Gamma-ray Mass Attenuation Coefficient of Environmentally Friendly $Bi_{0.5}Na_{0.34}K_{0.11}Li_{0.05}Ti_{1-x}Ni_xO_3$ Ceramics

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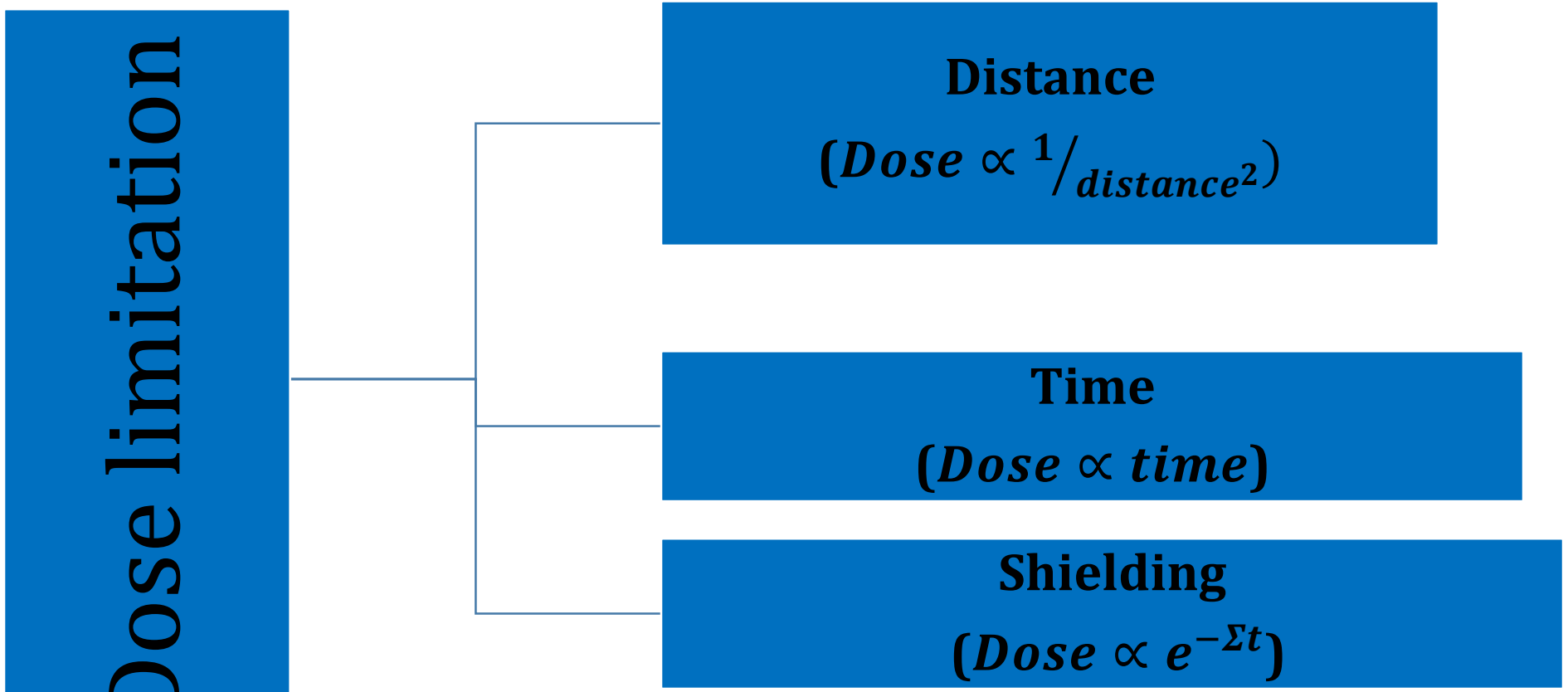
Introduction

- Nuclear Science and technology is a conventional and rapidly expanding area of research and innovations.

- Uncontrolled exposure to ionising radiation however, have deleterious effects on man, devices and the environment.

- Radiation protection techniques needs to be more sophisticated/robust and effective for radiation applications to be sustainable.

Radiation Protection Techniques



Shielding Materials

- **Nearly all materials can be used as shields but available space, dose limitation and sundry properties limit the use of many.**

- **Lead and concrete are traditional shields with some shortfalls.**

- **Composite materials such as glasses, alloys, ceramics, glasses *et al.* are conventionally proffered for shieling applications.**

$Bi_{0.5}Na_{0.34}K_{0.11}Li_{0.05}Ti_{1-x}Ni_xO_3$ (BNKLT-xNi) Ceramics

- High density Pb-free ceramics
- Possess interesting dielectric and ferroelectric attributes
- Potential for application in electronics and radiation shielding based on the density and chemical composition
- High Bi and Ti content are strong indications for high cross section for gamma-rays and thus radiation protection applications.

