UV Enhancement of Etch Parameters of Nuclear Tracks in CR-39

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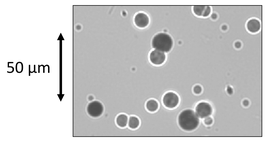
Motivation



We are seeking a way to distinguish between track pits and "noise." One such method is increasing track pit size relative to the size of "noise" pits.

Abstract

The use of CR-39 plastic as a nuclear particle track detector is an effective technique for recovering data in high energy particle experiments including inertial confinement nuclear fusion. To analyze particle track data after irradiation, CR-39 is chemically etched at elevated temperatures with Sodium Hydroxide, producing measurable pits at the nuclear track sites. When CR-39 is exposed to ultraviolet light between nuclear irradiation and chemical etch, an increase in pit diameter by a factor of as much as 1.7 occurs due to an enhancement in the track etch rate relative to the bulk etch rate. We have focused specific attention on pinpointing the critical wavelengths which produce this effect: UV below approximately 320nm is effective, and work is proceeding to determine whether the effect ceases at a shorter wavelength. A detailed analysis of how this effect depends on the intensity and duration of ultraviolet exposure is underway. Initial results suggest that this is not simply proportional to UV energy absorbed.

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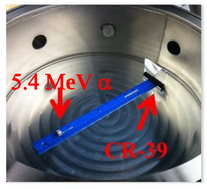
Procedure



Alpha Particle Irradiation
2 hours in vacuum

UV Exposure
ReptiGlo Terrarium Lamp
6 days

Chemical Etch
6N NaOH, 80°C
6 hours

Data Analysis
Petrographic Microscope

Alpha Particle Irradiation
- A CR-39 coupon was exposed to a 5.4MeV Americium-241 alpha emitter in a one mTorr vacuum at a distance of 25cm for two hours.

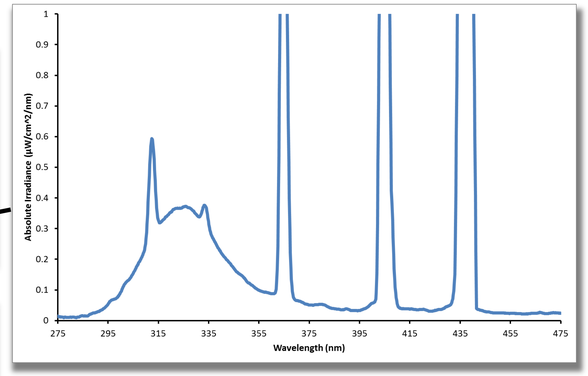
UV Exposure
- The CR-39 coupon was exposed to ultraviolet radiation from a ReptiGlo Desert Terrarium lamp for six days through a diffuser at a total distance of 6.5cm.

Chemical Etch
- The coupon was etched in a 6N NaOH solution at 80°C for six hours.

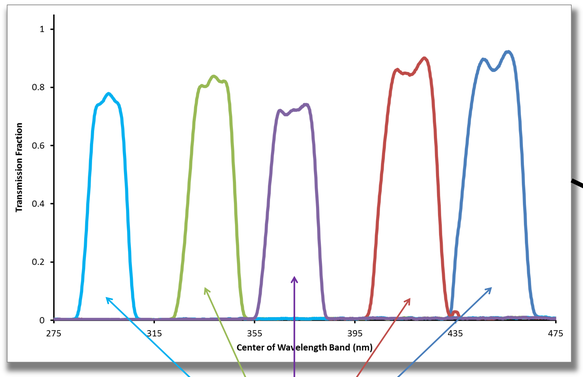
Data Analysis
- A petrographic microscope was used to observe and take measurements of pit diameters.

Effect of UV on Nuclear Tracks in CR-39

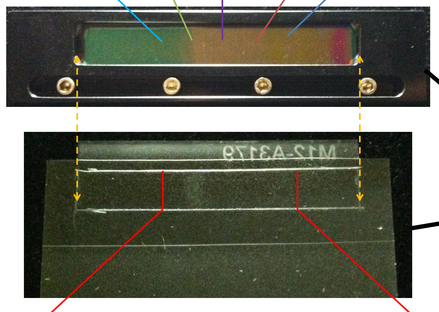
The ReptiGlo Desert Terrarium Lamp was the brightest UV light source readily available to us. It has several thin peaks at longer wavelengths as well as a wider peak centered at 320 nm.



