Development of Phosphate Glass doped with Barium for Radiation Shielding

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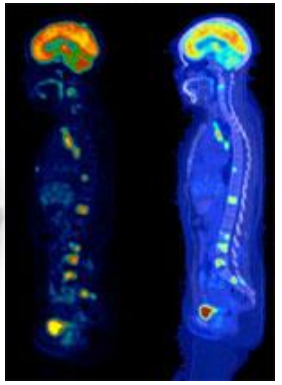
CHIANG MAI UNIVERSITY

Introductions

Introductions

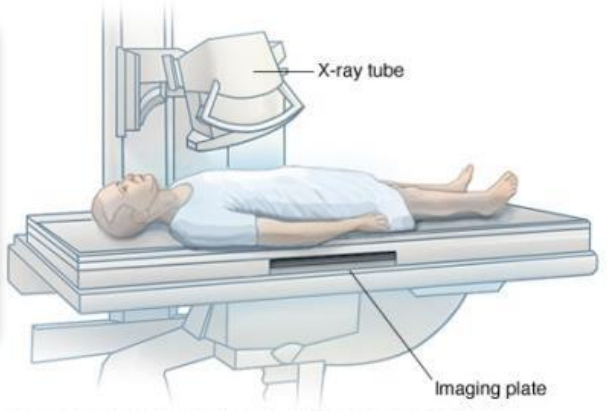
Diagnostic

Nuclear Medicine

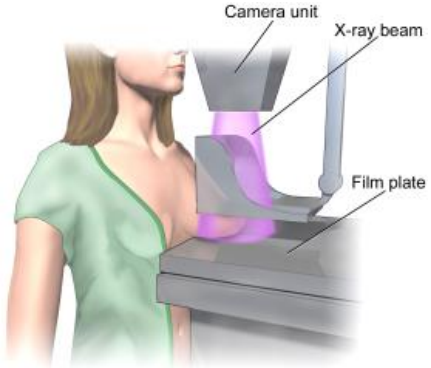


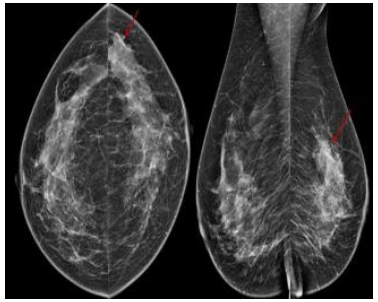
Therapy

General X-ray

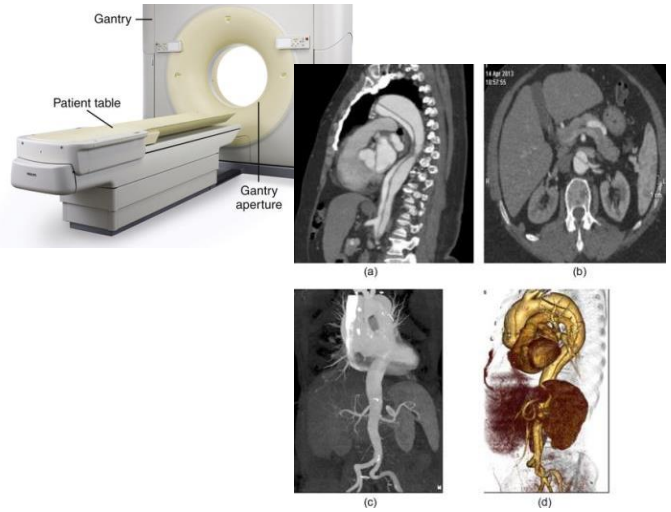


Mammography

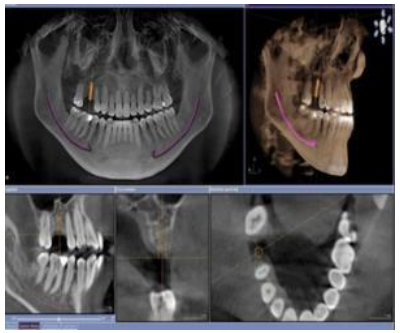




CT Scan



Dental



Introductions

Diagnostic

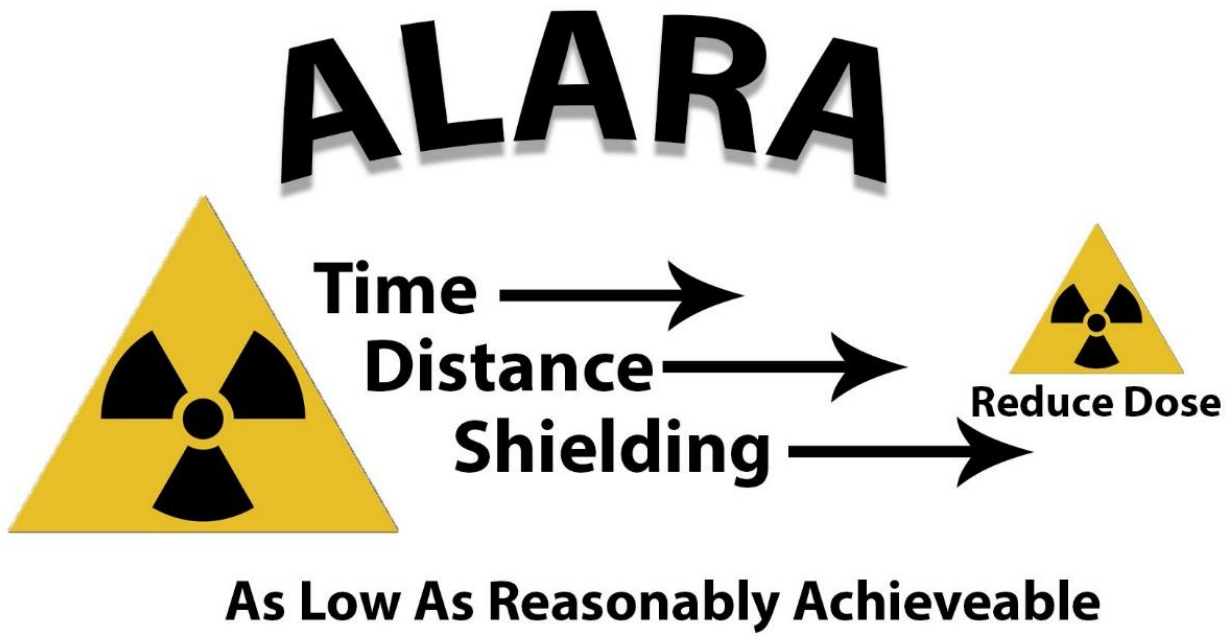
Exposure Technique

Voltage: 40 - 120 kVp
Current : 100-400 mA
Time : 0.01-10 s

Introductions

National Council on Radiation Protection and Measurements

NCRP 103



Glass Radiation Shielding

Lead (Pb)

http://www.x-raymate.com/images/DSC0064%20%E0%B8%89%E0%B8%B2%E0%B8%81%2011.JPG

https://www.siamchemi.com/wp-content/uploads/2017/04/%E0%B9%81%E0%B8%A3%E0%B9%88%E0%B8%95%E0%B8%B0%E0%B8%81%E0%B8%B1%E0%B9%88%E0%B8%A7.jpg

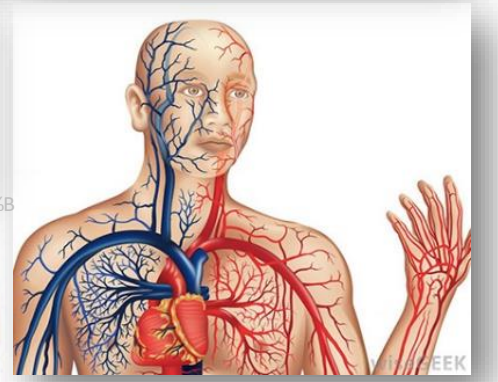
Toxicity

https://png.pngtree.com/element_origin_min_pic/17/07/16/

https://www.matichon.co.th/wp-content/uploads/2018/03/%E0%B8%A0%E0%B8%9B-%E0%B9%84%E0%B8%95%E0%B8%A7%E0%B8%B2%E0%B8%A2.jpg

