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Alpha Auto-Radiography of Gas Lantern Mantles

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Abstract: Gas lantern mantles containing thorium oxide glow with a dazzling light when lantern fuel is burned on the mantle. The distribution of thorium in the whole gas mantle sample was studied by using alpha auto-radiography technique through detecting alphas emitted by thorium and its daughters. This was done by sandwiching the mantle between two sheets of nuclear track detectors type PM-355 super grade and x-ray films for 21 days each. The technique showed that thorium is distributed in all of the mantle fabric and both x-ray film and nuclear track detector showed good resolution.

Keywords: Gas lantern mantles, alpha auto-radiography, thorium distribution, PM-355 and x-ray films.

Introduction

Thorium is used for producing luminescence in gas-lantern mantels. It is introduced into the mantels by impregnating the fabric mesh with thorium nitrate which changes to thorium oxide when the mantle is burned in air[1]. It is the thorium oxide that produces the incandescence when the lantern fuel burns on the mantle[2]. Many research groups have studied thorium content and radioactivity of gas lantern mantles[2-7].

Gas lantern mantles are usually used in rural areas and in camping as a source of light where electricity is not available. Many types of mantles usually imported from different countries are in use in Saudi Arabia. Thorium content in samples of these mantles and risk assessment to users were carried out in previous studies[6,7].

Alpha particle radiography technique has been used by many investigators to study biological samples and insects[8-11]. Charged-particle radiography has been used by various authors, [Benton *et al.,* (1980) and Souza *et al.,* (1995)] for studying biological samples. Hashemi-Nezhad and Durrani (1986) and Su (1993) used the technique for studying small insects.

It is hard to find a reference about the distribution of thorium in the gas lantern mantles or their alpha radiography.

In this paper the distribution of thorium on the mantel mesh is studied by alpha auto-radiography on nuclear track detectors (PM-355 super grade) and on x-ray films.

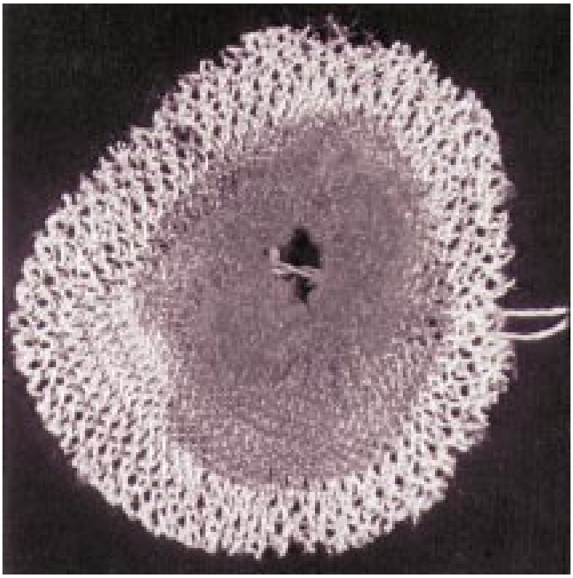
Experimental Method

One gas lantern mantle was divided into two layers and both were sandwiched and pressed between two sheets of PM-355 super grade nuclear track detectors and left for 21 days to have alpha auto-radiography from thorium and its daughters for both inside and outside surfaces of the mantel. The PM-355 nuclear track detectors were then chemically etched with 20% KOH at 60ºC for 7 h. Photographs of the two sides of one of the layers (a- inner side and b- outside) are shown in Figure 1. Auto-radiography of the two sides of the layer on the PM-355 detector are shown in Figure 2 (a & b) respectively. The same layer of the gas lantern mantle was consequently sandwiched between two x-ray films used routinely for medical purposes (type, M-MAT-E, Kodak-New York) and placed in a cassette for the same period (21 days). Then the two x-ray films were processed automatically and the alpha auto-radiography of the two sides are shown in Figure 3 (a & b) respectively. Long exposure time for both nuclear track detectors and x-ray films was required because of the very low decay rates of thorium ($T_{1/2} = 1.39 \times 10^{10}$ y) and its daughters.

