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Conference of Young Astronomers

SIMULATION AND EXPERIMENTAL ASSESSMENT OF GAMMA RAY SHIELDING EFFECTIVENESS IN EPOXY AND FIBER CLOTH COMPOSITE LAYERS

PhD research title: Radiation-Driven Astrochemical Processes In Ice Phases: Applications For Space Environments

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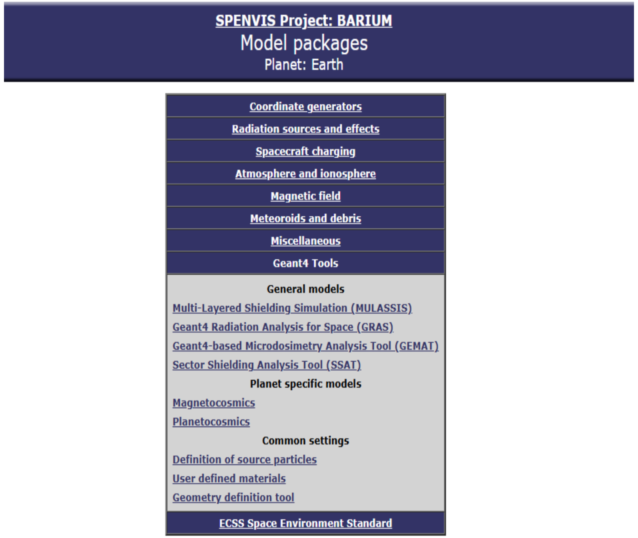
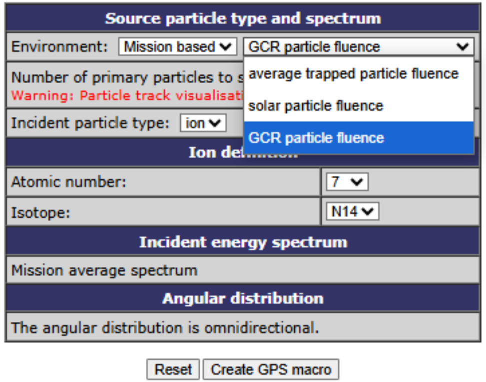
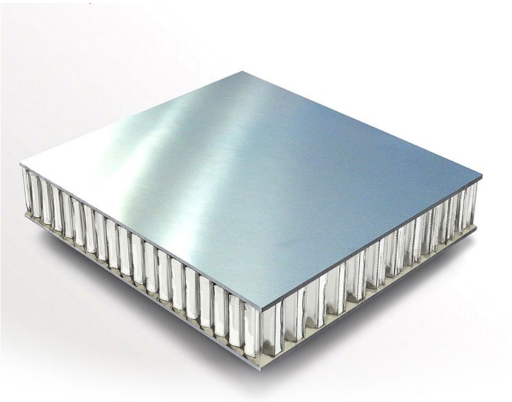
“Developement of lightweight sandwich pannels for radiation shielding solution in upper space application”





Tool developed by



Pakistan Space & Upper Atmosphere Research Commission & Institute of Space Technology

- Problem statement & objective
- Materials
- Synthesis
- Simulations & Experimental Setup
- Results & Discussion
- Conclusion

Problem Statement & Objective

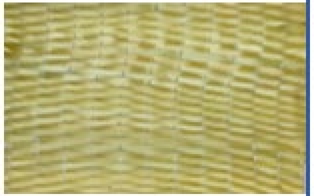
Problem Statement

Radiation exposure on long duration missions is one of the main design factor. Gamma rays are very energetic ionizing radiations and thus hazardous due to it's highest penetrating power.

Objective

The research aims to identify a material with good radiation shielding properties which is non-toxic, and cost-effective against gamma radiation.