http://ha[illegible]%E0%B8%B0%E0%B8%

https://www.health2click.com/wp-content/uploads/2018/07

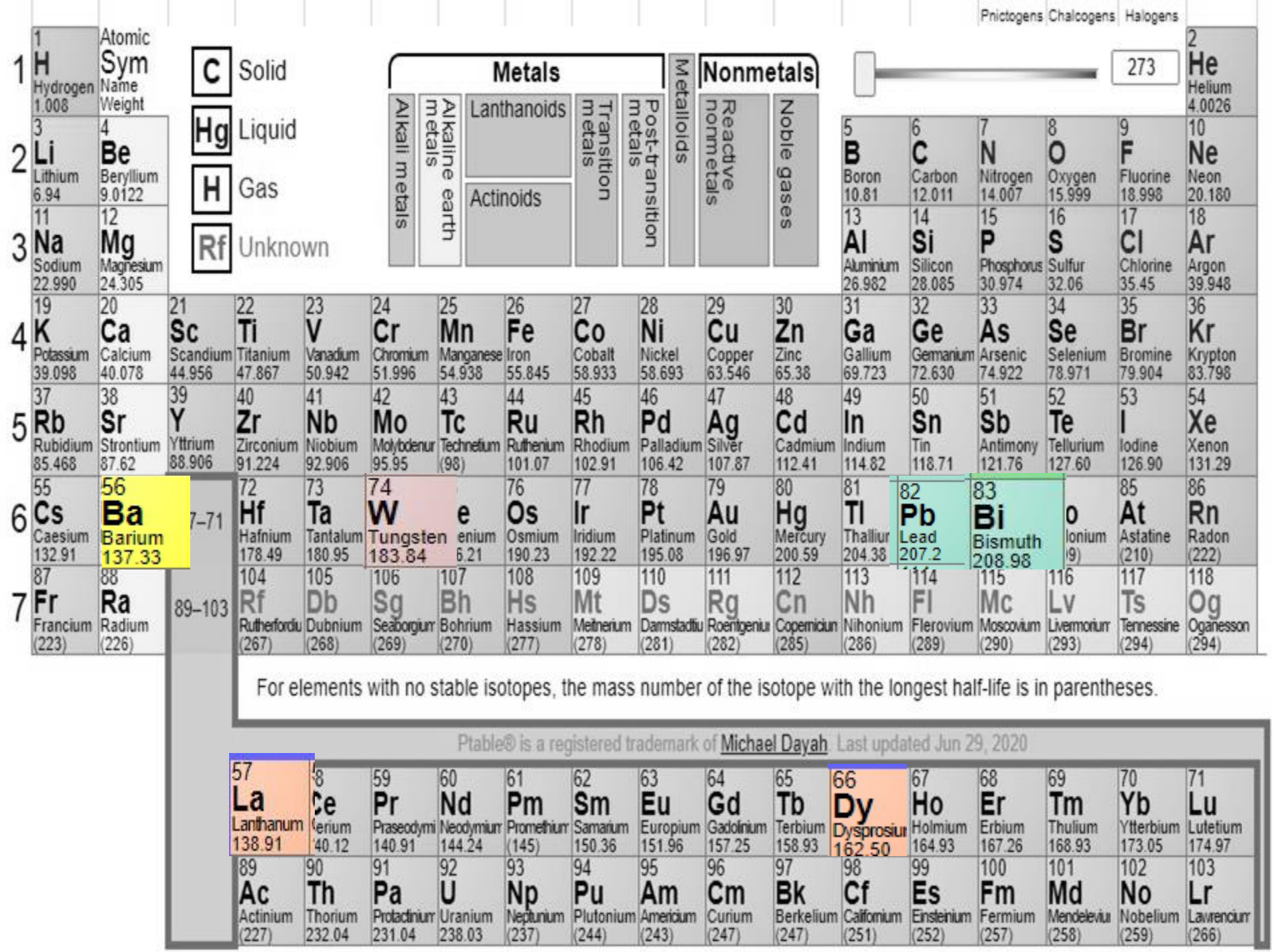


https://cosmoneochayawut.files.wordpress.com/2016/05/00.jpg?w=1400

Glass

https://upload.ecvv.com/upload/UserImage/20150728/LeadGlassforShieldingXray_75b244d5-341e-4d8c-8f33-ff68fe74f134.jpg

- High Transparency
- Doped Concentrations
- Low toxicity


Pnictogens
Chalcogens
Halogens
1
Atomic
Sym
Name
Weight
C Solid
Hg Liquid
H Gas
Rf Unknown
Metals
Alkali metals
Alkaline earth metals
Lanthanoids
Actinoids
Transition metals
Post-transition metals
Metalloids
Nonmetals
Reactive nonmetals
Noble gases
273
1 H Hydrogen 1.008
2 He Helium 4.0026
3 Li Lithium 6.94
4 Be Beryllium 9.0122
5 B Boron 10.81
6 C Carbon 12.011
7 N Nitrogen 14.007
8 O Oxygen 15.999
9 F Fluorine 18.998
10 Ne Neon 20.180
11 Na Sodium 22.990
12 Mg Magnesium 24.305
13 Al Aluminium 26.982
14 Si Silicon 28.085
15 P Phosphorus 30.974
16 S Sulfur 32.06
17 Cl Chlorine 35.45
18 Ar Argon 39.948
19 K Potassium 39.098
20 Ca Calcium 40.078
21 Sc Scandium 44.956
22 Ti Titanium 47.867
23 V Vanadium 50.942
24 Cr Chromium 51.996
25 Mn Manganese 54.938
26 Fe Iron 55.845
27 Co Cobalt 58.933
28 Ni Nickel 58.693
29 Cu Copper 63.546
30 Zn Zinc 65.38
31 Ga Gallium 69.723
32 Ge Germanium 72.630
33 As Arsenic 74.922
34 Se Selenium 78.971
35 Br Bromine 79.904
36 Kr Krypton 83.798
37 Rb Rubidium 85.468
38 Sr Strontium 87.62
39 Y Yttrium 88.906
40 Zr Zirconium 91.224
41 Nb Niobium 92.906
42 Mo Molybdenum 95.95
43 Tc Technetium (98)
44 Ru Ruthenium 101.07
45 Rh Rhodium 102.91
46 Pd Palladium 106.42
47 Ag Silver 107.87
48 Cd Cadmium 112.41
49 In Indium 114.82
50 Sn Tin 118.71