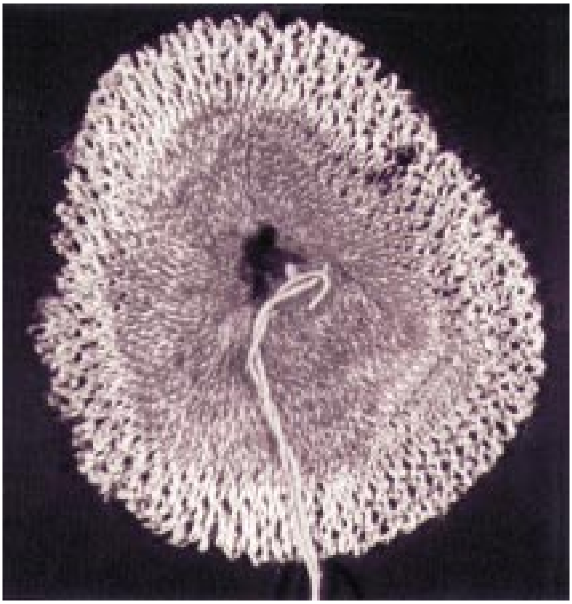
Results and Discussion

In previous studies, the thorium content of various imported gas lantern mantles was determined by a γ-spectroscopy[6] and a chemical analysis[7]. The thorium concentration in weight percent in mantles was found to range from 6.2% to 15.2%. Both methods cannot show the thorium distribution in the fabric mesh of the mantles. Therefore, this study was initiated.

A gas mantle of 7.28% weight percent thorium concentration was used to study the distribution of thorium in the whole gas lantern mantle using alpha auto-radiography technique through detecting alpha emitted by thorium and its daughters.

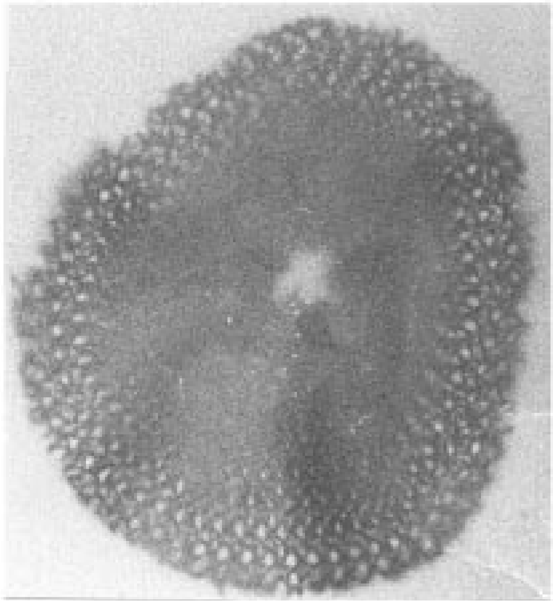


(a)

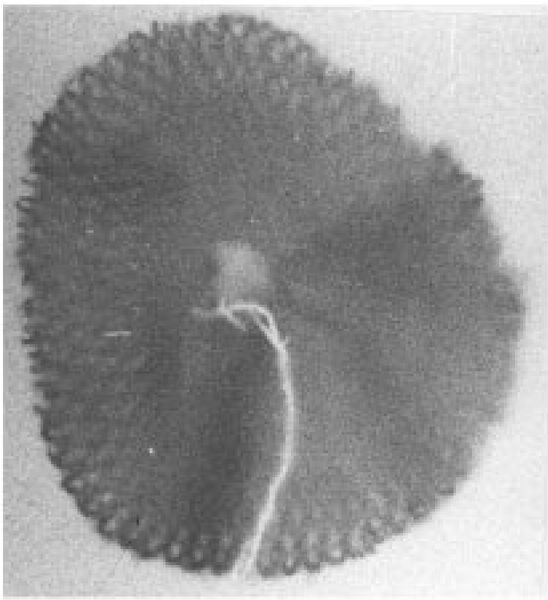


(b)

FIG. 1. Photographs of two sides of one layer of the gas lantern mantle, (a) inside (b) outside.

