TARGISOL hands on session.

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Abstract

Diffusion is often the dominant mechanism in the release of radioactive isotopes. DIFFUSE is a finite elements application that allows to make diffusion calculations under different regimes and with variable profiles and with time structures. DIFFUSE is part of the RIBO project.

1 Diffusion

1. The activity of radioactive atoms implanted in different matrices may be monitored to evaluate the diffusion coefficients of those isotope-matrix pairs. Let us imagine that $1.37\ \%$ of a certain isotope ^{A}X of half-life $T_{1/2} = 5\ s$ remains inside a $100\ \mu m$ foil $30\ s$ after the starting of the measurement.

   (a) What would remain if it were a stable nuclei?
   A- obviously $(2^{30/5} = 2^{6}) \cdot 1.37\ \% = 87.6672\ \%$

   (b) What would then be the diffusion coefficient? (consider a flat starting profile)

   (c) Check the correctness. Find 1.37 % by using the first law of Fick including radioactive decay.
   A- use 1(S) /2(3) /4(Rad...) /9(100) /10(100) /11(1E-8) /13(30) /14(600)

2. Improving diffusion...

   (a) Considering only diffusion (not decay). How long would it take to reach the same fraction (87.667 %) if the foil were only $50\ \mu m$ thick?
   A- use 1(S) /2(1) /3(50) /11(1E-8) /13(30) /14(600) $\rightarrow$ *7.5 s*
   A- or automatically, $T = 30 \cdot (50/100)^{2} = 7.5\ s$

   (b) What are the limitations to thinning the foils?
   A- Effusion, price, sintering.

(c) What would be the remaining fraction (no decay) after 30 s from a cylinder of a diameter of 30 μm with the same diffusion coefficient. And from a Sphere?

3. Depending on the matrix thickness and the energy of the irradiating beam, the starting concentration may be flat or it may show a distribution in space which may be estimated with software like TRIM.

   (a) Repeat the calculation 1.2. to extract the diffusion coefficient for the following starting distribution:

   $$exp\left(\frac{5\cdot(x-a)}{a}\right)\cdot\left(1-exp\left(\frac{(x-a)}{a}\right)\right) \quad (1)$$

   a is the thickness of the foil. 6:(exp(5 ⋆ (x-a)/a) ⋆ (1-exp((x-a)/a))
   1(S) /2(5) /4(Fancy) /6(...) /9(100) /10(100) /12(0.87667) /13(30) /14(300) $\rightarrow D = 2.08\cdot10^{-8}\ cm^2/s$

   (b) Plot the evolution C(x,t) for $D = 1\cdot10^{-8}\ cm^2/s$ with the peak starting profile and no decay up to 320 s in 40 time bins. What is the tendency of the concentration peak?
   A- 1(S) /2(4) /4(Fancy) /6(...) /9(100) /10(100) /11(1E-8) /13(30) /14(300) The distribution becomes symmetric with the peak in the center which smooths down progressively.

   (c) Compare it with the C(x,t) function for the flat starting concentration.
   A- 1(S) /2(4) /4( ) /9(100) /10(100) /11(1E-8) /13(30) /14(300) $\rightarrow D = 2.08\cdot10^{-8}\ cm^2/s$
   The distribution becomes symmetric with the peak in the center which smooths down progressively.

   (d) If the atoms stick in the surface for a relatively long time, the concentration in the surface of the foils increases. Does that favor diffusion from the foil?

4. Diffusion coefficient ...

   (a) What would be the remaining fraction after 30 s if the foil were heated in such a way that the diffusion coefficient would grow linearly from $0.5\cdot D_0$ to $1.5\cdot D_0$? (flat starting concentration, no decay).
   A- 1(S) /2(3) /4(Fancy Diff...) /8(Dc(0.5+(x/a)) /9(100) /10(100) /11(1E-8) /13(30) /14(300)* $\rightarrow$ *91.30 %.*

   (b) What would happen if the diffusion coefficient doubled after a rise of temperature?.

A- use 1(S) /2(1) /3(50) /11(2E-8) /13(30) /14(600) → 15 s
A- or automatically, $T = 30 \cdot (10^{-8}/2 \cdot 10^{-8}) = 15\ s$

(c) What are the limitations to rising the temperature in the foils?
A- Sintering, melting.

5. Pulsed beam ...

   (a) Obtain the diffusion release from a target (100 μm foils, $D = 10^{-8}\ cm^2/s$) under a pulsed beam of period $T_p = 1\ s$, for the cases $T_{1/2} = 10, 5, 1s$.
   A- use 1(S) /2(3) /4(Rad... Beam...) /5(10) /7(1) /9(100) /10(100) /10(100) /11(1E-8) /13(30) /14(900)

   (b) What can you conclude?

2 Effusion

2.0.1 Effusion