51 Sb Antimony 121.76
52 Te Tellurium 127.60
53 I Iodine 126.90
54 Xe Xenon 131.29
55 Cs Caesium 132.91
56 Ba Barium 137.33
57–71
72 Hf Hafnium 178.49
73 Ta Tantalum 180.95
74 W Tungsten 183.84
76 Os Osmium 190.23
77 Ir Iridium 192.22
78 Pt Platinum 195.08
79 Au Gold 196.97
80 Hg Mercury 200.59
81 Tl Thallium 204.38
82 Pb Lead 207.2
83 Bi Bismuth 208.98
85 At Astatine (210)
86 Rn Radon (222)
87 Fr Francium (223)
88 Ra Radium (226)
89–103
104 Rf Rutherfordium (267)
105 Db Dubnium (268)
106 Sg Seaborgium (269)
107 Bh Bohrium (270)
108 Hs Hassium (277)
109 Mt Meitnerium (278)
110 Ds Darmstadtium (281)
111 Rg Roentgenium (282)
112 Cn Copernicium (285)
113 Nh Nihonium (286)
114 Fl Flerovium (289)
115 Mc Moscovium (290)
116 Lv Livermorium (293)
117 Ts Tennessine (294)
118 Og Oganesson (294)
For elements with no stable isotopes, the mass number of the isotope with the longest half-life is in parentheses.
Ptable® is a registered trademark of Michael Dayah. Last updated Jun 29, 2020
57 La Lanthanum 138.91
58 Ce Cerium 140.12
59 Pr Praseodymium 140.91
60 Nd Neodymium 144.24
61 Pm Promethium (145)
62 Sm Samarium 150.36
63 Eu Europium 151.96
64 Gd Gadolinium 157.25
65 Tb Terbium 158.93
66 Dy Dysprosium 162.50
67 Ho Holmium 164.93
68 Er Erbium 167.26
69 Tm Thulium 168.93
70 Yb Ytterbium 173.05
71 Lu Lutetium 174.97
89 Ac Actinium (227)
90 Th Thorium 232.04
91 Pa Protactinium 231.04
92 U Uranium 238.03
93 Np Neptunium (237)
94 Pu Plutonium (244)
95 Am Americium (243)
96 Cm Curium (247)
97 Bk Berkelium (247)
98 Cf Californium (251)
99 Es Einsteinium (252)
100 Fm Fermium (257)
101 Md Mendelevium (258)
102 No Nobelium (259)
103 Lr Lawrencium (266)

