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ジルコニウム96を用いたニュートリノを放出しない2重ベータ崩壊事象の探索実験　Ｉ

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2012年9月11日

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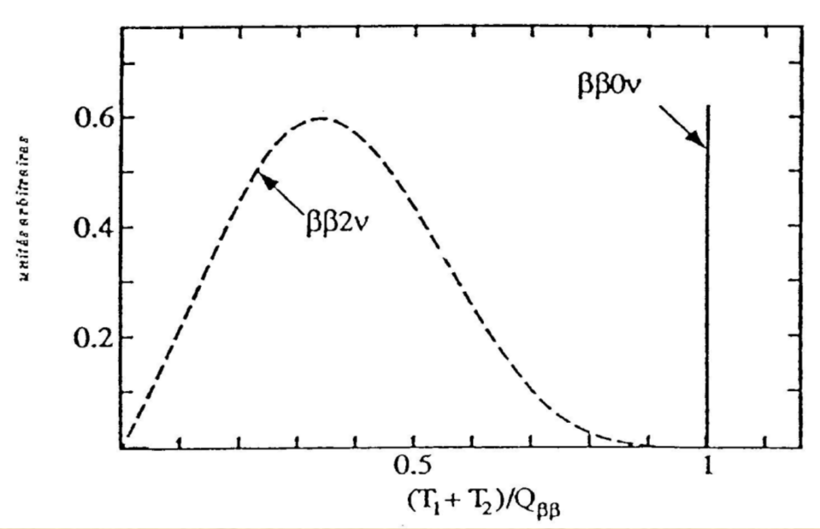
Neutrinoless double beta decay

$\beta\beta$ emitters with $Q_{\beta\beta} > 2$ Mev

Transition	$Q_{\beta\beta}$ (keV)	Abundance (%) ($^{232}Th = 100$)
$^{110}Pd \rightarrow ^{110}Cd$	2013	12
$^{76}Ge \rightarrow ^{76}Se$	2040	8
$^{124}Sn \rightarrow ^{124}Te$	2288	6
$^{136}Xe \rightarrow ^{136}Ba$	2479	9
$^{130}Te \rightarrow ^{130}Xe$	2533	34
$^{116}Cd \rightarrow ^{116}Sn$	2802	7
$^{82}Se \rightarrow ^{82}Kr$	2995	9
$^{100}Mo \rightarrow ^{100}Ru$	3034	10
$^{96}Zr \rightarrow ^{96}Mo$	3350	3
$^{150}Nd \rightarrow ^{150}Sm$	3667	6
$^{48}Ca \rightarrow ^{48}Ti$	4271	0.2



$$[T_{1/2}^{0\nu}(0^+ \rightarrow 0^+)]^{-1} = G_{0\nu}(E_0,Z)|M_{0\nu}|^2 \langle m_\nu \rangle^2$$

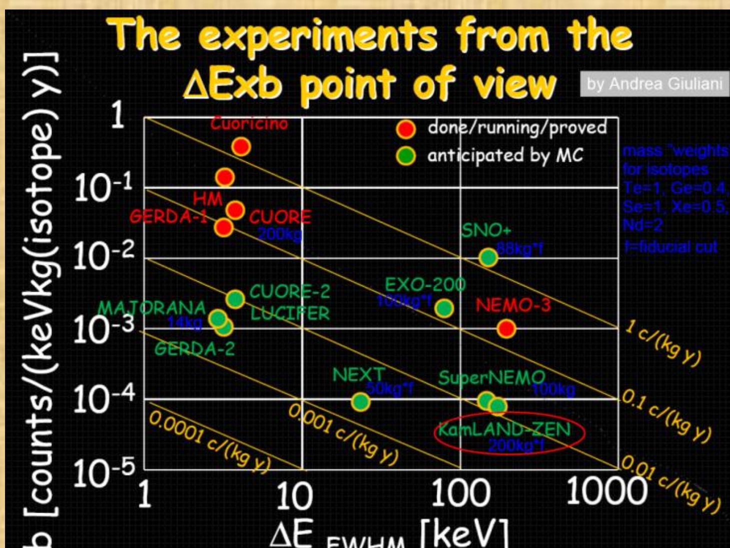
$T_{1/2} \sim a(Mt/\Delta EB)$ a: abundance M: mass