Objective of Study

In view of the chemical composition of the $Bi_{0.5}Na_{0.34}K_{0.11}Li_{0.05}Ti_{1-x}Ni_xO_3$ ceramics, this study was aimed at evaluating their gamma-ray shielding potentials.

Materials and Method

- $Bi_{0.5}Na_{0.34}K_{0.11}Li_{0.05}Ti_{1-x}Ni_xO_3$ ceramics (BNKLT-xNi with x = 0, 0.005, 0.010, 0.015 and 0.020)
- The corresponding density of the BNKLT-xNi is 5.75, 5.85, 5.88, 5.82, and 5.79 cm^2/g
- Mass attenuation coefficient $(^{\mu}/_{\rho})$: $^{\mu}/_{\rho} = \sum f_i \left(\frac{\mu}{\rho}\right)_i$ (1)

f_i and $\left(\frac{\mu}{\rho}\right)_i$ represents the weight fraction of chemical species in the ceramics

- $^{\mu}/_{\rho}$ of the ceramics was determined at low source (photon) energies (0.365, 0.662, 1.173, and 1.332 MeV) by the use of EPICOM spreadsheet.
- The EPICOM spreadsheet is based on the Electron-Photon Interaction cross sections 2017 (EPICS2017) data library

Results and Discussion

Table 1. μ/ρ (cm^2/g) value of the ceramics.

Ceramics	μ/ρ (cm^2/g)
BNKT-0Ni	0.1984 – 0.0548
BNKT-0.005Ni	0.1983 – 0.0549
BNKT-0.01Ni	0.1981 – 0.0549
BNKT-0.015Ni	0.1980 – 0.0549
BNKT-0.02Ni	0.1978 – 0.0549