Glass Formula

P_2O_5-NaF-ZnF_2-AlF_3-BaO

High Atomic Number (Z = 56)

Low toxicity

High Density

Enhance Radiation Absorption

P_2O_5-NaF-ZnF_2-AlF_3

High Transparency

High Reflective index

Colorless

Strong structure

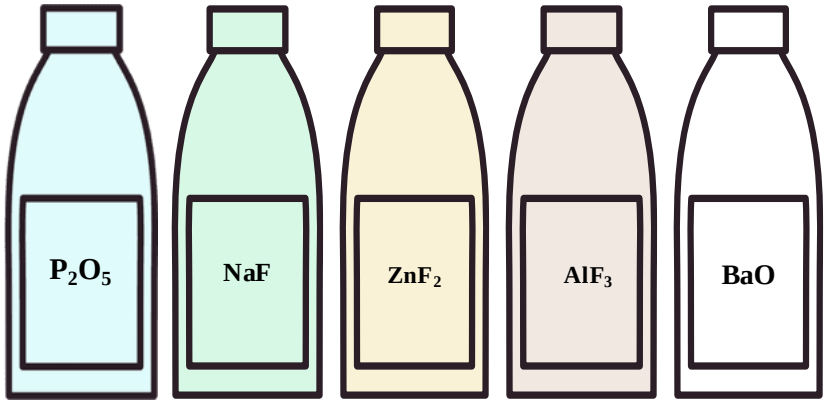
Thermal stability

Chemical stability

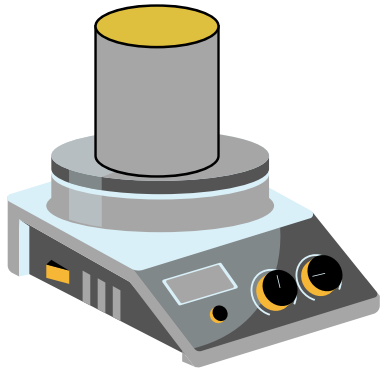
The glass samples with composition

$70P_2O_5$-15NaF-$5ZnF_2$-$10AlF_3$-XBaO

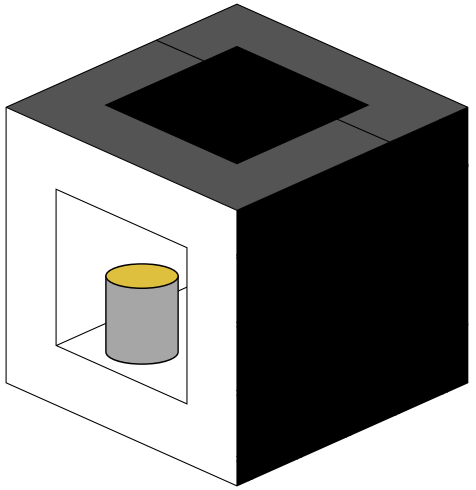
(where x = 0, 3, 9 and 15 mol%)



Chemical compositions using in glass composition



Preparing 20 g. following by glass composition

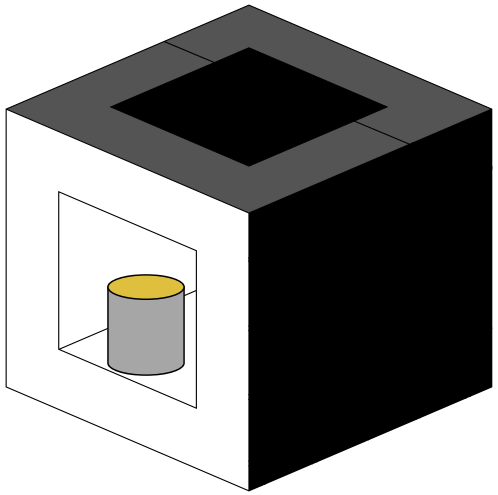


Melting at 1150 °C for 1.5 hrs.

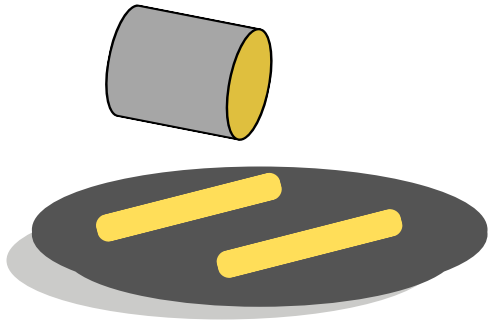
The glass samples with composition

$70P_2O_5$-15NaF-$5ZnF_2$-$10AlF_3$-XBaO

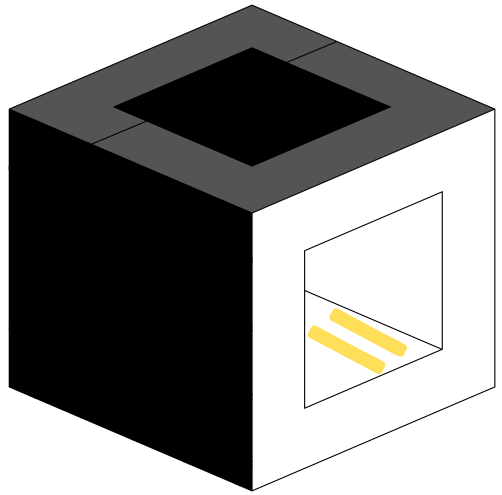
(where x = 0, 3, 9 and 15 mol%)



Melting at 1150 ° C for 1.5 hrs.