t: meas.time ΔE: energy res. B: BG rate

Requirement :Low BG, Large target mass, High energy resolution

Neutrinoless double beta decay using liquid scintillator

- Experimental limits for neutrino mass

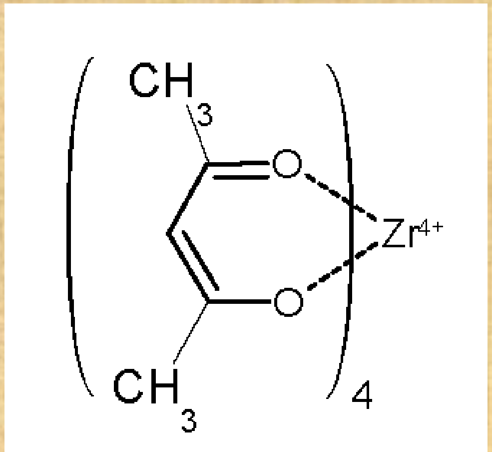


- Requirement for $\langle m_\nu \rangle \sim 10meV$
  - high energy resolution 4%@2.5MeV
  - low background rate 0.01count kg^{-1} y^{-1}
  - ton scale of target

Liq. Scintillator is easy to scale up target volume

Synthesize zirconium complex for resolving liquid scintillator

- Zirconium complex with β diketon

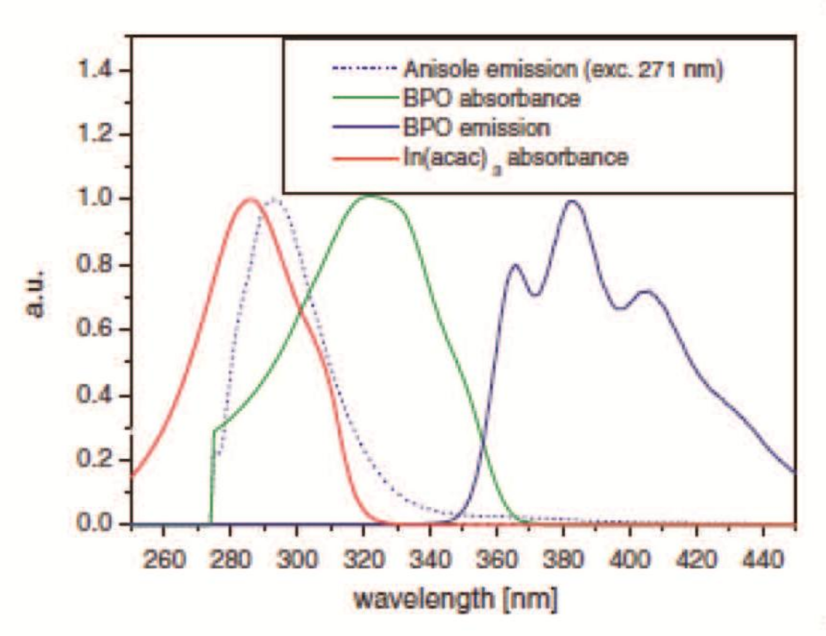


Zirconium Acetyl Acetone

- Advantage
  - good solubility (over 10wt.%) for Anisole (PhOMe)
  - Stable and cheep
- Disadvantage
  - Low scintillation light yield

