Shielding of Eight Polymers Against Galactic Cosmic Radiation (GCR) on Whole Body and Two Organs in the Martian Environment Using OLTARIS

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Abstract: The goal of this research is to develop in-space manufactured polymers that will shield against radiation for humans and electronics. NASA plans to launch a nuclear reactor to the Moon in 2030. There will be energy available for curing polymers, in addition to the solar energy from the Sun, for Moon-to-Mars missions. The current research is to profile common polymers to understand their shielding against Galactic Cosmic Radiation (GCR) on the Martian surface. Simulations were made using the NASA Langley developed On-Line Tool for the Assessment of Radiation In Space (OLTARIS) with water as the standard detector for tissue. Data were collected for the Effective Dose Equivalence (mSv/Day) versus Shield Thickness (Areal Density) in g/cm^2 for eight polymer shields (polyacrylamide, polyaryl ether ketone (PAEK), polydimethylsiloxane, polyfluorinated ethylene propylene (Teflon), polyimide (Kapton), polytriethylene glycol divinyl ether, polyvinyl chloride (PVC unplasticized), and styrene butadiene co-polymer). Elemental aluminum was used for reference. The best polymer for the whole body and the brain and lung organs are given.

Objectives

- Develop in-space manufactured polymers for human tissue shielding in deep space.
- Profile eight common polymers for their radiation shielding strength.[1]
- Compare 1-cm sphere thick polymers for radiation shielding of Galactic Cosmic Radiation (GCR).

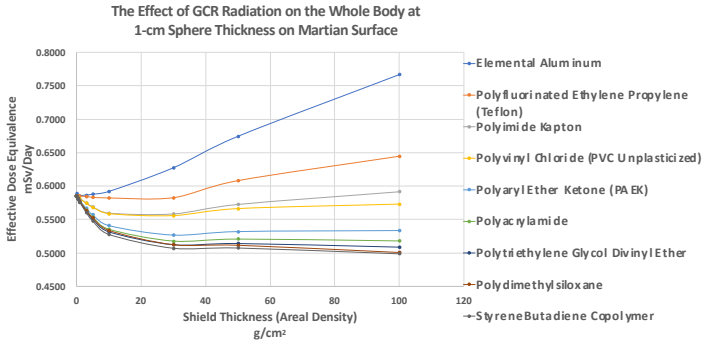
Approach

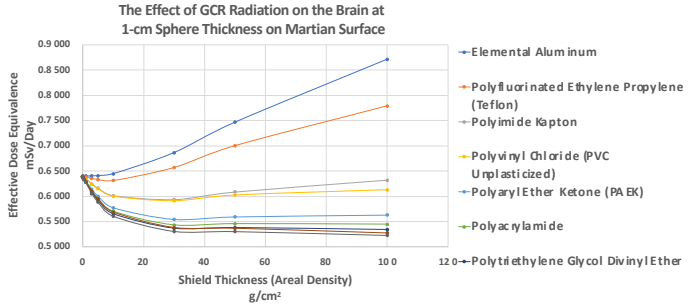
- Effective dose equivalence is the weighted average of radiation doses to specific organs measured in Sieverts.
- Spacecraft such as the Viking I and Viking II have gathered atmospheric data on Mars.[2]
- Martian seasonal dates are given in reference to its orbit around the sun.[2]
- This research was conducted at sea level for the Martian surface.
- The OLTARIS computational code was used as an algorithm for eight polymers and elemental aluminum as reference.
- OLTARIS is based on the High Charge and Energy Transport (HZETRN2005) code.[3]
- The parameters for assessment are:
  - Badhwar-O'Neil 2020 Model
  - Galactic Cosmic Radiation (GCR)
  - 2010 Solar Minimum
  - NASAQ Quality Factor
  - FAX (Female Adult voXel 2005) Anatomical Model
  - Mars Surface

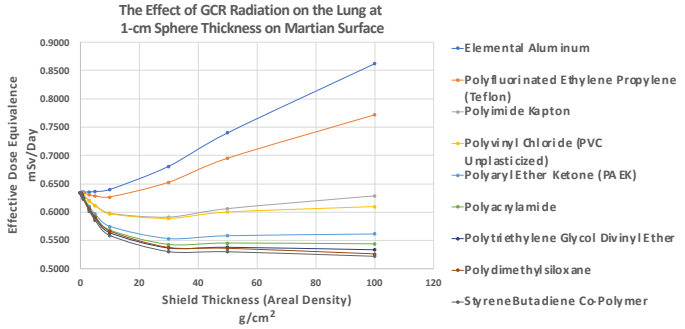
Discussion

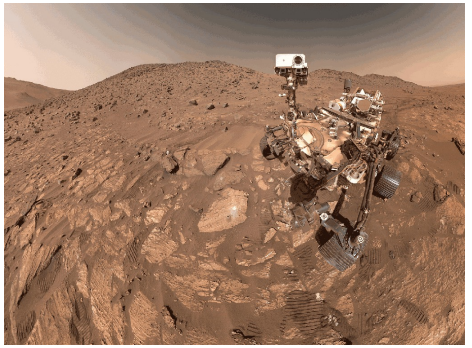
- In the FAX, never smoker environment, for whole body, polydimethylsiloxane and styrene butadiene co-polymer are competing as best polymer for GCR shielding on Mars surface at 1-cm sphere thickness.
- For both brain and lung tissue, styrene butadiene co-polymer is best for shielding.

Results









Perseverance Mars Rover 2020. Credit: NASA.

Conclusions/Future Works

- Styrene butadiene co-polymer is one to investigate more as to why it is an effective radiation shield at 1-cm sphere thickness for FAX, never smoker, NASAQ bodies.
- The next work is to compare/contrast how the FAX would perform at below sea level atmospheric pressure.

References

1) Decker, Christian; et al.: Synthesis of Nanocomposite Polymers by UV-Radiation Curing. Polymer, 46 (2005) 6640-6648.

2) Smith, Michael D.: Spacecraft Observations of the Martian Atmosphere. Annu. Rev. Earth Planet. Sci., 36 (2008) 191-219.

3) Singleterry, Robert C., Jr.; Blattnig, Steve R.; Clowdsley, Martha S.; Qualls, Garry D.; Sandridge, Christopher A.; Simonsen, Lisa C.; Norbury, John W.; Slaba, Tony C.; Walker, Steven A.; Badavi, Francis F.; Spangler, Jan L.; Aumann, Aric R.; Zapp, E. Neal; Rutledge, Robert D.; Lee, Kerry T.; and Norman, Ryan B.: OLTARIS: On-Line Tool for the Assessment of Radiation In Space. NASA/TP-2010-216722.

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