Alpha Track Detection from Industrial Effluents on Polymeric CR-39 Solid State Nuclear Track Detector

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Introduction

- Radioactivity is prevalent in the Earth's natural environment due to the presence of cosmogonic and primordial radionuclides. It is commonly found in in various ecological, geological and environmental formations such as , rocks, soils, sand, plants, water, and air.
- The release of alpha- emitting natural radionuclides like ^{238}U , ^{232}Th and ^{222}Rn during production, manufacturing and discharge processes has steadily increased. Monitoring alpha radioactivity in the air, solid and liquid waste from these industries is crucial.
  - Thermal Power Plants
  - Fertilizer Plants
  - Granite Industries

Solid State Nuclear Track Detection

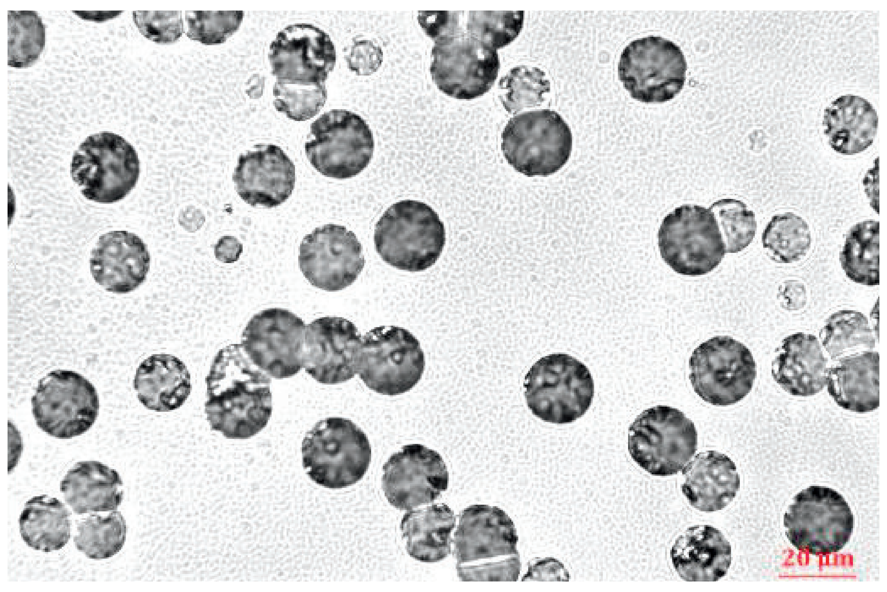
- Solid-state nuclear track detectors (SSNTDs) are materials, like certain types of crystals or polymers, that record the tracks of charged particles resulting from nuclear interactions. These detectors are often used in radiation dosimetry and nuclear physics experiments to study ionizing radiation.
- Simplicity, High Sensitivity & Cost effectiveness are inherent features.
- The CR-39 detector stands as the backbone of the SSNTD technique.
- Invaluable for quantifying emissions of extremely low rates of charged particles such as alpha particles.
- Exceptionally user friendly & cost effective.
- Adaptable detector nature No radioactive decay No electronic break down
- Collective nature of stored information Applicable to various geometrical measures including 2π, 4π, For ward & Backward geometry.

Tetraethyl Ammonium Bromide: As New Chemical Etchant

Adding TEAB to NaOH etchant accelerates track formation with rapid interaction and energy transfer on the detector surface, efficiently revealing track path. The use of TEAB as a phase transfer catalyst enhances the effectiveness and accessibility of complementary raw materials in this modern chemical etchant.