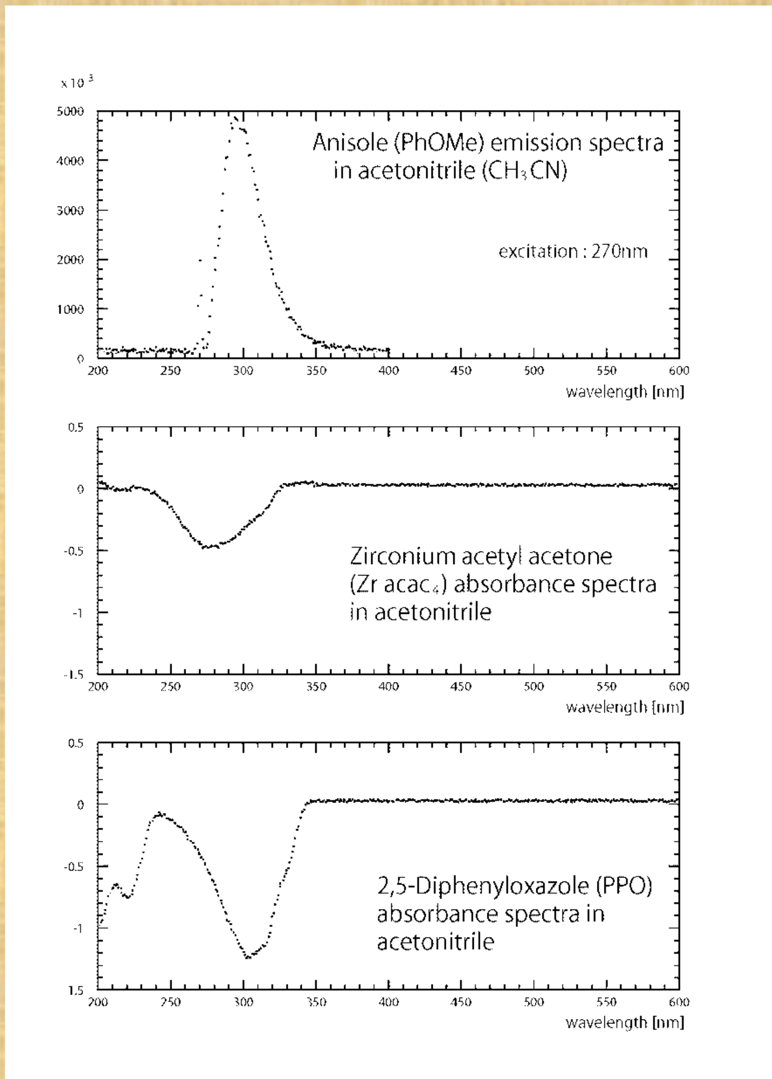
What's problem

- Absorption spectra of $In(acac)_3$ (indium acetyl acetone) was overlapped with the emission spectra from Anisole（Chem. Phys. Lett., 435(2007), 252)



Same overlap of the emission and the absorption spectrum would be occurred even if different metal (Zr) was used.

Absorption spectra of $Zr(acac)_4$



- The emisson spectra of anisole was observed around 295nm.
- The absorption spectra $Zr(acac)_4$ was observed around 270nm.

Same problem due to small scintillation light yield could be expected.

