Nano drug delivery systems

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1. Introduction

In our previous study we have shown the first order kinetics of nano drug delivery system. Nanoparticle drug delivery at targeted sites based on first order kinetics was studied by simulations. The continuous process of attachment and detachment at the targeted site was visualized using Monte Carlo methods. Lower initial concentration was found to cause better reaction rate with the targeted site. Adhesion and detachment rate contribution in the reaction rate was shown. A concept of threshold surface concentration for initiation of reaction was proposed [1]. The *in-silico* simulations have been very useful as well as shown future prospects in drug delivery [2]. A respiratory track deposition model was reported recently for aerosol drugs [3]. Controlled drug delivery is required to deliver drugs at desired rates. A number of drug delivery formulations have been proposed [4].Monte Carlo simulation were performed for the formation of micelles in a ternary system composed of water solvent, oil solute and amphiphilic diblock copolymers [5]. Nanorobotic DDS using Multi agent system simulations have also been modeled [6]. Pharmokinetic modeling estimating the biochemical reaction and transport parameters were proposed [7]. The most widely accepted model for drug release system was proposed by Higuchi [8] according to which

$$M_t = A\sqrt{D(2C_o - C_s)C_s t} \qquad (1)$$

Where M_t is the amount of drug released per unit time t, A is the release area, D is the drug diffusion coefficient, C_o is the initial drug concentration and C_s is the drug solubility ($C_o > C_s$). A power law equation to model the release kinetics is given by eqn (2) [9]

$$\frac{M_t}{M_\infty} = Kt^n \qquad (2)$$

where M_∞ the amount of drug released after an infinite time, K is is a constant and n is an exponent related to the release process. The control in a DDS is made by combining the drug with a polymer or lipid and release of the drug takes place in a predesigned manner. The initial models were proposed and modified based on polymer-solvent systems [10-12].Swarm based drug loaded nano particles simulation has been proposed [13]. The polymers erode slowly for controlled drug release. The polymer is considered as a lattice and the lattice points at erosion sites which are random in nature and a random life time numbers is assigned to each site as given in eqn 3.

$$e(t) = \lambda e^{-\lambda t} \qquad (3)$$

Where λ is the erosion rate constant and *e(t)* is the probability that the polymer will erode completely at time t with its first contact with water. The time t is given by

$$t = \frac{1}{\lambda n}\ln(1 - \epsilon) \qquad (4)$$

Where n is the grid size and ϵ is the random number between 0 and 1. A value of 0 indicates complete degradation of the polymer to a crystallized monomer. Mass loss of the monomer then takes place by diffusion which also accounts for the porosity in the material[14].A novel rod-like nanocarrier by using the coarse grained model-based density functional theory has been proposed [15].

2. Simulation Studies

We started by choosing an array random numbers between 0 and 1 for ϵ. We considered the erosion rate to be varying between 1 and 10 % per unit second. The value of n was again varied from 1 to 10. The values were put in equation (4) and polymer erosion time was obtained (Fig 1) using MATLAB codes as given below.

```
e=rand(1,10);
k=1:10;
n=1:10;
L=log(1-e);
for i=1:10
for j=1:10
for m=1:10
t(i,j,k)=L(i)/(k(j)* n(m));
end
end
end


plot (t(:))
```

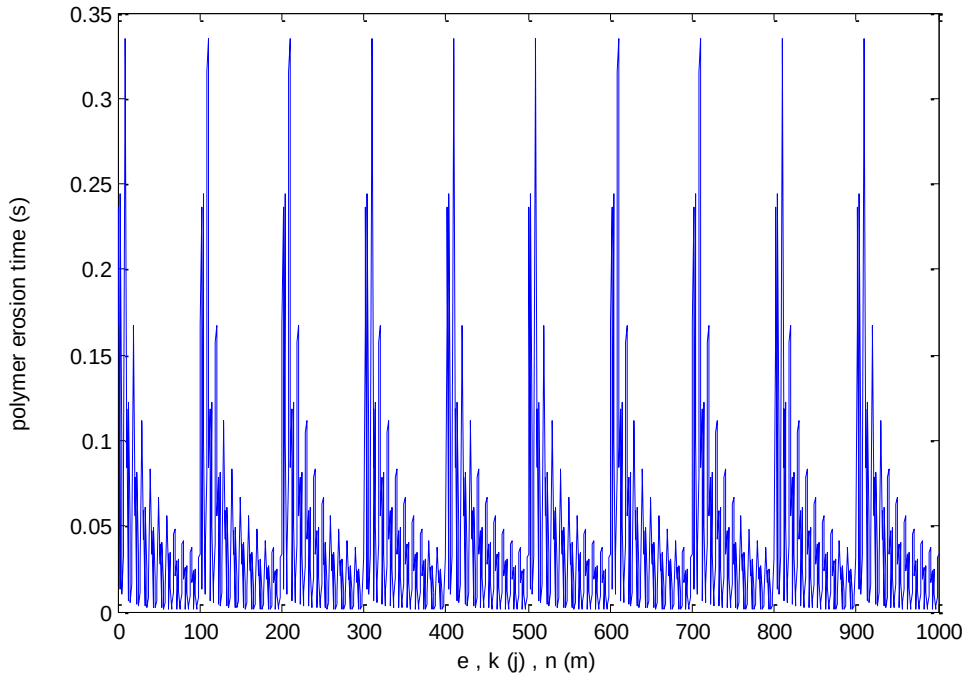

Fig 1: Polymer erosion time with ϵ, erosion rate and grid size.

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