Michigan State University
DEPARTMENT OF CHEMICAL ENGINEERING AND MATERIALS SCIENCE

CHE 210: Modeling and Analysis of Transport Phenomena Spring 2010

Group Project

Assignment date: Friday, April 2, 2010
Due date: Monday, April 19, 2010 (**Submit project in 2527 EB by 4:30 PM**)

PROBLEM STATEMENT

Transdermal drug delivery systems (TDDS) are important devices for delivering a variety of drugs through the skin for systemic circulation[1-4]. Drugs delivered transdermally include nicotine to aid smoking cessation, fentanyl to manage pain, estradiol for postmenstrual syndrome, testosterone for hypogonadism in males, and scopolamine for motion sickness. It is estimated that TDDS now make up more than 10% of the multi-billion dollar drug market. The drug is usually incorporated into a patch that is applied directly to the skin. It then diffuses across the skin membrane into the body. The mass transport across the skin can be modeled by Fick's Law. However, because of the complexity of the system (layers of materials with different transport properties), these equations are best solved numerically[2, 5]. In this project you will be required to read a minimum of six references[a] on TDDS, and analyze the mass transport of one of the following drugs across the skin barrier: nicotine, fentanyl, estradiol, testosterone or insulin.

SPECIFIC PROJECT REQUIREMENTS:

1. Discuss the relative merits of TDDS versus standard methods of drug administration (injections, oral delivery, etc.). Suggested section of paper: Introduction.
2. Discuss the structure and function of a transdermal patch manufactured by a particular company, along with its strengths and weaknesses. Do this for two different manufacturers. Suggested section: Introduction.
3. Discuss the structure of the skin and how this affects the transport of therapeutic drugs across the membrane. Suggested section: Theory.
4. Derive the mass transfer equation(s) required to model the transport of drugs across the skin. Suggested section: Theory.
5. Write a MATLAB program to solve the equation(s) above. Then, using nicotine, fentanyl, estradiol, testosterone or insulin as a model drug, assess the effect of skin permeability, patch area, body volume, and barrier thickness on a) rate of drug delivery, b) concentration of drug in the blood as a function of time, c) cumulative amount of drug delivered to the body, and d) time required to reach 99% of the steady state concentration in the body. Comment on the implications of your results. Suggested section: Results and discussion.
6. Present a summary of your key results, and comment on the potential for using TDDS for delivery of therapeutic drugs. Suggested section: Conclusions.

Additional information: To do the calculations outlined under item 5, you will need to search the literature to determine reasonable values of the following parameters for the drug you choose: skin permeability, typical patch area(s), typical initial concentrations of drug in patch, typical body volumes, barrier permeability, and target drug concentrations in the blood.

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[a] At least three must be technical references; the others can be from trade journals or manufacturers' literature.

PROJECT REPORT:
Your report should be no more than five (5) double-spaced typed pages in length (1.5 spacing in word processors). The abstract, figures, tables, etc. are not included in the page limit. Do not use a font smaller than 12 point. Each page must be numbered, including all pages in the appendix.

At the minimum, the report **must** include the following sections in the order given:

1. Cover page: this should include the title of your project, and the names of all the group members who worked on the project. The cover page must be signed by all group members, attesting to the fact that the work is ***entirely*** your own.
2. Abstract: this should be no more than 500 words (single-sapced). It should state the problem and its relevance, briefly describe the methods you used, list your key results and implications, and the conclusions of your study.
3. Introduction: use this section to establish the significance of this technology, and to address the other requirements listed on page 1.
4. Theory: use this section to present the mathematical analysis of the problem, and to address the other requirements listed on page 1.
5. Results and Discussion: your results should be presented in the form of tables and/or graphs. You should clearly and logically discuss your results and their implications, including comparisons to other delivery systems for the same drug. It should also include any additional calculations and/or analyses you would recommend for this project.
6. Conclusions: everything in this section must follow logically and directly from your results and discussion section; no new information should be provided here.
7. References: Provide a complete list of all references you used for your project, including books, papers, etc.
8. Appendix: put the details of your derivations here. You should also include the complete results of any computer simulations you ran.

Penalty for plagiarism: Plagiarism is a very serious academic fraud. By signing the cover page of your report, you are each attesting that the project is ***solely the work of your group***. ***All*** *group members will get a score of* ***zero*** *(0.0) for the project if any part of the report is plagiarized.* If you do not know what plagiarism is, have your entire group schedule an appointment with me.

Cited References

1. Giudice, E. L.; Campbell, J. D. Needle-free vaccine delivery. *Advanced Drug Delivery Reviews* **2006,** 58, (1), 68-89.
2. Hadgraft, J. Skin deep. *European Journal of Pharmaceutics and Biopharmaceutics* **2004,** 58, (2), 291-299.
3. Thomas, B. J.; Finnin, B. C. The transdermal revolution. *Drug Discovery Today* **2004,** 9, (16), 697-703.
4. Vaszar, L. T.; Sarinas, P. S. A.; Lillington, G. A. Achieving tobacco cessation: Current status, current problems, future possibilities. *Respiration* **2002,** 69, (5), 381-384.
5. Johnson, M. E.; Blankschtein, D.; Langer, R. Evaluation of solute permeation through the stratum corneum: Lateral bilayer diffusion as the primary transport mechanism. *Journal of Pharmaceutical Sciences* **1997,** 86, (10), 1162-1172.