Mass attenuation coefficient

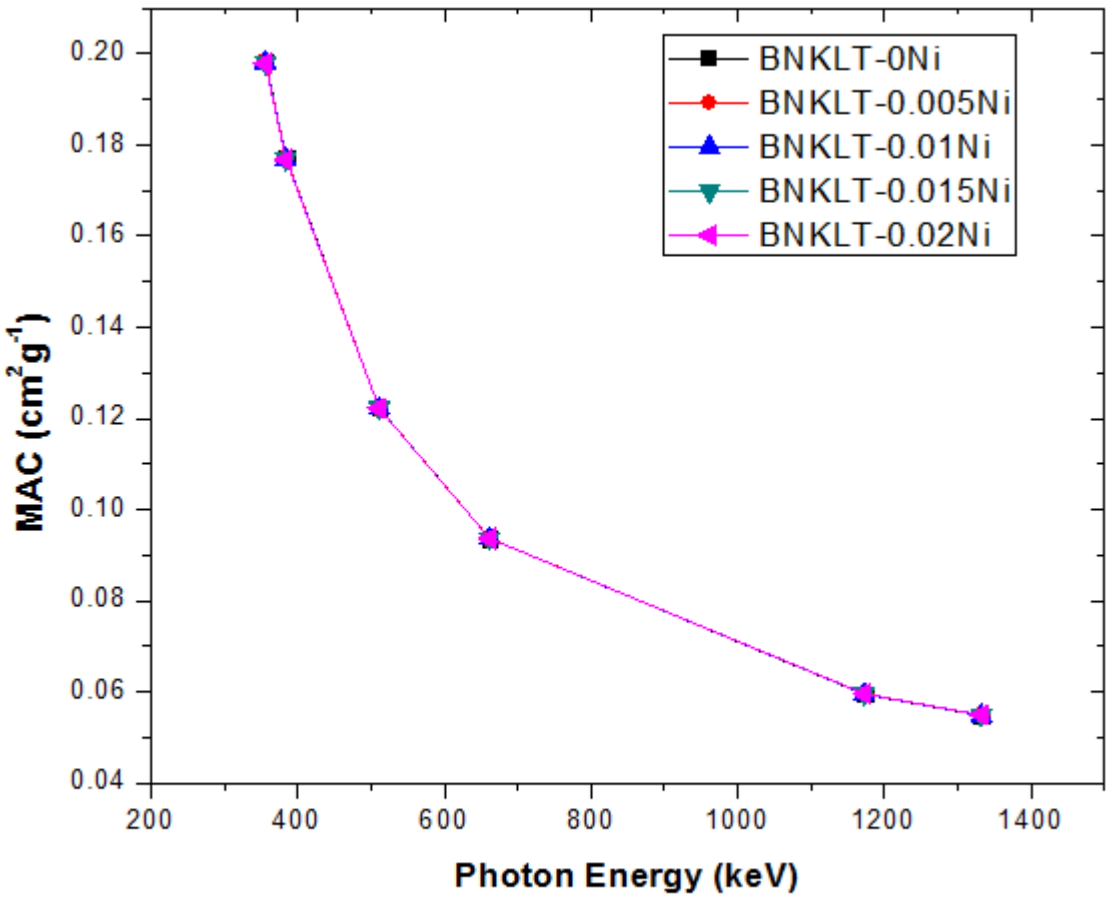


Figure1. Energy dependence of MAC for the ceramics.

Comparison of the ceramics with conventional shields

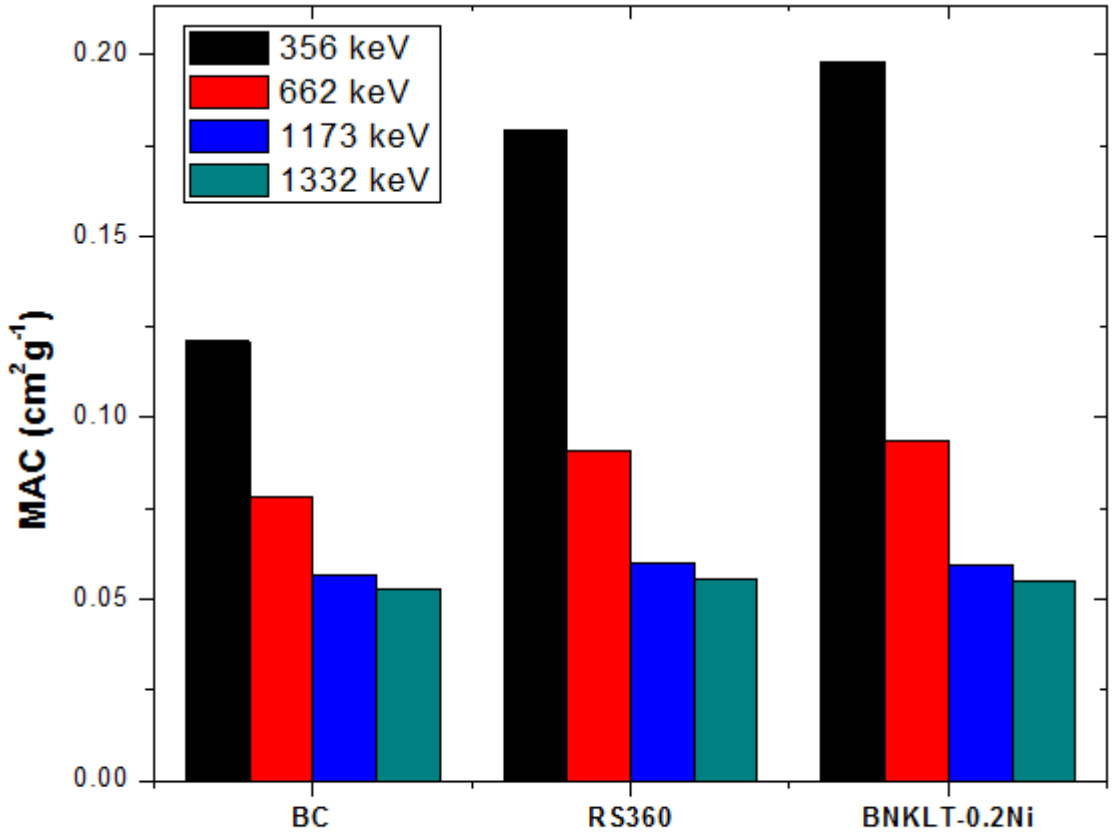


Figure 2. Comparison of MAC of BNKLT-0.2Ni, BC, and RS360.

Conclusion

- The BNKLT-xNi ceramics have high photon cross section due to their Bi content and mass density.
- BNKLT-xNi ceramics superior shielding capacity compared to barite concrete and RS360 commercial glass shield.
- BNKLT-xNi ceramics have strong potential applications in gamma radiation shielding especially at low photon energies.

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