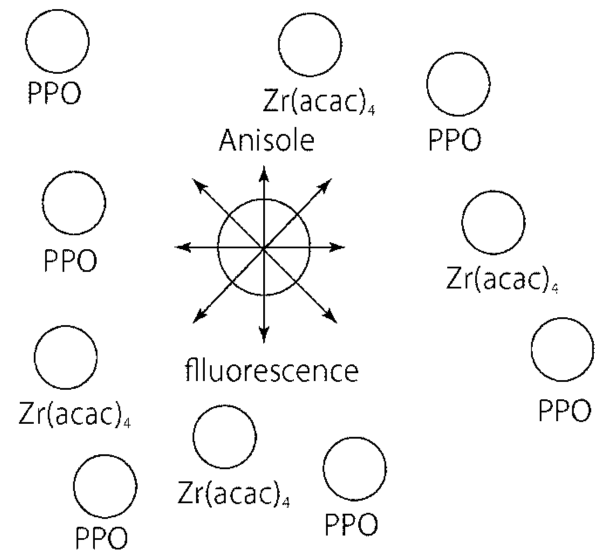
How to expect the light yield

- Assuming to same cross section for light

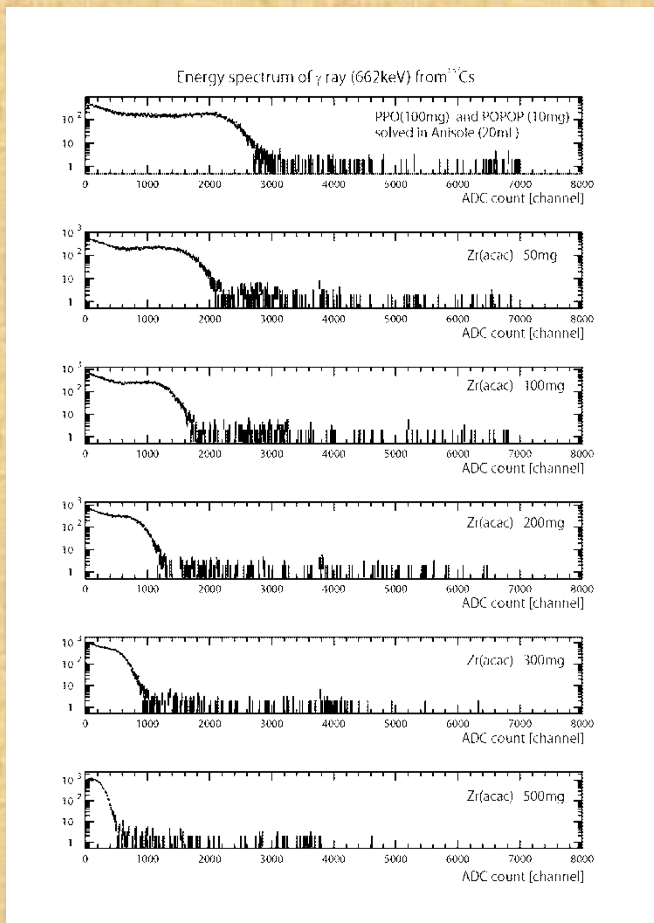
$$\text{Light yield} = L_0 \times \frac{N_{ppo}}{N_{ppo} + N_{Zr(acac)4}}$$

L_0 : Light yield of anisole + PPO+POPOP

N_{ppo} and $N_{Zr(acac)4}$: No. of molecular of PPO and $Zr(acac)_4$

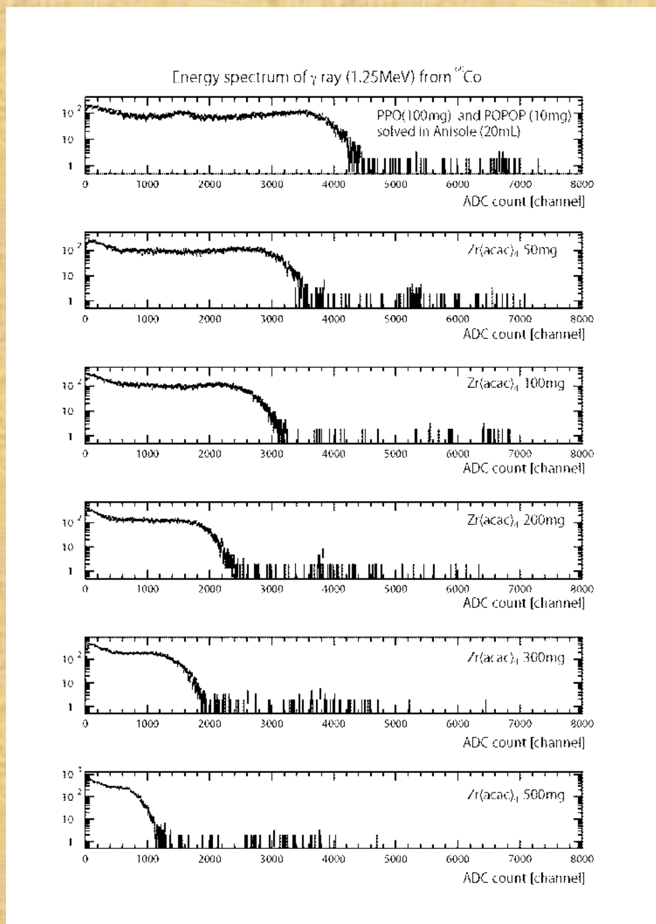


Variance of Light yield (^{137}Cs) vs concentration of $Zr(acac)_4$



concentration of $Zr(acac)_4$	Observed channel	Expected channel
0 mg	2450	2450
50mg	1800	1997
100mg	1400	1687
200mg	950	1284
300mg	650	1038
500mg	300	750