Materials



Kevlar Fabric

WS2 micron powder

Epoxy & Hardener

Kevlar
- outstanding strength-to-weight ratio - very strong relative to its weight
- Low Density
- Maintains its strength and integrity at high temperatures
- Can maintain its structure under prolonged stress

Epoxy
- Thermal Stability
- High Strength
- can be easily processed using common manufacturing techniques
- Forms strong bonds with materials

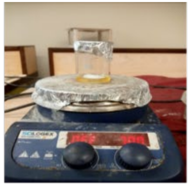
WS_2
- Good Radiation Shielding Properties
- Lightweight Structure
- Temperature Stability
- good mechanical stability

Synthesis

1. Measuring epoxy on weight balance

2. Adding acetone in epoxy

3. Sonication of epoxy for 15 minutes



4. Stirring of epoxy for 15 minutes

5. Measuring WS_2 on weight balance

6. Adding WS_2 in epoxy

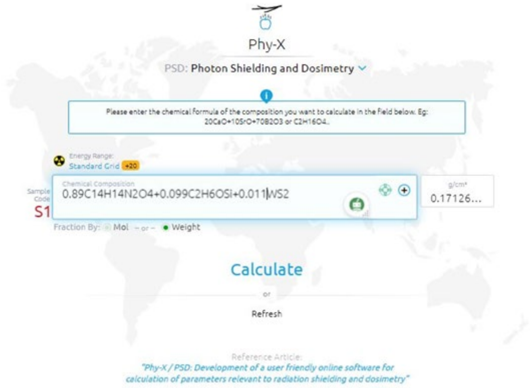
7. Sonication of epoxy and WS_2 for 15 minutes

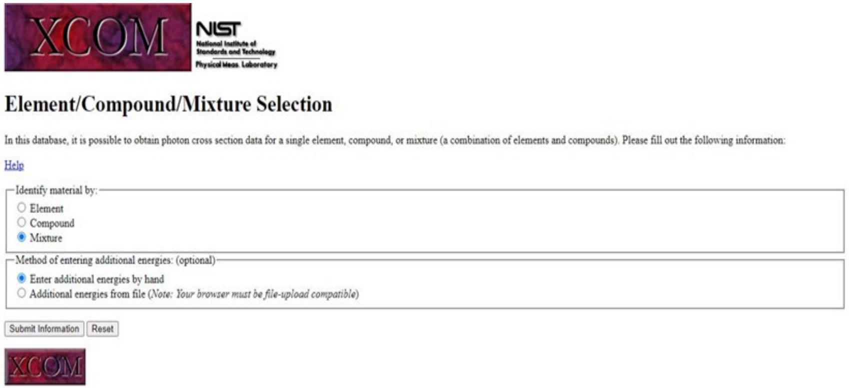
8. Stirring of epoxy and WS_2 for 15 minutes

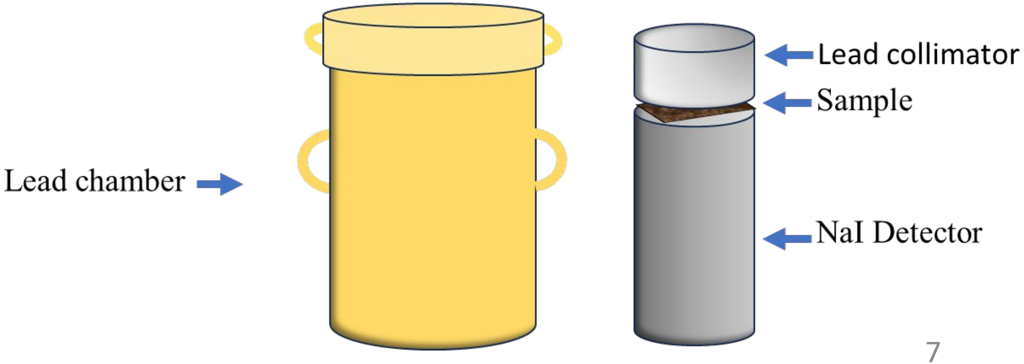
Sample	Thickness (mm)	WS2 %
1	0.64mm	6.1
2	0.97mm	7.4
3	1.19mm	7.9

