

S. Kiyotake(B4)

Supported by Grant-in-Aid for Scientific Research(S) (T. Suda)

Summary

- ULQ2 project needs polyethylene target with the ratio of C/H are precisely known (Δ = 0.1%).
- We started with normal CH_2 powder:
  - FTIR; no contamination when making sheet from powder
  - CHN analysis; C & N ratios are OK. H & O ??
  - LC/MS; Additive (irgafos®168) was found -> How much ?
  - Making sheets; Uniform (+/- 3%) sheet w/o bubbles
- Remaining tasks
  - Making 100 μm^t sheet with 100% pure CH_2 powder
  - Checking the reduction of thickness by beam irradiation
  - Polymerization of $^{12}CH_2$ powder