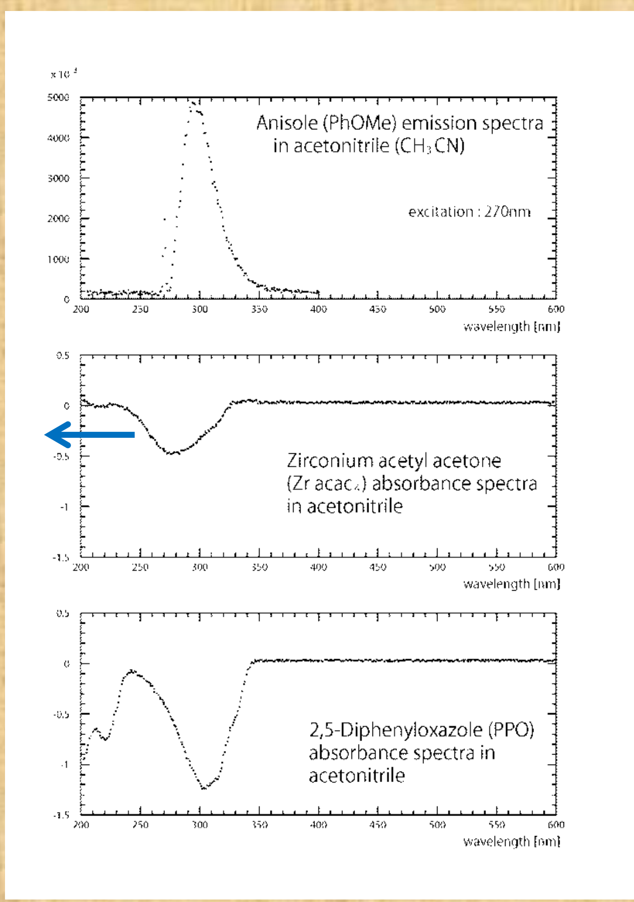
Variance of Light yield (^{60}Co) vs concentration of $Zr(acac)_4$



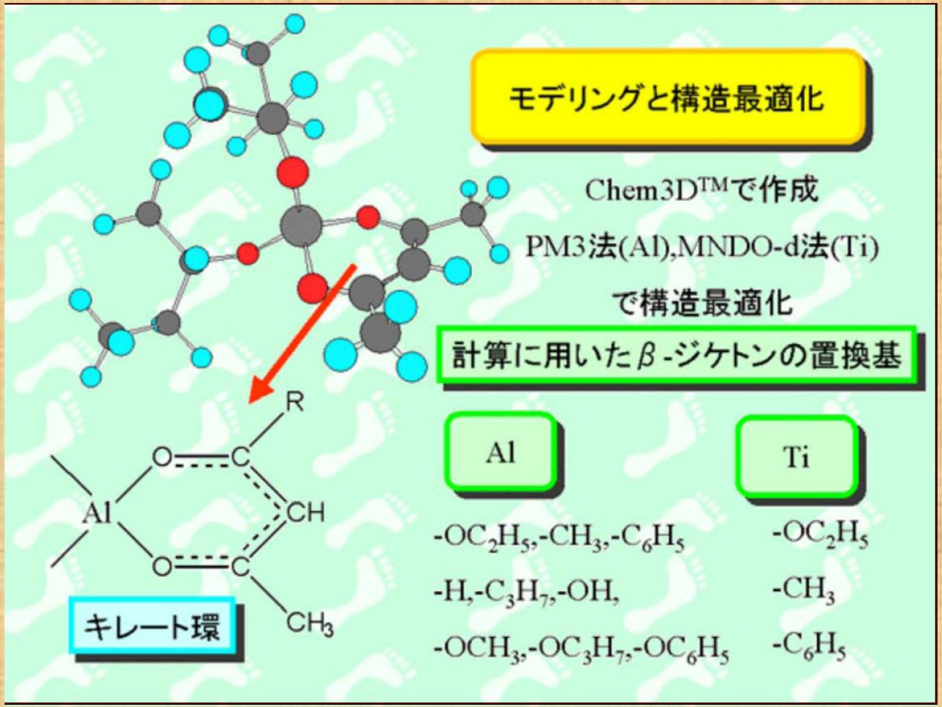
concentration of $Zr(acac)_4$	Observed channel	Expected channel
0 mg	3850	3850
50mg	3175	3138
100mg	2800	2651
200mg	2000	2018
300mg	1600	1613
500mg	900	1178