Fig. Synthesis of composite

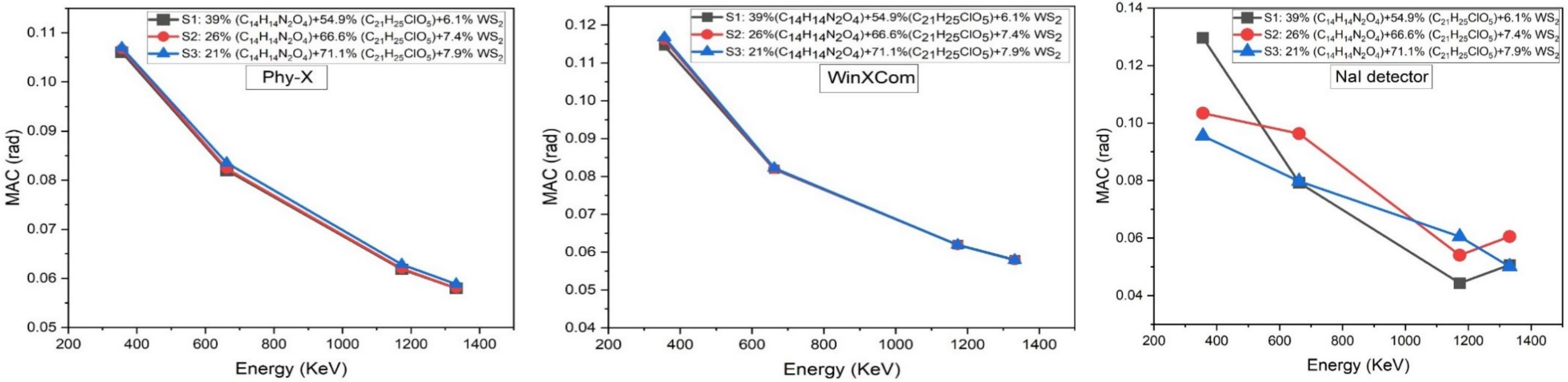
Simulations & Experimental setup







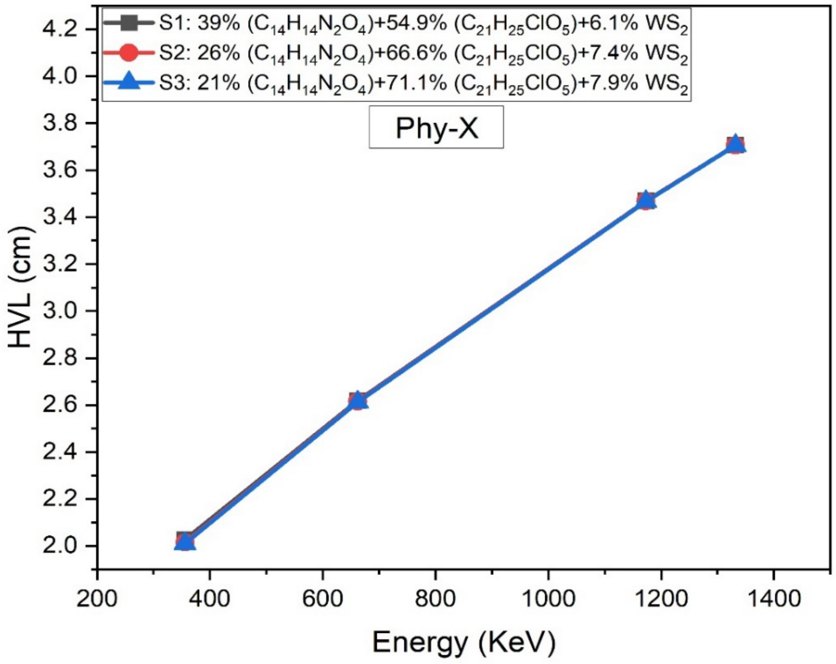
Result: Mass attenuation coefficient



(a) (b) (c)

Fig. Comparison of Mass attenuation coefficient (MAC) of samples (a) calculated using PhyX (b) calculated using WinXCOM online tools and (c) measured experimentally by using NaI detector.

Result: Half Value Layer (HVL)