Steps involved in Solid State Nuclear Track Detection

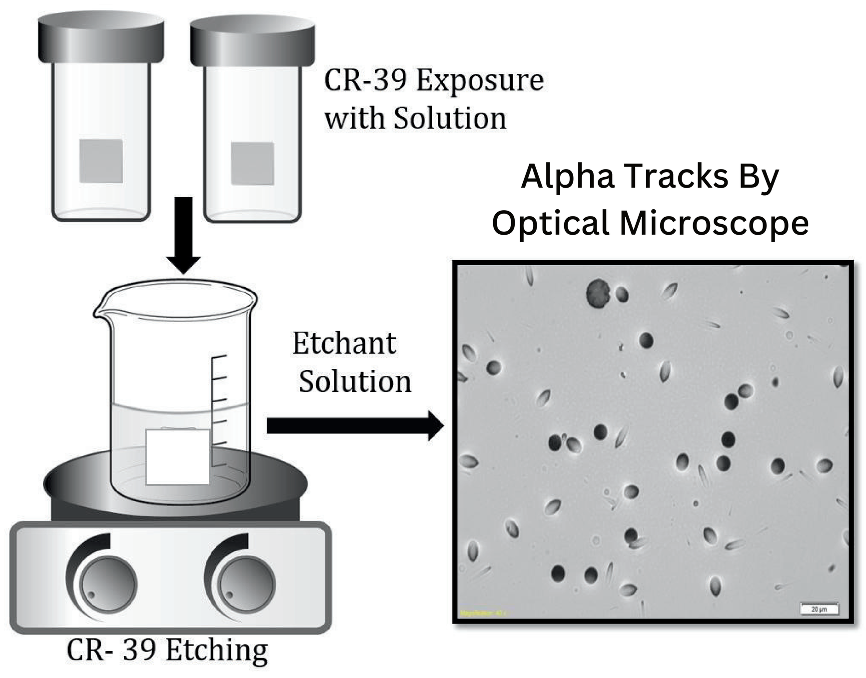
Registration of Latent tracks	Enlarging Tracks (Etching)	Counting of Tracks



Experimental

- Standardizing CR-39
- Employing $[Th(NO_3)_2.5H_2O]$ as the RS

1. Subjecting CR-39 (0.5 mm, Size: 1X1 cm^2) to Effluents (10mL) exposure.
2. Preparing Etchant with 5% w/w Tetra Ethyl Ammonium Bromide with 6M NaOH
3. Etching CR-39.
4. Measuring Track Density using formula: $T_d = \frac{Total\ counts}{Total\ \ area}$
5. Track Diameter: Magvision Softare
6. Track Registration Efficiency: $K_{wet} = \frac{T_d}{n\lambda t}$
7. Analyzing Track Profile using Techniques Spinning Disc Confocal Microscope & Atomic Force Microscope, ESEM, LM
8. Conducting ICP-MS & EDXRF Analysis for comprehensive assessment.

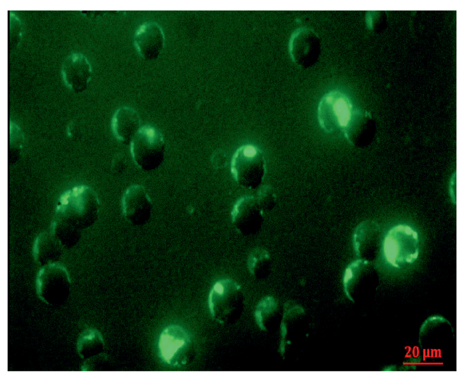


1. Concentration:(600 ug/L)	4. Temperature: (60˚ C) 7. Thickness: (0.6mm)
2. Etching Time : (6H)	5. Normality: (6N) 8. Detector: (CR-39)
3. Exposure time: (24H)	6. Amount of TEAB Added to NaOH : (5%)