Next step

- Move absorption peak to shorter wave length



- How to do it?
  substituent groups

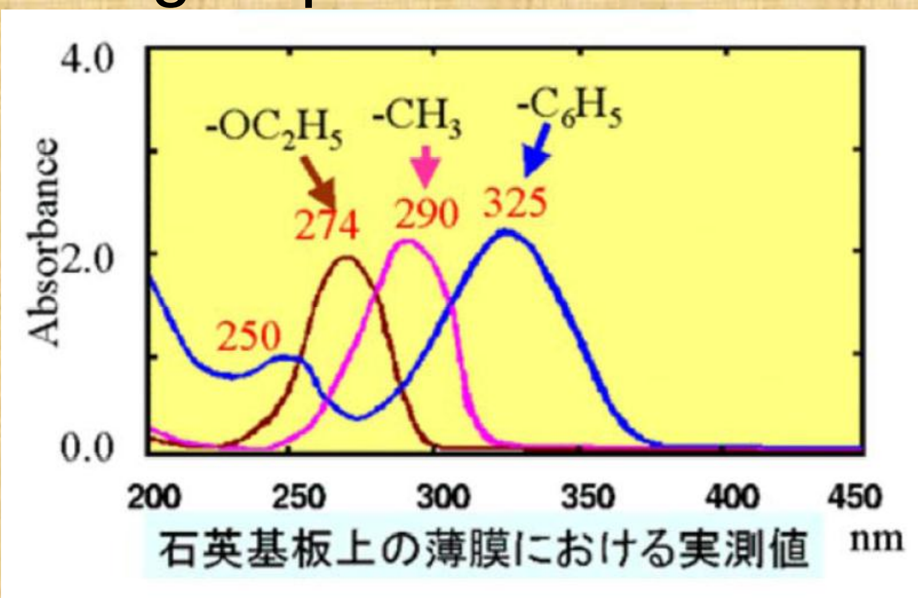


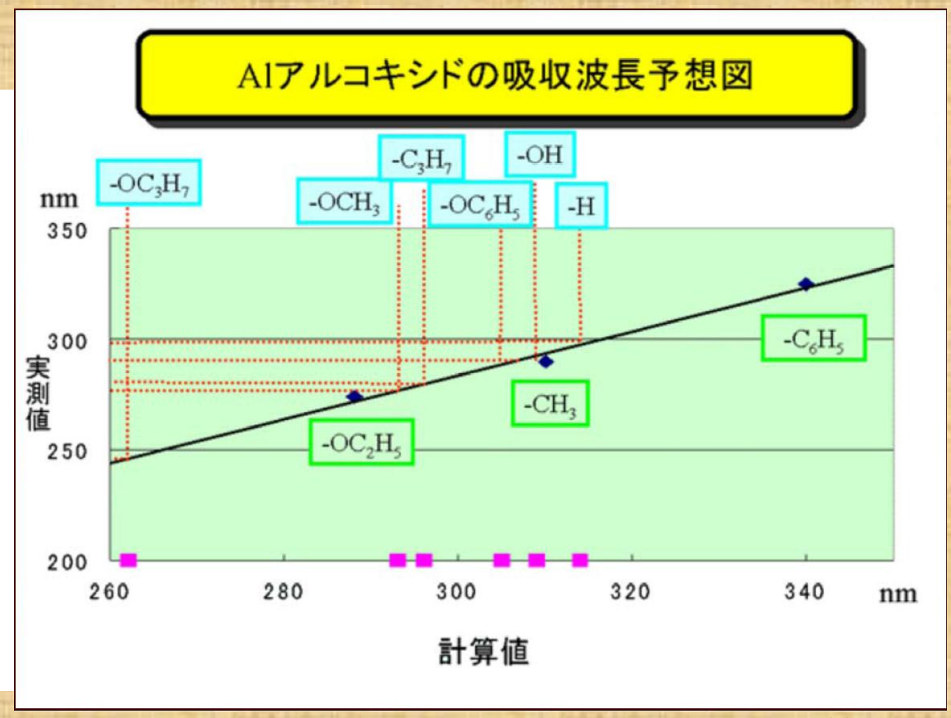
Courtesy of Prof. Y.Kowada (Hyogo University of Education)

