Effect of sodium salicylate (SS) on the determination of Pb-210/Bi-210 by Cerenkov counting

Wang Yadong, Song Lijuan, Dai Xiongxin
China Institute for Radiation protection, China
Outline

• Introduction
• Preliminary tests with SS
• What causes the increase of efficiency
• Conclusions
Introduction

- **Cerenkov counting**
  - The threshold energy for beta: 0.263 MeV (refractive index = 1.33)

- **Advantages**
  - An natural discriminator of high-energy beta from low-energy beta and alpha
  - No cocktail mixing with samples
  - Could be used further after counting

Fig 1 Simplified decay chain of Pb-210
**Introduction**

- **Cerenkov light of Bi-210**
- Cerenkov efficiency: lower than 20%
- $E_{\beta\text{average}} = 0.389\text{Mev}$
- A large proportion of Cerenkov light lie in UV region

- **Wavelength shifting**
- Sodium salicylate

![Fig 2 Spectra of Cerenkov light created in water for various electron energies](image)

- Solubility: 1000g/L (20°C)
- Absorption spectrum: 85.0~350.0 nm
- Fluorescence spectrum: around 425.0 nm
Preliminary tests with SS

- **Experimental**
  - Spiked with **Pb-210 standard**
    (Pb-210, **Bi-210** and **Po-210** are in equilibrium)
  - **Instrument**: Hidex 300SL
    (with 3 PMTs enabling TDCR)

- **Results**
  - Assuming that all the pulses are caused by Cerenkov light of Bi-210
  - Detection efficiency:
    - without SS, **15.1%**
    - with 0.05g/g SS, **100.3%**
Preliminary tests with SS

• Screening the concentrations of SS for the best

It was unexpected

Po-210 and Pb-210 might produce scintillation light.
What causes the increase of efficiency

• Scintillation?
• Experiment preparation

I. Separation of Bi-210 and Po-210 by Sr-resin
    Calibration by LSC using UG AB: a) TDCR, b) decay curve of Bi-210
    Both Bi-210 and Po-210 were purified well

II. Simplifying experiment
    Ni-63 as alternative of Pb-210
    Ni-63: $E_{\beta_{\text{max}}}=0.067\text{Mev}$
    $E_{\beta_{\text{average}}}=0.017\text{Mev}$
    Daughter: stable Cu-63
What causes the increase of efficiency

- **Scintillation**!

  - The efficiency of Pb-210 standard (with Bi-210 and Po-210 in equilibrium) is equal to the sum of Bi-210 and Po-210
  - The efficiency of Po-210 is high because of scintillation
  - The efficiency of Bi-210 reaches 35%
  - The efficiency of Ni-63 (Pb-210) is almost zero
What causes the increase of efficiency

- The increased efficiency of Bi-210

The increased efficiency of Bi-210 by adding SS might be caused by three possibilities,

a) scintillation

b) wavelength shifting the Cerenkov light

c) refractive index
Refractive index of SS and NaCl solutions

<table>
<thead>
<tr>
<th>Concentration (g/g)</th>
<th>Refractive index</th>
<th>Refractive index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SS</td>
<td>NaCl</td>
</tr>
<tr>
<td>0</td>
<td>1.3333</td>
<td>1.3333</td>
</tr>
<tr>
<td>0.010</td>
<td>1.3354</td>
<td>1.3350</td>
</tr>
<tr>
<td>0.047</td>
<td>1.3435</td>
<td>1.3417</td>
</tr>
<tr>
<td>0.089</td>
<td>1.3526</td>
<td>1.3490</td>
</tr>
<tr>
<td>0.163</td>
<td>1.3695</td>
<td>1.3620</td>
</tr>
</tbody>
</table>

- The increase of refractive index by adding SS is **not** mainly contributed to the increase of efficiency.
Conclusions

• Sodium salicylate acts as a scintillator and produce scintillation light by alpha particles;
• The increased efficiency of Bi-210 by SS is not mainly due to the increase of refractive index;
• Both wavelength shifting and scintillation light from SS may be contributed to the increase of efficiency for Bi-210 and need to be demonstrated further.
Thank you for your attention