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Md Rajib Anwar, Kyle V. Camarda, Sarah L. Kieweg

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Mathematical Model of Microbicidal Flow Dynamics and Optimization of Rheological Properties for Intra-vaginal Drug Delivery: Role of Tissue Mechanics and Fluid Rheology

Md Rajib Anwar [a], Kyle V. Camarda [a,b], **Sarah L. Kieweg** [a,c,d,*]

[a] Bioengineering Graduate Program, The University of Kansas

[b] Department of Chemical & Petroleum Engineering, The University of Kansas

[c] Department of Mechanical Engineering, The University of Kansas

[d] Department of Obstetrics & Gynecology, School of Medicine, The University of Kansas

Abstract

Topically applied microbicide gels can provide a self-administered and effective strategy to prevent sexually transmitted infections (STIs). We have investigated the interplay between vaginal tissue elasticity and the yield-stress of non-Newtonian fluids during microbicide deployment. We have developed a mathematical model of tissue deformation driven spreading of microbicidal gels based on thin film lubrication approximation and demonstrated the effect of tissue elasticity and fluid yield-stress on the spreading dynamics. Our results show that both elasticity of tissue and yield-stress rheology of gel are strong determinants of the coating behavior. An optimization framework has been demonstrated which leverages the flow dynamics of yield-stress fluid during deployment to maximize retention while reaching target coating length for a given tissue elasticity.

Keywords

Microbicide gel, Non-Newtonian fluid, Yield stress, Thin film flow, Numerical optimization, Tissue biomechanics

[*] Correspondence to: The University of Kansas, 3144D Learned Hall, 1530 W. 15th Street, Lawrence, KS 66045, USA. Tel.: +1 785 864 3354.
E-mail address: kieweg@ku.edu (Sarah L. Kieweg)