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MATHEMATICAL MODELS FOR CONTROLLED DRUG RELEASE FROM A SWELLING HYDROGEL

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In this thesis, we developed several mathematical solutions of drug release from controlled drug delivery systems, specifically hydrogel. The development of these mathematical solutions is divided into three parts. The first part is solving the analytical solution of controlled drug release from a swelling hydrogel with constant diffusion coefficient, which is referred as the one-phase model. The model was then extended to consider the dynamic behavior of the diffusion coefficient for a swelling device, which was solved in the second part. The extended model is called as the two-phase model. Then, the final part of the mathematical solutions is simulating the controlled drug release from the swelling hydrogel in a one-compartmental system. In the first part, we used the advection-diffusion equation to obtain the equation of drug concentration in the hydrogel. The Landau transformation and separation of variables method were applied in solving this model. Further, we developed the one-phase model using the acquired drug concentration model. Then, we tested the three different growth patterns of hydrogel, which are linear, exponential and logistic growth pattern with the experimental data of three different formulations of hydrogel. Among the considered patterns, logistic growth pattern shows the best fit with the experimental data. Thus, only the one-phase model with logistic growth pattern was fitted to the experimental data of the three hydrogels. Next, we have done the second part using the

similar approach as developing the one-phase model. Considering the dynamic diffusion coefficient for a swelling device, we split the entire drug release process into two phases. Each phase has a different constant diffusion coefficient. This approach was previously used to cater initial burst phenomenon where the first phase is the burst release phase and the second phase is the normal release phase. A continuity condition was adapted in solving the model to ensure continuous release between the two phases. The numerical test of the two-phase model shows a better fit with the experimental data compared to the one-phase model. Finally, in the third part, we regarded the small intestine as one single compartment where all of the drug delivery processes take place. We applied the one-compartmental model to simulate the drug release in small intestine. The numerical test on the model shows that the one-compartmental model can simulate the current drug present in the small intestine.

dipertimbangkan, corak pengembangan logistik menunjukkan pemadanan yang paling sesuai dengan data eksperimen. Oleh itu, hanya model satu-fasa dengan corak pengembangan logistik dipadankan dengan data eksperimen ketiga-tiga hidrogel. Seterusnya, kami menyelesaikan bahagian kedua dengan menggunakan pendekatan yang sama seperti membangunkan model satu-fasa. Dengan mempertimbangkan pekali resapan dinamik bagi peranti yang mengembang, kami membahagikan keseluruhan proses pembebasan dadah kepada dua fasa. Setiap fasa mempunyai pekali resapan pemalar yang berbeza. Pendekatan ini sebelumnya digunakan untuk memenuhi fenomena pelepasan mendadak di mana fasa pertama adalah fasa pelepasan mendadak dan fasa kedua adalah fasa pelepasan normal. Syarat keselanjaran digunakan untuk memastikan pelepasan berterusan di antara kedua-dua fasa. Ujian berangka menunjukkan model dua-fasa menghasilkan padanan yang lebih baik dengan data eksperimen berbanding model satu-fasa. Akhir sekali, di bahagian ketiga, kami menganggap usus kecil merupakan satu kompartmen di mana semua proses penyampaian ubat akan berlaku. Kami menggunakan model satu-kompartmen untuk mensimulasikan pelepasan dadah terkawal di dalam usus kecil. Ujian berangka pada model ini menunjukkan bahawa model satu-kompartmen boleh mensimulasikan aras semasa ubat di dalam usus kecil.