Coal Discharge Field

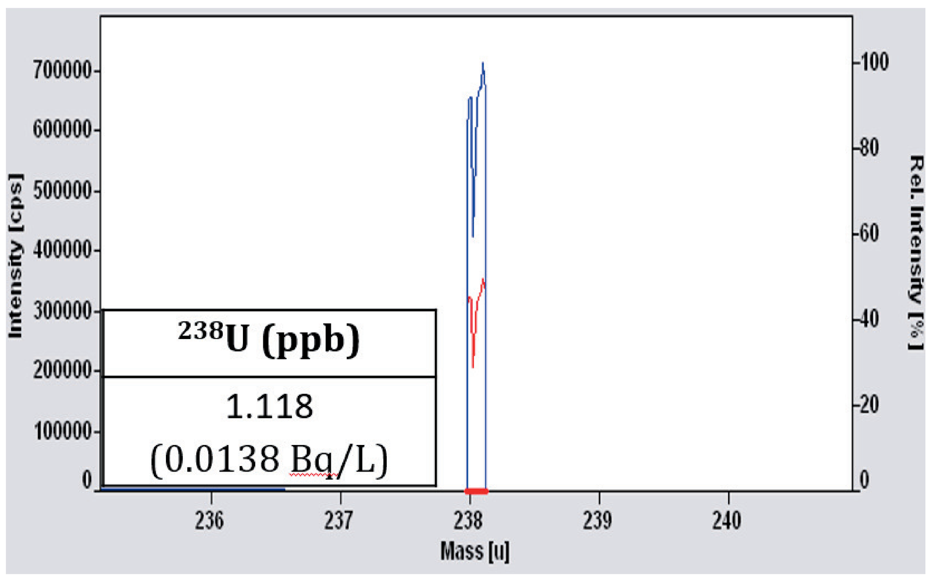

Coal Effluents Sampling

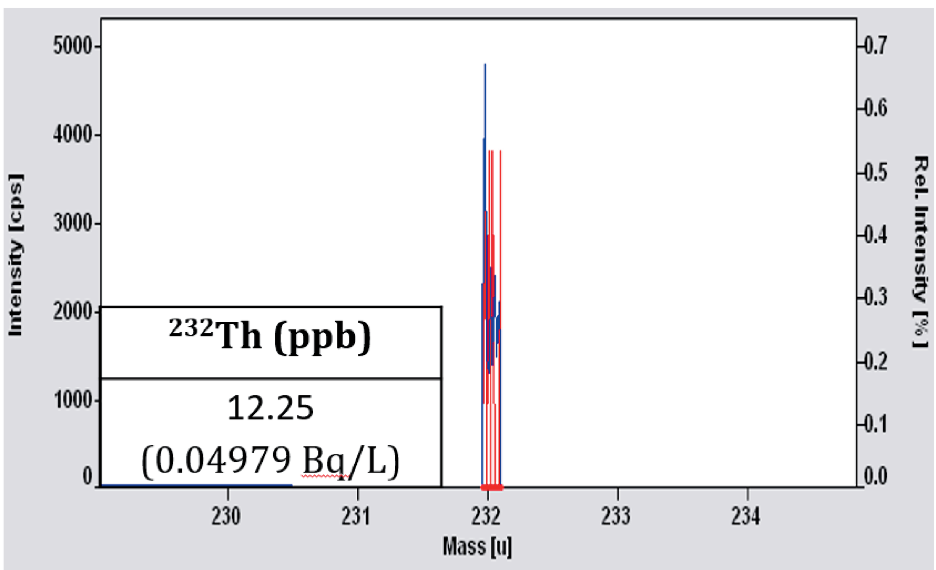

SSNTD Setup


Track Detection

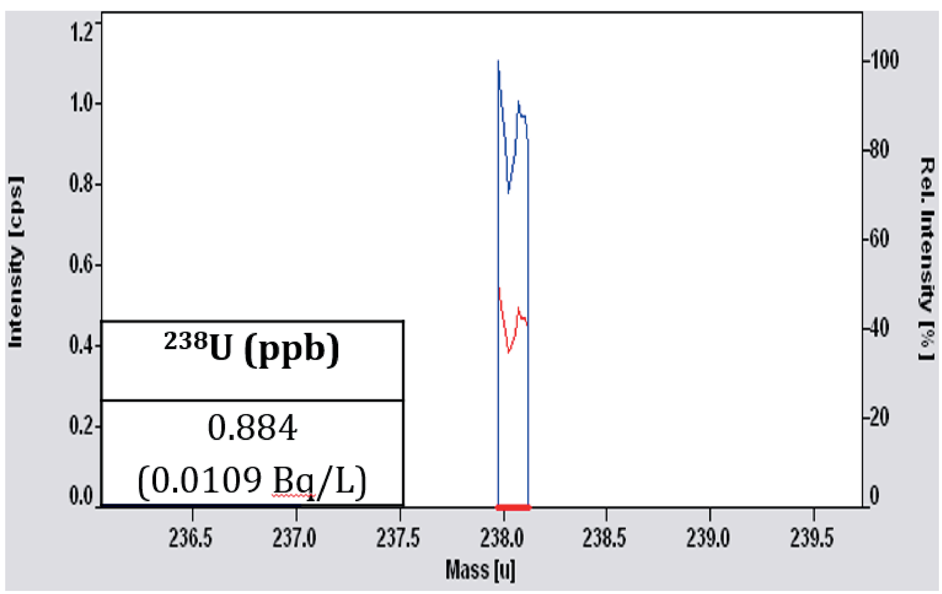
Radionuclide Contents of Effluent Samples By ICP-MS