Pouring on graphite plate at room temperature



Annealing at 350 ° C for 3 hrs.

$70P_2O_5$-15NaF-$5ZnF_2$-$10AlF_3$-XBaO

(where x = 0, 3, 9 and 15 mol%)

$70P_2O_5$

5NaF

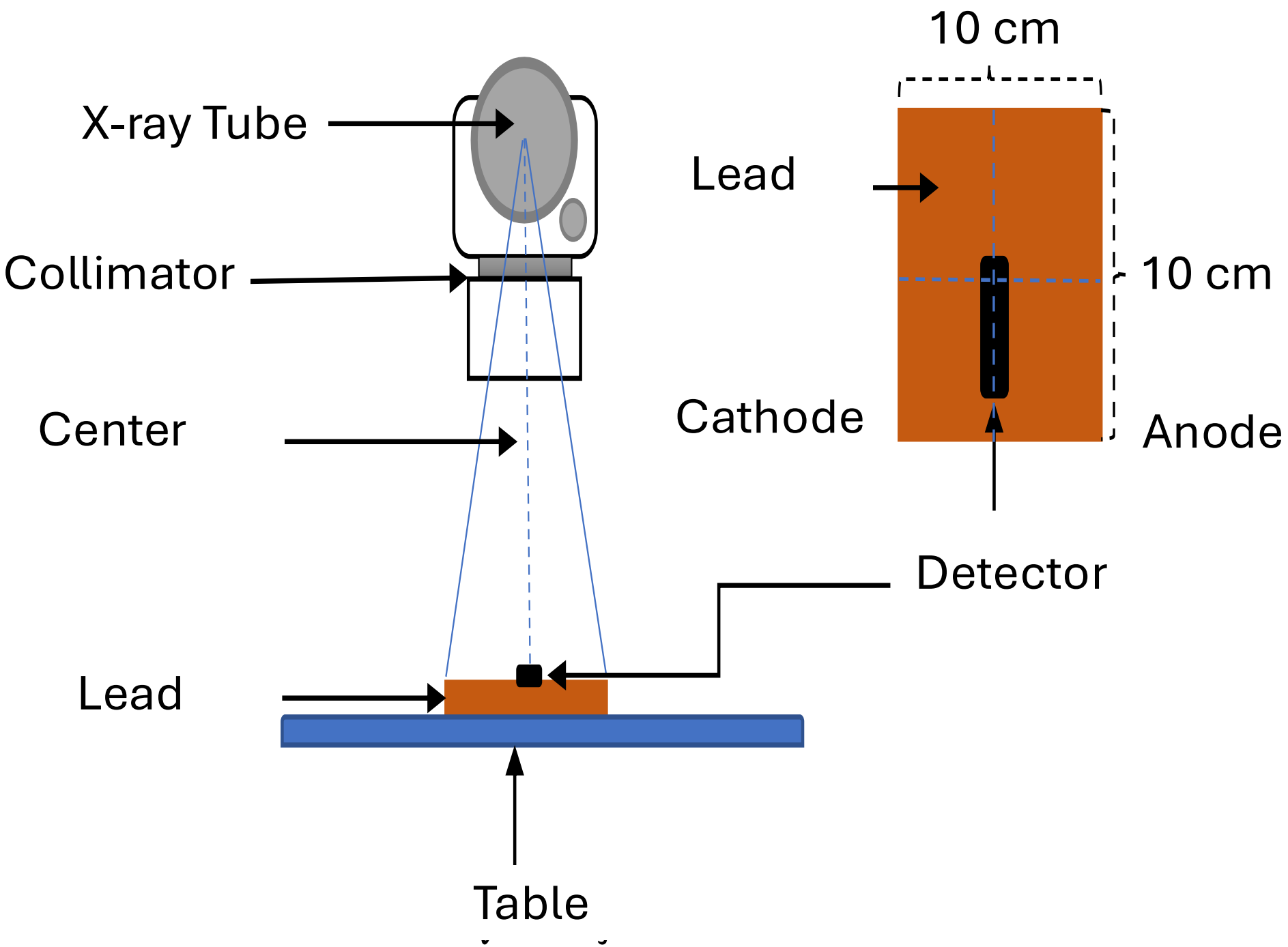
$5ZnF_2$

$10AlF_3$

xBaO

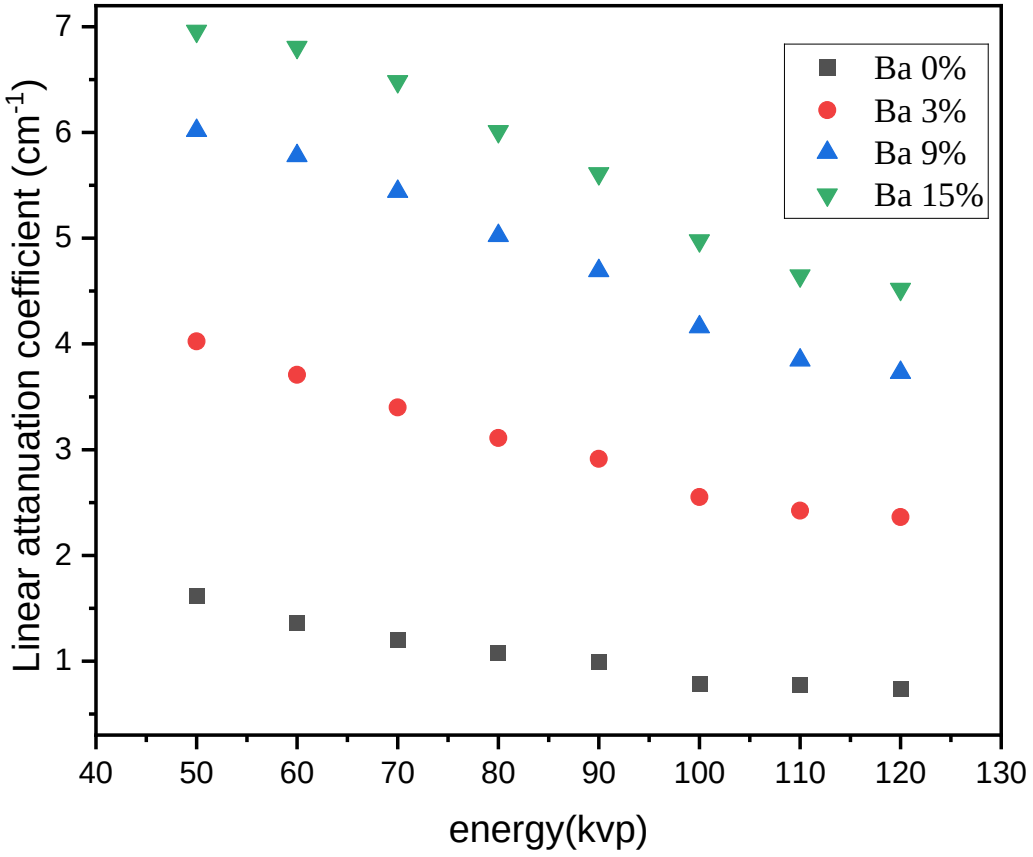
Radiation Characterization