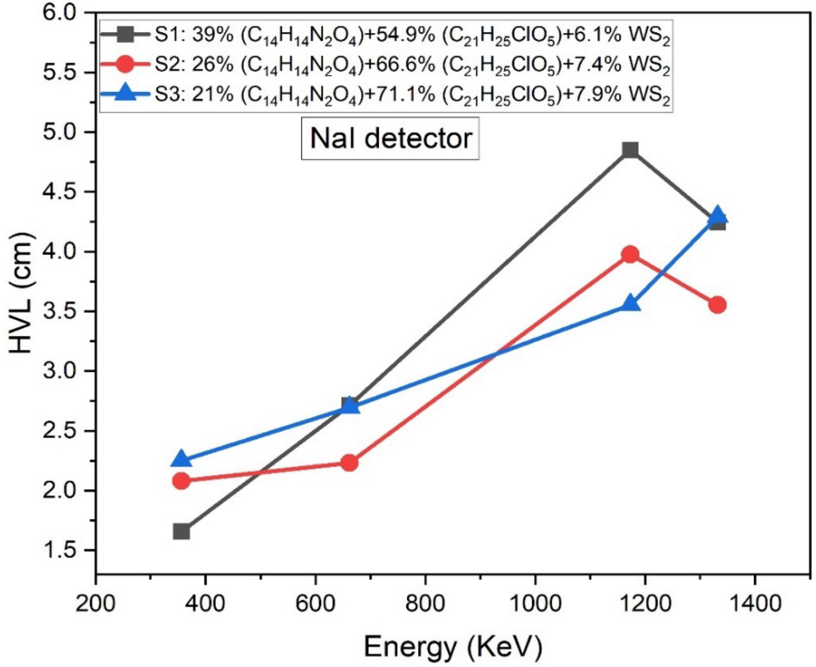
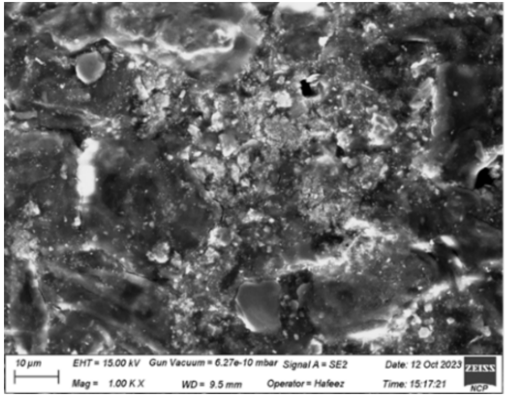
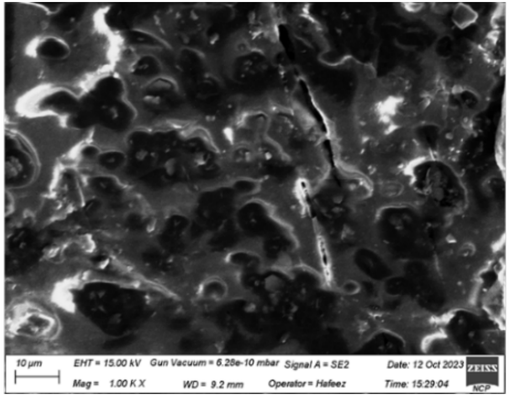
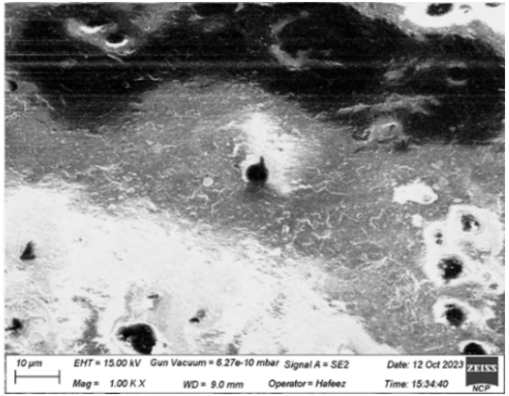


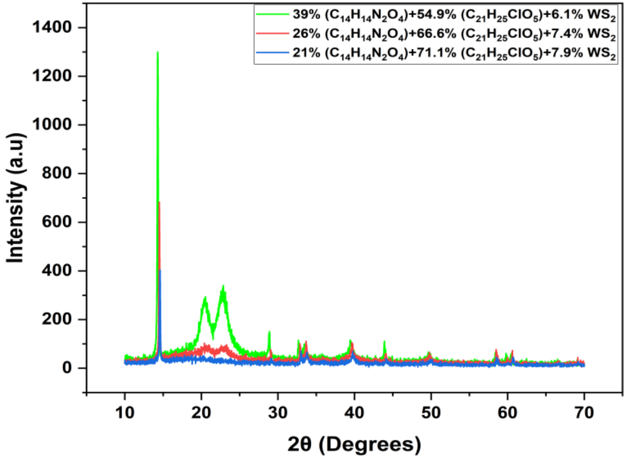
Fig. Comparison of Half value Layer (HVL) of samples (a) calculated using PhyX online tool and (b) measured experimentally by using NaI detector with calculated values.