http://www.hi-ho.ne.jp/hosomi/sotsuron

Variance of absorbance peak for several substituent groups

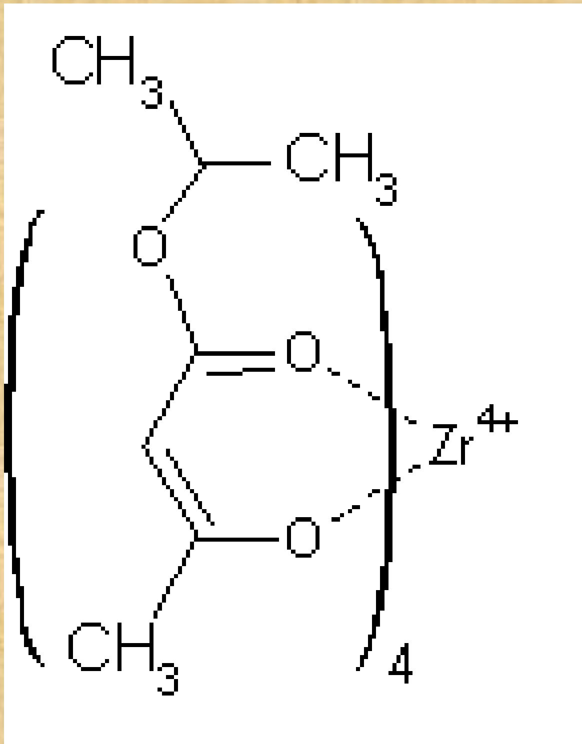
- Measured absorbance peaks for several substituent groups
- Expected absorbance peak for several substituent groups



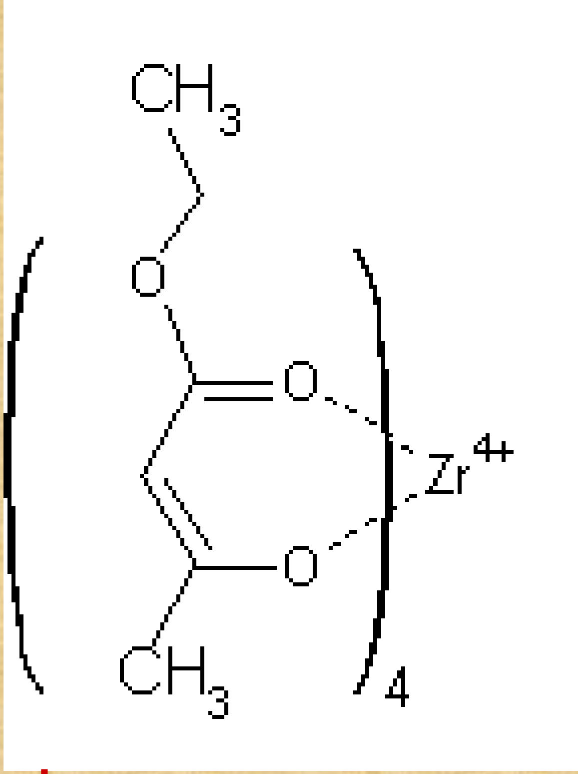


Zr β-diketon complex introducing substituent groups

MeCOCH2COOPr-Zr complex



MeCOCH2COOEt-Zr complex



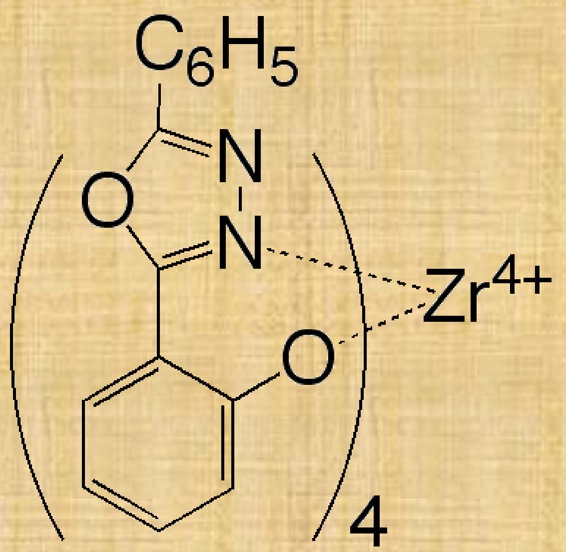
Now synthesizing…

Conclusion

- Confirm huge solubility for $Zr(acac)_4$ in Anisole. (>~10wt.%)
- Observed weaker scintillation light yield as proportional to the concentration of $Zr(acac)_4$ due to overlap of the absorbance of $Zr(acac)_4$ and the emission of anisole.
- Introduce $-OC_3H_7$ or $-OC_2H_5$ substituent groups for $Zr(acac)_4$ to shorten wave length for absorbance peak. (now synthesizing…)

Another developments

- Synthesize Zr-ODZ complex



Now synthesizing…

- large Quantum Yield : ~0.8

large light yield expected

- Emission WL: ~ 450nm

PMT sensitive

- unknown solubility?
- Best solvent : PhCN ?

予備