- **Linear Attenuation Coefficient *(μ)***
- **Mean free path *(MFP)***
- **Half Value Layer *(HVL)***
- **Tenth value layer *(TVL)***


X-ray Tube
Collimator
Center
Lead
Table
10 cm
Lead
10 cm
Cathode
Anode
Detector

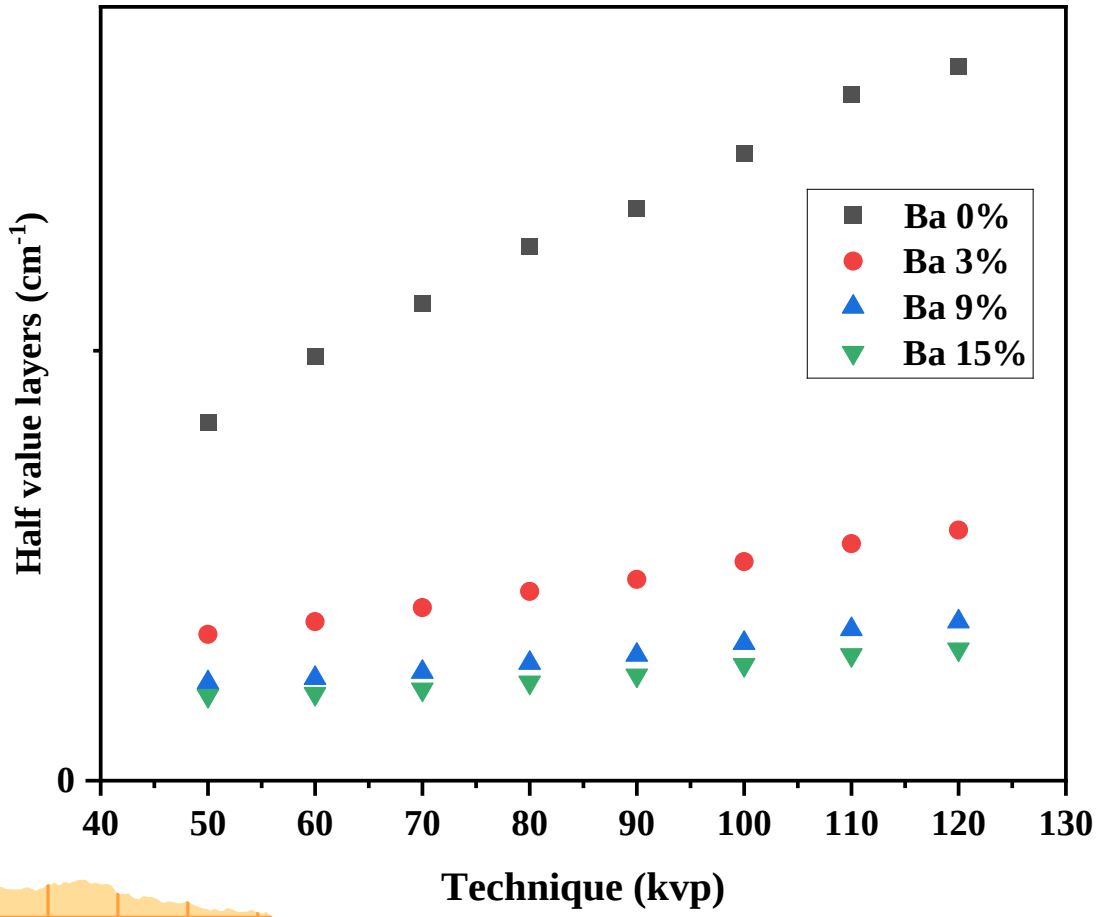
Linear Attenuation Coefficient (μ)

