Motivation

- CR-39 detectors are used in nuclear science for low energy heavy ions, pion induced fission reactions, high energy heavy ions reactions, study of complex radiotoxicity, study of astrophysics and cosmic radiations and UV dose assessment.
- CR-39 detectors are also used in optoelectronic and photorefractive devices, fusion track dating, mineral exploration, ion lithography, alpha dosimetry and neutron dosimetry.
- CR-39 plastic detector is an amorphous polymer with attractive engineering properties including high impact strength, low moisture absorption, low combustibility, good dimensional stability and high light transmittance.
- The last property has resulted in the application of CR-39 as an impact-resistant substitute for window glass.
- CR-39 is transparent in the visible spectrum and is almost completely opaque in the ultraviolet range.
- CR-39 detectors has the highest abrasion/scratch resistance of any uncoated optical plastic.
- CR-39 particle track-etched membranes are used as templates in nano tubes and nano wires manufacturing.
- Interaction of electromagnetic radiations with CR-39 plastic detector causes structural changes in the detector.
- The extent of change depends on the factors like radiation type, exposure time, temperature, exposure condition, radiation type energy of incident radiation, irradiation condition, etching process etc.
- Passage of swift heavy ions in the materials creates large-scale lattice defects due to radiation damage along the path of the ion, which leads to the formation and transport of reactive species that can permanently change the physicochemical properties of these Solid State Nuclear Track Detectors.

Experimental Details

- 25 samples of CR-39, 0.9 mm thick cut in the dimension 1cm x 1cm divided into 5 sets each having 5 detector pieces.
- Set I (Post exposed) : Alpha (α) rays (60 min) CR-39 at 120 nm.
- Set II (Post exposed) : Alpha (α) rays (60 min) CR-39 at 160 nm.
- Set III (Pre exposed) : UV radiations (120 min) CR-39 at 120 nm.
- Set IV (Pre exposed) : UV radiations (160 min) + Alpha (α) rays (60 min) CR-39.
- Set V (Un exposed) : Alpha (α) rays (60 min) CR-39.

The plastic is made by the polymerization of the oxyxyl-2,1-ethylenedie-2,2-propanoyl methyl of carboxic acid. The monomer is an ally 1 resin having following functional group:

\[
\text{CH} = \text{CH} - \text{CH} = \text{CH} - .
\]

The plastic is made by the polymerization of the oxyxyl-2,1-ethylenedie-2,2-propanoyl methyl of carboxic acid. The monomer is an ally 1 resin having following functional group:

\[
\text{CH} = \text{CH} - \text{CH} = \text{CH} - .
\]

Fig. 3. Monomer of CR-39 Plastic Detector

Fig. 4. Variation of ln(Vα/να) with 1/T (1000K) for post, pre and un exposed CR-39 detectors.

Fig. 5. Variation of ln(Vα/να) with 1/T (1000K) for post, pre and un exposed CR-39 detectors.

Table 4. Bulk and Track activation energies for un, post and pre exposed CR-39 detectors

Table 5. Various track etching parameters for un exposed (only alpha) CR-39 detectors

Table 6. Various track etching parameters for un exposed (only alpha) CR-39 detectors

Table 7. Various track etching parameters for pre exposed (α + UV) CR-39 detectors

Table 8. Various track etching parameters for pre exposed (α + UV) CR-39 detectors

Conclusions

- The bulk etch and track etch rate increase with the exposure of IR radiations in case of post exposed as compared to the un exposed Lexan detectors, indicating the chain scission process during the exposure to IR radiation.
- The bulk etch and track etch rate decrease with the exposure of infrared radiations in case of pre-exposed as compared to unexposed Lexan detectors, indicating the cross linking process during the exposure to IR radiations.
- The sensitivity decreases with the exposure of IR radiation (post-exposed) and increases with the exposure of IR radiation as compared to un-exposed Lexan detector.
- Critical angle slightly decreases with the exposure of UV radiation in case of pre exposed as compared to un exposed CR-39 detectors.
- Critical angle increases with the exposure of UV radiation in case of post-exposed as compared to un exposed CR-39 detectors.
- Efficiency decreases with the exposure of UV radiation (post exposed) and increases with the exposure of UV radiation as compared to un-exposed Lexan detector.
- Bulk activation energy decreases in case of pre-exposed and post-exposed as compared to un-exposed CR-39 detectors but increases with UV dose.
- Track activation energy remains constant in case of pre-exposed and decreases in case of post-exposed as compared to un-exposed CR-39 detectors but increases with UV dose.
- The ratio Eα/Vα can be taken as a signal of track forming particle as it is reasonably constant for a certain range of etching conditions.
- For the detection of high energy particles like cosmic rays, the CR-39 detector is to be used with UV radiations before exposure.
- For the detection of low energy particles, UV radiation treatment is to be done with CR-39 detector once treated with ion irradiation and then etched at 55-65 °C in 6.0 N NaOH solution.

Acknowledgement

Authors are grateful to Prof. B. K. Singh Physics Dept., BHU for providing UV irradiation facility. CE352 (Alpha particle) Source and etching facility in Nuclear Physics Laboratory.

References

- R. K. Jain et al. NIM B 274 (2012) 100-104.
- R. K. Jain and Ashok Kumar, NIM-B 475 (2007) 244-251.
- Ashok Kumar et al. J. Rechnical Nucl Chem 293 (2010) 95-98.
- R. K. Jain et al., Int. J. Mod. Phys. E 20 (2011) 1950110-1950110.
- R. K. Jain et al., Radiat. Meas. 107 (2016) 106442-106442.