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# Analytical Solution of the Effects of Applied Electrical Field to Drug Delivery in Electrochemotherapy

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Cancer is a disease that has plagued the earth for thousands of years, being the second leading cause of death in the United States. With many forms of the illness and no entirely effective mode of treatment, improving the effectiveness of presently available pharmaceutical drugs is of utmost importance. Chemotherapy is one such treatment, utilizing various drugs to weaken and kill the affected cells effectively. Drugs on their own can only carry themselves deep into the tumor by their inherent characteristics and how those interact with their environment, such as the drug concentration and drug uptake. Electrochemotherapy takes this treatment to the next stage, offering an external electrical field to drive the penetration of chemotherapeutic drugs into cancerous tumors through a process known as electrophoresis. Electrochemotherapy is especially useful as a non-invasive procedure, eliminating the need for surgical methods to cut into the patient.
This study investigates the effects of electrochemotherapy by introducing a modified mathematical formulation that captures the effects of an applied DC electrical field on the penetration of chemotherapeutic drugs into tumorous cells. Differential equations model the scenario to the second order based on a cylindrical depiction of the blood vessel as the drug source. The concentration of the drug is assumed to be one-dimensionally distributed radially at steady state, with the influence of the electrical field incorporated through an additional evaluation. The

electroporation effect over the tumor up-taking drug is modeled as a first order chemical reaction. Nondimensionalization techniques are applied to broaden the scope of application scenarios in the final solution. The modified Bessel function is employed to propose a unique solution to the system. Specific attention is needed to accurately represent real tumor microenvironments and electrical field distributions by providing a clearer link between specific treatment parameters such as drug concentration, drug uptake, and electrical field strength. The end equations yield simulated data about how deep the drug can penetrate the tumor at various applied electrical fields and the fraction of tumorous cells killed.