$$\mu = \frac{ln(\frac{I_0}{I})}{x}$$



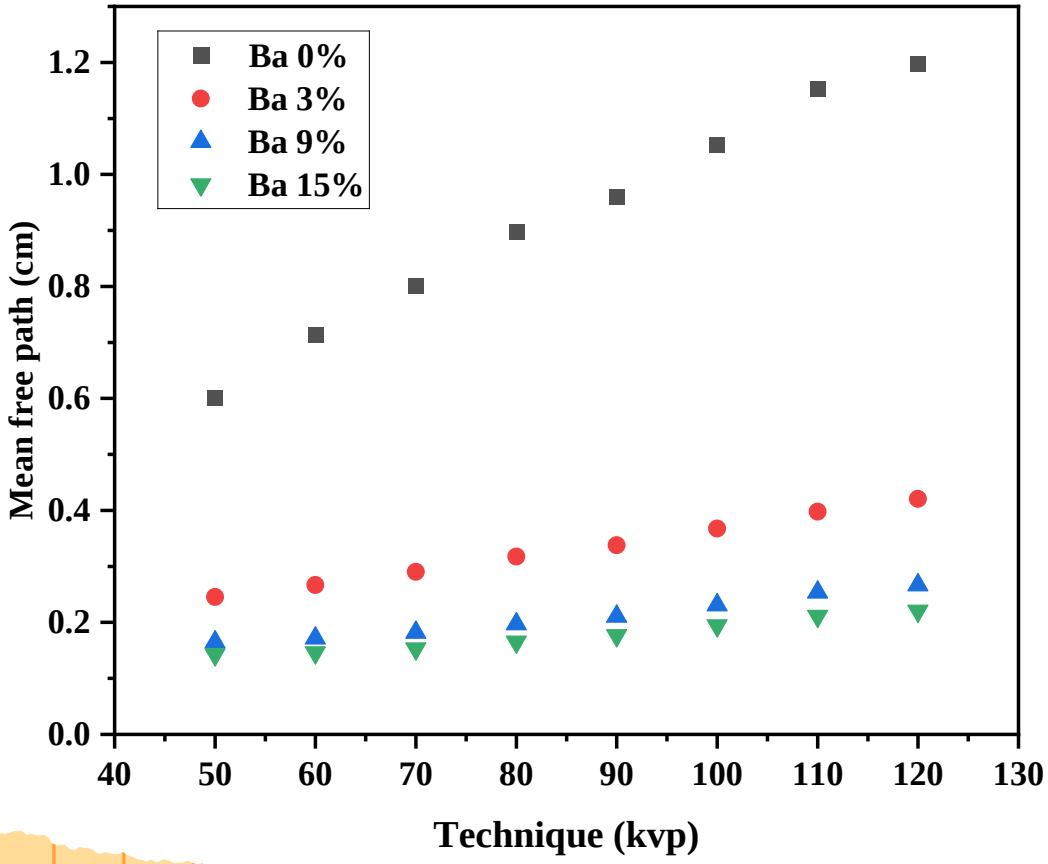
Half Value Layer (HVL)