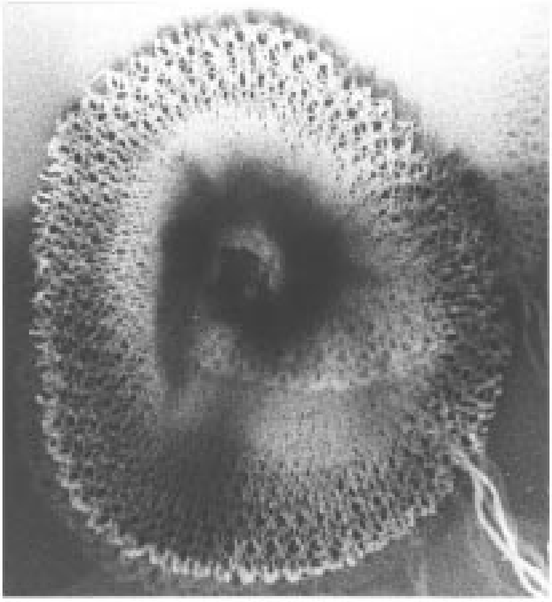


(a)

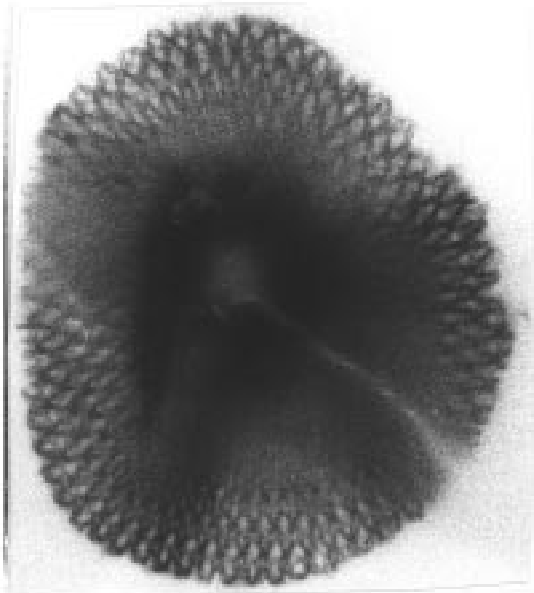


(b)

FIG. 2. Alpha auto-radiography of gas lantern mantle on PM-355 track detector for (a) inside layer surface and (b) outside layer surface of the mantel.



(a)



(b)

FIG. 3. Alpha auto-radiography of gas lantern mantle on x-ray film for (a) inside layer surface and (b) outside layer surface of the tunnel.

The following findings are deduced from the comparison between the photograph of the two sides of one layer of a gas lantern mantle (Figure 1), alpha auto-radiography on nuclear track detectors type: PM-355 super grade (Figure 2) and alpha auto-radiography on x-ray film (Figure 3).

1. Both PM-355 and x-ray film, Figure 2 and 3, show similar and very clear mapping of the mantle fabric. This mapping is originated from alphas emitted due to the presence of thorium and its daughters in the mantle. This means that thorium is distributed in all the mantle fabric.

2. The center of the mantle shows more concentration of thorium and its daughters as can be seen from the blackness of the x-ray films in the middle of Figure 3. This is attributed to the fact that in the center there is more alpha radioactivity than in the edges because the fabric in the center area is more tight than the outer edge parts and because there is an extra collection of fabric in the center as shown in Figure 1.

3. The x-ray film detects both alpha and low energy x-and γ-rays, while PM-355 detects only alpha particles. Therefore an experiment was carried out to check the sensitivity of the x-rays films to gamma rays emitted by thorium and its daughters in the mantle by fixing the gas lantern mantle on x-ray film with its paper envelope to stop alpha particles for 10 days. No sign of darkening of the x-ray film was found which indicates that this type of films are not sensitive to the γ-rays nor to the β particles emitted by the thorium and its daughters, because of their low radioactivity and high gamma energy relative to x-ray.

4. The string of the mantle is non radioactive as it is apparent from Figures 2b and 3b, where its location did not show alpha tracks because it shields PM-355 and x-ray film from the emitted alphas. This indicates that the string does not contain thorium.