Morphological and Structural analysis

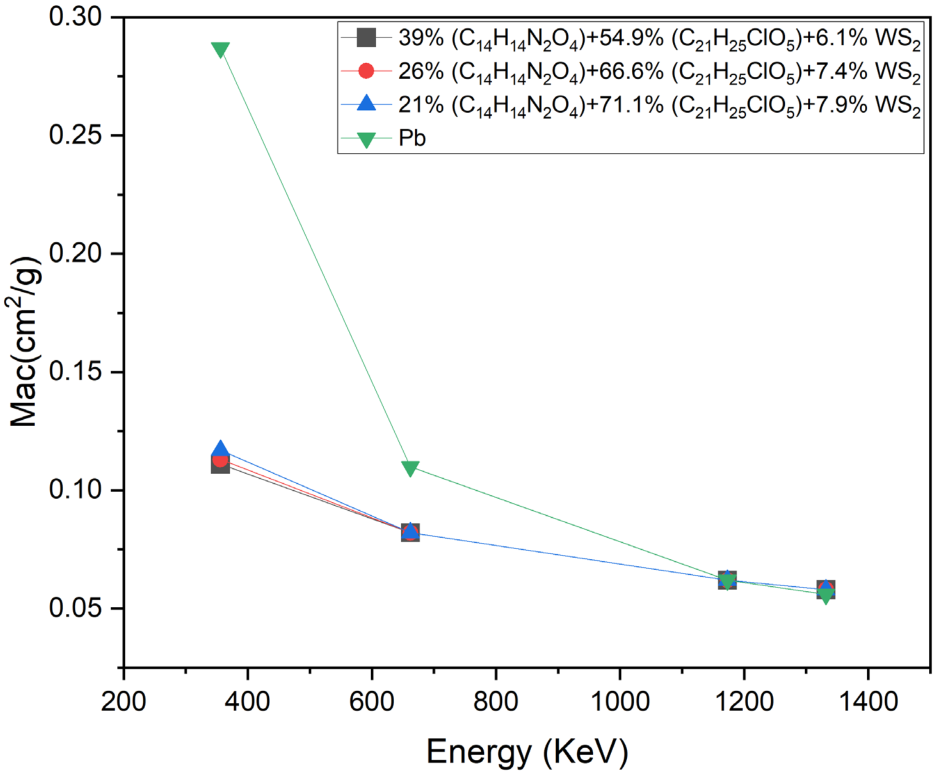








Comparison



- Lead (Pb) shows much **higher MAC** at **lower energies**, confirming its superior attenuation capability at low energies

Decrease in MAC with increasing energy:

- → Confirms reduced shielding effectiveness at higher gamma energies
- → **Thicker shielding** is required to compensate for higher photon penetration

Composite material density:

- → ~3.224 g/cm³, which is approximately **72% lighter** than lead
- → This makes the material highly suitable for aerospace and space applications, where weight is a constraint

Best performing formulation:

- → 21% ($C_{14}H_{14}N_2O_4$), 71.1% ($C_{21}H_{25}ClO_5$), 7.9% WS_2
- → Exhibits slightly better attenuation across all energy levels among tested composites

Conclusion of this study

Considering the space environment, although composites do not outperform lead at low energies, they offer a balanced trade-off between performance and weight and emerge as a ***favorable choice for gamma radiation*** shielding due to their **competitive MAC values**, **non-toxic nature**, and **cost-effectiveness** as compared to the traditional shielding material "**lead**" for gamma radiations. These factors collectively make the composites a ***better alternative***. However, the final decision should still be based on a comprehensive evaluation of the specific needs and goals of the space mission.

Title of the PhD research: Radiation-Driven Astrochemical Processes In Ice Phases: Applications For Space Environments

1) Focus of the Research

- Investigates radiation-driven chemical processes in astrophysical ice analogues
- Explores the influence of ice phases (**amorphous vs. crystalline**) on chemical reactions
- Examines the role of temperature, radiation type, and dose on molecular changes
- Explores key phenomena: **phase transitions**, **ice compaction**, **radiolytic decay**, and **new molecule formation.**

2) Objectives

Systematically study the **effect of radiation** (electrons, ions, photons) on different **ice phases.**

- Prepare astrophysical **ice analogues** in ultrahigh-vacuum, cryogenic environments
- **Irradiate samples** using various radiation sources: electrons, ions, and UV photons
- Acquire **real-time spectroscopic and spectrometric** data
- Quantify:

I. Destruction rates of parent ices

II. Formation rates of new molecules

III. Phase-dependent chemical differences

Thank you!