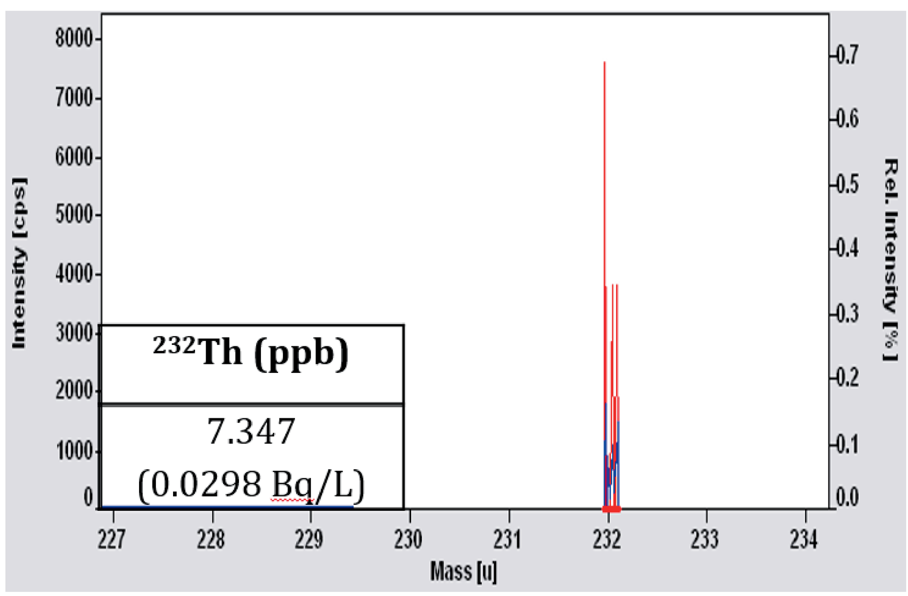
^{238}U & ^{232}Th Contents from Fertilizer Industrial Effluents



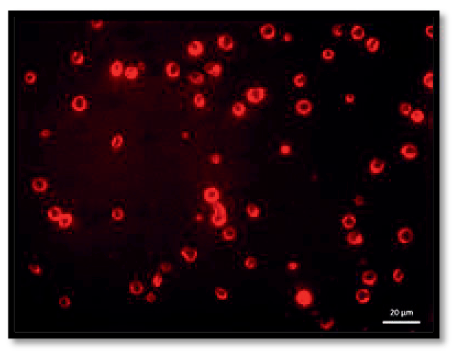


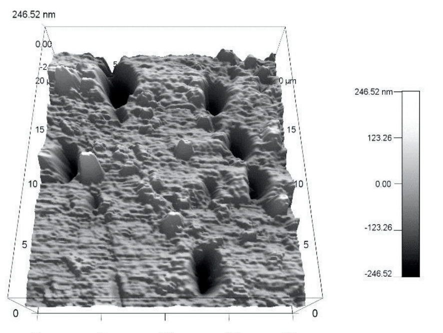
^{238}U & ^{232}Th Contents from Granite Industrial Effluents

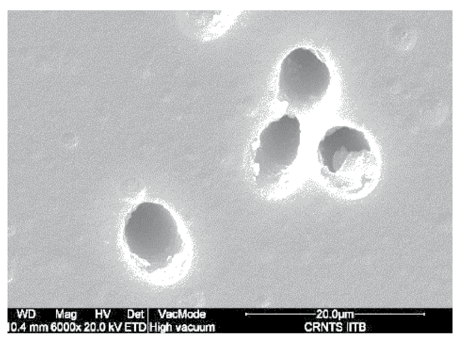


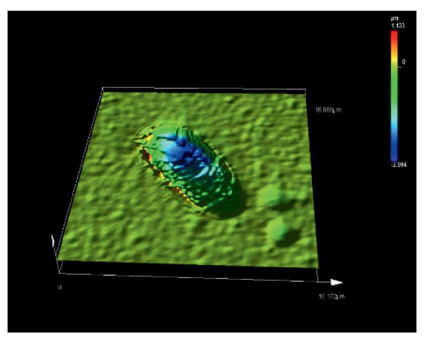


Results


Alpha Tracks by SD Confocal From Fertilizer


3D View of the tracks by AFM, From Fertilizer Industrial Effluents


ESEM Track profile from PF Effluent on CR-39 Using 5% TEAB + 6 NNaOH


Laser Microscopy: Track profile on CR-39 Using 5 % TEAB + 6 N NaOH

- The CR-39 detector exhibits distinctive dark black circular tracks, varying in proportions and depth. These tracks signify low-level alpha radioactivity.

Conclusions

- The use of TEAB proves highly effective as an etchant, facilitating the detection & revelation of alpha tracks on the CR-39 surface from solution medium.
- Etching times of 1.5 & 6H for alpha track detection ^{238}U at 1.118 ppb (0.0138 Bq/L or 0.828 dpm/L) and Bq/L or 2.9874 dpm/L). ^{232}Th at 12.25 ppb (0.04979)

Acknowledgements

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References

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