Conclusion

Both PM-355 super grade nuclear track detectors and x-ray films (type, M-MAT-E, Kodak) are good tools for studying thorium distribution in the gas lantern mantles through alpha auto-radiography technique. The distribution indicates that thorium is distributed all-over the mantle fabric and not limited to a certain area. The area on the center of the mantle showed more dense tracks than the outer part because of the tightness of the fabric is more at the center and because there is extra collection of fabric in the center area. This proved that both PM-355 nuclear track detectors and x-ray films can be used for alpha auto-radiography of different materials and objects containing alpha emitter radioactive nuclides.

Acknowledgments

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References

[1] **Budnitz, R.J., Nero A.V., Murphy, D.J.** and **Graven, R.,** *Instrumentation for environmental monitoring,* **1:** 434 (1981).

[2] **Luetzelschwab, J.W.** and **Googins, S.W.,** Radioactivity released from burning gas lantern mantels. *Health Physics,* **46:** 873-881 (1984).

[3] **Mohammadi, H.** and **Mehdizadeh, S.,** Re-indication of ^{232}Th content and relative radioactivity measurements in a number of imported gas mantels. *Health Physics,* **44:** 649-653 (1983).

[4] **Couch, J.G.** and **Vaughn, K.L.,** Radioactive consumer products in the classroom. *The Physics Teacher,* **33:** 18-22 (1995).

[5] **Doretti, L., Ferrara, D.** and **Barison, G.,** Determination of thorium isotopes in gas lantern mantels by alpha spectrometry. *J. Radioanalytical and Nuclear Chemistry,* Articles, **141:** 203-208 (1990).

[6] **Aksoy, A., Al-Jarallah, M.I.** and **Abu-Jarad, F.,** Measurements of thorium content and radioactivity in gas mantels. *The Arabian Journal for Science and Engineering,* **22:** No. 1A (1997).

[7] **Al-Jarallahh, M.I., Al-Arfaj, A., Aksoy A.** and **Abu-Jarad, F.,** Chemical analysis of thorium content in gas mantles. *The Arabian Journal of Science and Engineering,* **33**: No. 1A, (1998).

[8] **Benton, E.V., Henke, R.P., Tobias, C.A., Holley, W.R., Fabrikant, J.I.** and **Henshaw, D.L.,** Charged-particle radiography. In *Proc. of 10th Int. Conf. SSNTDs, Lyon and suppl. 2, Nucl. Tracks.* Pergamon Press, Oxford, 725-732 (1980).

[9] **Hashemi-Nezhad, S.R.** and **Durrani, S.A.,** Charged-particle radiography of insects, using accelerated alpha-particles and plastic SSNTDs. *Nuclear Tracks* **12:** 493-497 (1986).

[10] **Su C-S.,** Charged-particle radiography of small insects. *Nucl. Tracks. Radiat. Meas.,* **22:** 877-883 (1993).

[11] **Souza, B.A., Cabral, S.C.** and **Lopes, R.T.,** Radiography of biological specimens with alpha particles and the CR-39 SSNTD. *Radiat. Meas.,* **25:** 381-384 (1995).

التصوير الإشعاعي الذاتي لفتائل فوانيس التريك

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المستخلص . تستخدم فوانيس التريك بشكل واسع في الكثير من البلدان . وتحوي فتائل التريك على الثوريوم المشع . وعند إشعال الفتيل في التريك يتوهج أوكسيد الثوريوم بشدة ، وقد تمت دراسة توزيع الثوريوم في فتيل التريك باستخدام التصوير الذاتي لجسيمات آلفا المتحررة من الثوريوم وولائده وكذلك باستخدام فيلم الأشعة السينية ، وتم ذلك بضغط الفتيل بعد فتحه بين كاشفين من كواشف الآثار النووية ، ووضع الفتيل بعد ذلك بين فيلمين للأشعة السينية لمدة ٢١ يومًا . وأظهرت كلتا التقنيتين أن الثوريوم موزع على كل نسيج الفتيل ، وكانت الدقة في إظهار الثوريوم في كلتا التقنيتين جيدة .