# The Response of CR-39 Plastic Track Detector to Fission Fragments at Different Environmental (Temperature) Conditions

R. K. Jain[1*], Ashok Kumar[2], R. N. Chakraborty[3] and B. K. Nayak[4]
[1]Physics Department, A B E S IT, Ghaziabad- 201009 INDIA2
[2]*Physics Department, J R E Group of Institutions, Greater Noida – 201308 INDIA*
[3]*Physics Department, D S College, Aligarhi-202001 INDIA*
[4]*Nuclear Physics Division, Bhabha Atomic Research Centre, Mumbai - 400085, INDIA*
*. * email: rkjain3@yahoo.com*

## Introduction

The science & technology of Solid State Nuclear Track Detectors (SSNTDs) began in 1958 by D.A. Young [1]. Young discovered the first track in LiF Crystal. Fleischer et. al, [2] gave a comprehensive survey of SSNTDs that show the track effect. Out of several SSNTDs, CR-39 offers several advantages over alternative charged-particle detectors. CR-39 is passive plastic detector, it is immune to electromagnetic radiation and largely immune to X-rays which are commonly produced in different environments. The main use of CR-39 plastic detector is in the field of health physics, such as for detection of proton, helium and heavy charged particle, radon monitoring and neutron dosimetry [3]. We have used the CR-39 for fission fragments measurement at different environments i.e. at different temperatures after storage for 2, 4, 6, 8, 10 and 12 months from the time of manufacturing the CR-39. We have noticed that the diameter of etch pits observed in CR-39 some reports about aging and/or fading effect of CR-39 [3]. However, we felt the necessity to examine more systematically the effect of environment for the sheets of CR-39. In this study, the effect of storage on track registration property of CR-39 has been investigated.

## Experimental Procedure

Pieces of CR-39, manufactured by Intercast Europe Co., Parma, Italy, were irradiated with normally incident alpha particles and fission fragments by using a $^{252}$Cf source at Nuclear Physics Division, B A R C Mumbai. CR-39 sheets were stored at different environments (temperature) for different times. Here we took the storage time from 1 month to 1 year and temperatures from 4$^{o}$C to 40$^{o}$C. Before the start of the experiment, the sheets of CR-39 used had already been stored in a refrigerator for one month and moreover for one year after it was manufactured at the time of the start of the experiment.

Pieces of CR-39 were enclosed one by one in polyethylene bags with zipper so that background due to radon progeny might not increase during the storage [4]. The outside of polyethylene bag was wrapped in aluminum foil to prevent the effect of ultraviolet radiation on the property of CR-39. The pieces of CR-39 were kept in a refrigerator of 4$^{o}$C and in laboratory at 25$^{o}$C and in an incubator at 40$^{o}$C. The storage period was one year the longest. The etching was done from the start of the storage for 2, 4, 6, 8, 10 and 12 months.

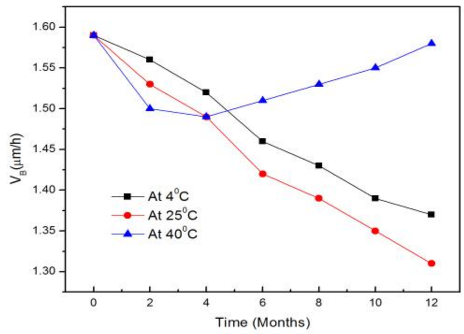


**Figure1** Variation of Bulk etch rate with Time at different temperatures.

## Irradiation Method

An electro-deposited radioactive source of $^{252}$Cf was used for the irradiation of fission fragments and alpha particles. A thin aluminum plate, 1.2 mm in thickness, was used as a collimator to minimize the source to CR-39 distance. The resultant irradiation distance was 2.0 mm in the air. The irradiation was 8 minutes. All pieces of CR-39 were etched in 6.25N NaOH solution at 70$^o$C for 4hrs and 30 minutes. The diameters of fission fragments were measured by using microscope (BH-2 Olympus) as discussed in our earlier paper [5]. The etch pit diameter D after etching for the time t is expressed by the equation: $D = 2V_b t$ [sqrt(V-1)/(V+1) where $V = V_t/V_b$ , $V_b$ is the bulk etch rate, $V_t$ is the track etch rate. Because $V_t/V_b >> 1$ for fission fragments, the bulk etch rate is approximately expressed as a function of the etch pit diameter of the fission fragment $D_f$. Therefore $V_b = D_f/2t$.

**Table 1**: Activation energy of Makrofol-E detector

| Temperature ($^0$C) | Time (Months) | Diameter (μm) | $V_B$ (μm/h) |
|---|---|---|---|
| 4 | 0 | 14.3 | 1.59 |
| | 2 | 14.0 | 1.56 |
| | 4 | 13.7 | 1.52 |
| | 6 | 13.2 | 1.46 |
| | 8 | 12.9 | 1.43 |
| | 10 | 12.5 | 1.39 |
| | 12 | 12.3 | 1.37 |
| 25 | 0 | 14.3 | 1.59 |
| | 2 | 13.8 | 1.53 |
| | 4 | 13.4 | 1.49 |
| | 6 | 12.8 | 1.42 |
| | 8 | 12.5 | 1.39 |
| | 10 | 12.2 | 1.35 |
| | 12 | 11.8 | 1.31 |
| 40 | 0 | 14.3 | 1.59 |
| | 2 | 13.5 | 1.50 |
| | 4 | 13.4 | 1.49 |
| | 6 | 13.6 | 1.51 |
| | 8 | 13.8 | 1.53 |
| | 10 | 14.0 | 1.55 |
| | 12 | 14.2 | 1.58 |

## Results and Discussion

Table 1 shows the variation of track diameter and bulk etch rate with time (2, 4, 6, 8, 10 and 12 months), at different temperatures (4, 20 and 40$^0$C). Figure 1 shows the change in bulk etch rate for different time intervals at 4, 20 and 40$^0$C. It is clear that at 4$^o$C and 25$^o$C, the etch pit diameters of fission fragments decreased slowly that is why bulk etch rate also decreased slowly with time of storage (Figure 1). At 40$_o$C, the etch pit diameters of fission fragments once decreased and then slowly increased again. Our data agree well with the data of Hiroko ENOMOTO and Nobuhito ISHIGURE [4].

## Conclusion

When CR-39 is used for radon monitoring / alpha detection / fission fragment detection / neutron dosimetry, the following points should be paid attention to: (1) the detector should be stored in a refrigerator before exposure and until etching after the exposure, (2) the change in the sensitivity between the time of calibration and the time of use should be evaluated and the counting efficiency at the measurement should be corrected and (3) for comparison or for interpretation of experimental results in different experiments the effect of storage should be carefully considered.

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## References

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[4] Hiroko ENOMOTO and Nobuhito ISHIGURE *National Institute of Radiological Science*, 4-9-1, Anagawa, Inage, Chiba, Japan
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