$$HVL = \frac{ln2}{\mu}$$

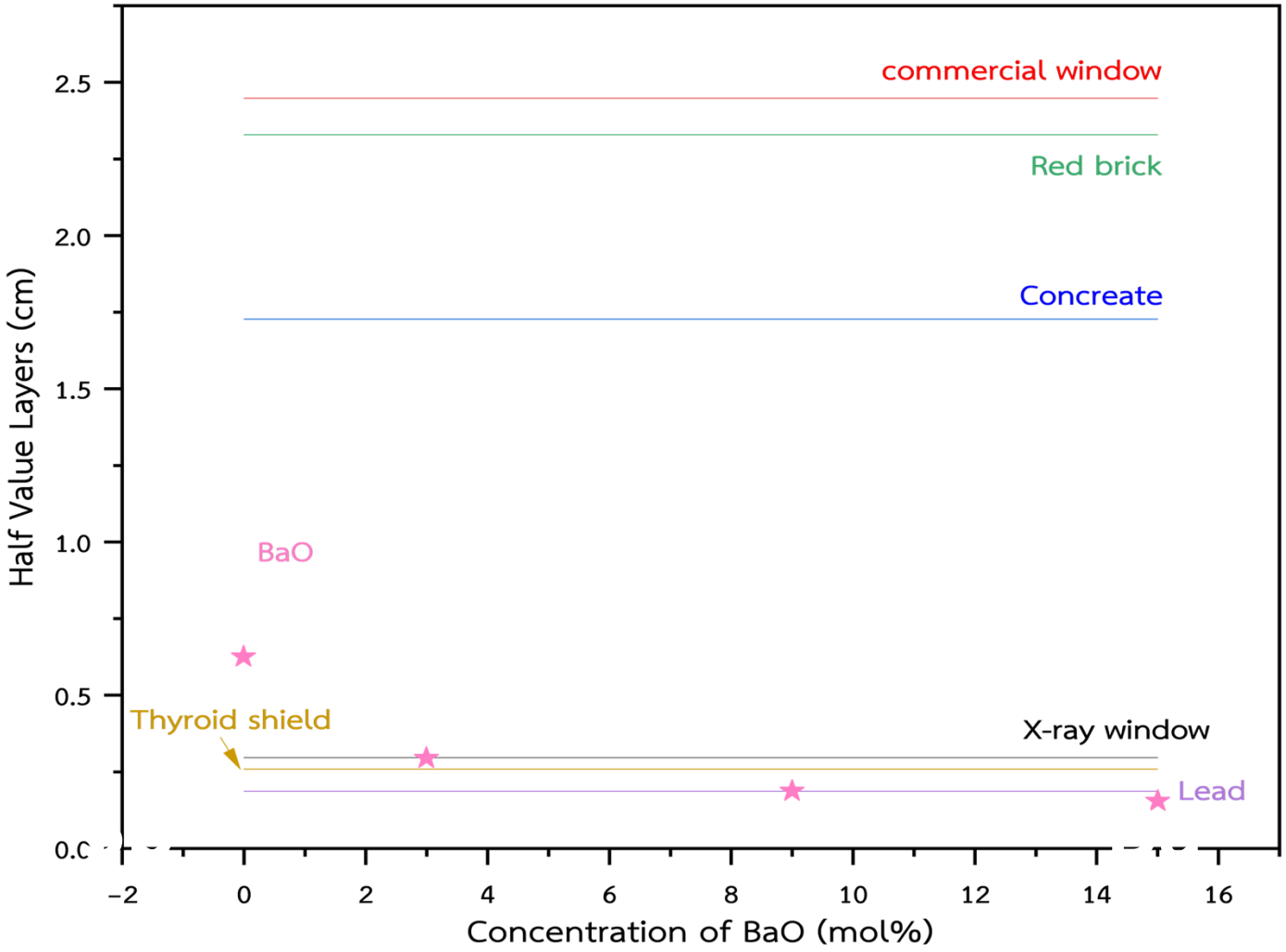


Mean Free Path (MFP)

$$MFP = \frac{1}{\mu}$$



5 HVL Compare with standard materials at 120 kVp

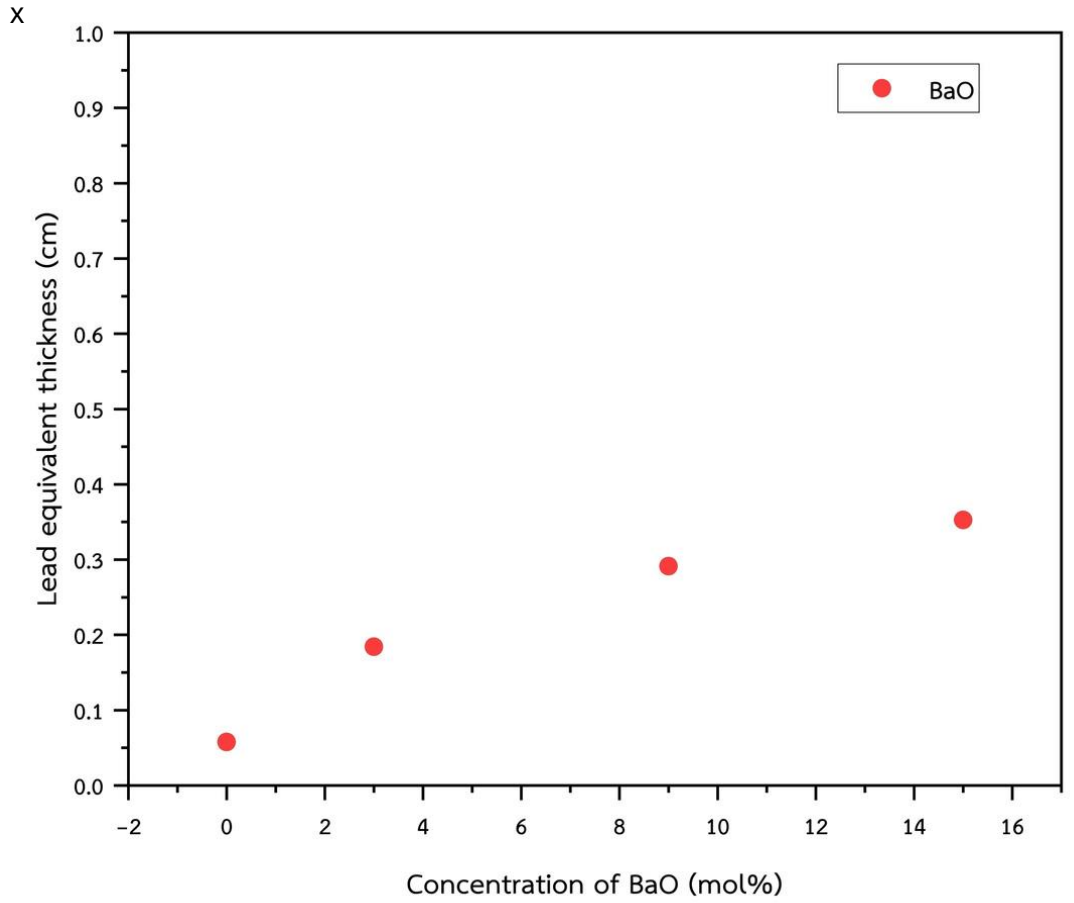


Lead equivalent thickness

$$d_{lead} = \frac{\mu_{glass}}{\mu_{lead}} \times d_{glass}$$

μ Linear attenuation coefficient

d Thickness



Conclusion

Concentration of glasses ↑	Concentration of glasses ↓
μ ↑	μ ↓
MFP, HVL, TVL ↓	MFP, HVL, TVL ↑

Thank you

Thank you