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Deposition of Radioactive Admixture on Particles in Gas Phase

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Aerosol particles in both outdoor and indoor environments are known to be vehicles for the transfer of radioactivity. It is very relevant to solve the problems of the transfer of contaminants both in the free atmosphere and in premises during accidents and abnormal objects using radioactive substances. However, to date, insufficient attention has been paid to solving these problems. In this work, we propose a model of coagulation between atomic radioactive impurities (ARIs) and aerosol particles of various sizes. For simplicity, it was assumed that the concentration of aerosol particles $c(i)_g$ was not very high and coagulation between them might not be taken into account. It was also assumed that the ARI concentration has stabilized and reached steady state; only collisions between aerosol particles and ARP were taken into account, which led to the redistribution of radioactivity on aerosol particles of a certain size g:

$$\frac{dc(g,0,t)}{dt} = -\alpha(g)c(g,0,t)n + \lambda c(g,1,t)$$

$$\frac{dc(g,i,t)}{dt} = \alpha(g)c(g,i-1,t)n - \alpha(g)c(g,i,t)n - i\lambda c(g,i,t) + (i+1)\lambda c(g,i+1,t)$$

$$\frac{dn(t)}{dt} = I - \sum_{i}^{N} \alpha(g)c(g,i,t)n - \lambda n$$

$$c(g,t) = \sum_{i}^{\infty} c(g,i,t)$$

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To solve these equations, the formalism of the generating function was used as [1]: F(z, t)=$\sum_{i=0}^{\infty} c(g,i,t)z^i$

The corresponding transformations made it possible to find a solution to the system of differential equations, which depends on the initial conditions. If we assume that at the initial moment of time:
c(g, i, t=0)=$\delta_{i,0}c(g,0)_0$

That is, at the initial moment of time there were no ARPs deposited on the particles, then the solution can be presented in the form: F(z, t)=c(g, 0)$_0 e^{\frac{\alpha n}{\lambda}(1-z)\left(e^{-\lambda t}-1\right)}.Thisprocedureallowsonetofindallsolutions$c(g, i, t)$bysuccessivelydifferentiating$F(z, t)$andequating$z=0$.Inaddition, thesystemofdifferentialequationswassolvednu$
0) $= \delta_{i,0}c(g,0)_0$

That is, at the initial moment of time there were no ARPs deposited on the particles, then the solution can be presented in the form: $F(z,t) = c(g,0)_0 e^{\frac{\alpha n}{\lambda}(1-z)\left(e^{-\lambda t}-1\right)}$. This procedure allows one to find all solutions $c(g,i,t)$ by successively differentiating $F(z,t)$ and equating $z = 0$. In addition, the system of differential equations was solved numerically using the same initial conditions. It was found that the exact analytical solution is in good agreement with the numerical one.

![enter image description here][1] [1]: https://sun9-51.userapi.com/impg/4NxxLmPOYkhPDgjUdwXWTA55HFTd97ddUPUjfA

Figure 1. Distribution of activity on particles containing different numbers of ARI.

The graph shows the first 4 dependences of particle concentration with no ARI and with 1, 2, 3 and 4 ARI per aerosol particle. An example is given for the value of the dimensionless parameter $\frac{\alpha(g)n}{\lambda} = 1$.

It is also clearly illustrated by graphs in Fig. 1 that at $t \to \infty$ all concentrations reach a stationary regime; this can also be concluded by consideration of the form of the corresponding differential equations. The asymptotic behavior corresponds to the expressions:

$c(g,i,t \to \infty) = \frac{1}{i!}\left(\frac{\alpha(g)n}{\lambda}\right)^{i} c(g,0,0)$

The obtained analytical and numerical solutions complement each other, since when comparing theoretical and experimental data it is necessary to take into account that the number of particle fractions obtained remains finite.

[1] A.A. Lushnikov, Evolution of Coagulating Systems, J. Colloid Interface Sci., 45 (1973) 549 - 556.

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