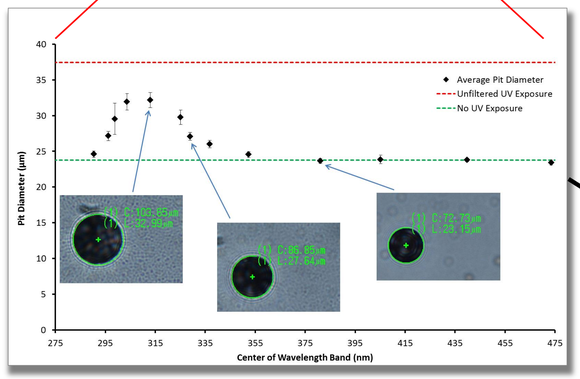
Additional experiments were completed using a Tungsten-Halogen Lamp, which had a 3400K blackbody spectrum. For these Halogen lamp experiments, an infrared absorbing "Schott glass" was used with the diffuser to block wavelengths above 850nm. The broader spectrum used in these experiments showed that wavelengths above ~320nm have a negligible effect on pit diameters.



This graph shows the fraction of light passing through the band-pass filter relative to the unfiltered spectrum at each of the marked positions on the filter. The band-pass filter blocks all wavelengths except for a 25nm wide band. The center of the wavelength band varies linearly with respect to position along the filter.



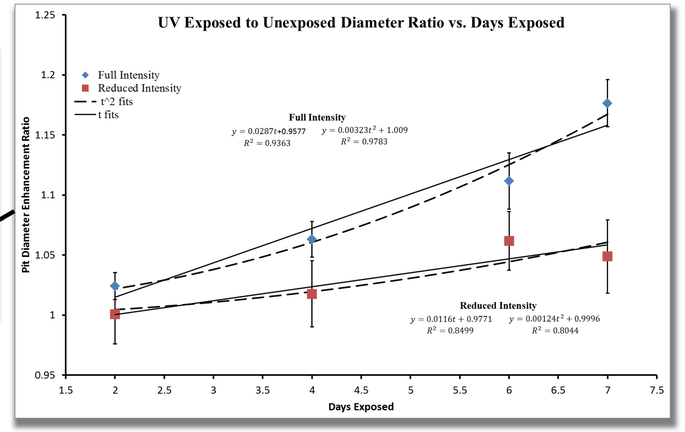
Here, you can see the band-pass filter and the CR-39 coupon that it was placed on. The orange dotted lines show where the lens of the filter was located on the coupon. The section of the CR-39 between the red lines is the area of the pit diameter measurements in the plot below. The foggy area near the left red line is a sign of noise associated with UV exposure. The foggy region corresponds to the wavelengths where the most enhancement occurs.



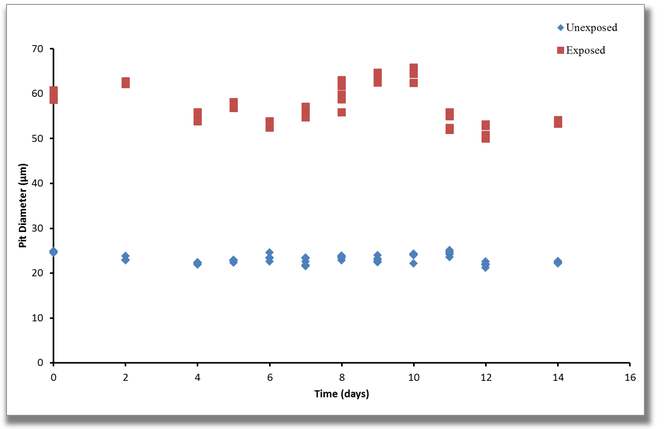
This plot shows how pit diameter corresponds with the intensity of the wavelengths that the CR-39 is exposed to. The inlaid pictures show pit diameters to scale at the corresponding wavelengths.

Pit Diameter Vs. Exposure Time

An experiment to find the relationship between exposure duration and pit enhancement yielded ambiguous and inconclusive results. The linear and squared fits of each data set had similar levels of correlation, meaning that no definite relationship could be concluded. More experimentation is needed to determine this relationship.



Healing



A null result in the enhancement of a coupon allowed to rest between exposure and etching raised concern about the possible "healing" of tracks over time. An experiment determined that there is no healing effect for rest periods of 14 days.

Future

Our group has two major goals for future experimentation. The first is to examine pits exposed to even shorter wavelengths in order to determine whether this effect continues deeper into the UV spectrum or if it just occurs for a small range of wavelengths. A xenon arc lamp would provide a spectrum deeper into the UV range than our current sources. Our second goal is to directly determine whether or not the track etch rate is enhanced more the bulk etch rate.